LNG TO POWER
OFICINA DE INFORMACION
VISITANTES

FECHA	NOMBRE	RESIDENCIA/INSTITUCION	TELEFONO	CORREO ELECTRONICO	FIRMA
23/03/2015.	Carlos Alejandro Calles N.	Urb. El Milagro	7640-6899	Consulta - Emp.	
23/03/2015	Edwin Jeovany Ascencio	Col. Sn Julia.	6139-3953	Empleo - CV.	
23/03/2015	José Mario Dueñas García	Col. Sn. Genaro.	7106-7433	Empleo - CV.	
23/03/2015.	Bartolo Flores Hernandez.	Sonzacate / Sauce.	2450-1727 7785-2977	Consulta - Empleo.	
23/03/2015.	Carlos Antonio Aguilar.	Col. Magdalena	7334-9193	CV - Empleo	
23/03/2015	Remberto Alfredo Herrera	Izalco.	2483-3503	CV - Empleo.	
23/03/2015	Remberto Alfredo Padre Herrera	"	7481-0780	CV - Empleo	
23/03/2015.	Selvin Balmore. Arevalo.	Sensunapan.	7605-7880.	CV - Empleo.	
23/03/2015	Max Antonio Torres.	El Sause.	7635-1282	CV - Empleo.	
25/03/2015	Benjamin Mendoza.	Col. Cel	7211-7164	Consulta Emp.	
6/4/2015.	Cecilio. Hernandez Valle.	col. Sn Fco.	2455-3000.	Consulta	
6/4/2015	Mario Douglas Lainez	Sonsonate / Sensunap.	7018-8893	Buenos comentarios Consulta - Empleo	
6/4/2015.	Daniel Antonio Ortiz.	Sonsonate / Tomas S.	7772-7155.	Consulta - Empleo.	
6/4/2015	José Mario Trejo.	Acajutla / Nueva Ac.	2452-6067	Consulta - Inicio	
6/4/2015	Fabio Mayen Molina.	Col. Obrera	2487-3910	Consulta - Inicio	
6/4/2015	Dagoberto Antonio Hernandez.	Sn Pedro Belen	6119-6495	Consulta	
6/4/2015.	Salvador Enrique Hernandez.	Sn Pedro Belen.	"	Consulta.	
7/4/2015.	Melvin Alexander Tue.	Palmeras / Sonso	2450-2431	CV.	
7/4/2015.	Eliseo Alvarado	Acaxual, 2.	2452-4572	CV.	
7/4/2015.	Elias Artiga Acevedo.	El Sunzita	2431-1835.	Consulta - Inicio	EAA
7/4/2015.	Bartolo. Flores Hernandez.	El Sauce / Sonzacate.	2450-1727	CV.	

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FECHA	NOMBRE	RESIDENCIA/INSTITUCION	TELEFONO	CORREO ELECTRONICO	FIRMA
12/03/15	Juan Ramon Nuñez	Los Laureles	71651919	Consulta Inicio	[illegible]
12/03/15	Carlos Enrique Escalante	Col. Magdalena	7439-8781	Consulta - Inicio.	[illegible]
13/03/2015	Juan Orlando Alarcon	Kilo/5	7152-4995	CV.	[illegible]
13/03/2015	Salvador Ernesto Hernandez	Caballero. Campamento.	7001-0386.		[illegible]
16/03/15	Ovad Isai Alas Mejia	Col. Acaxual 4	7638-0997	Consulta CV.	— Ulanadu
16/03/15	Juan Carlos Estrada	Los Manetes	7132-5562,	Consulta Inicio	Ulanadu
16/03/15	Rodolfo Antonio Hernandez	Los Manetes	73265637	Consulta - Inicio	Ulanadu
16/03/15.	Victor Manuel Vasquez.	Sonso/ Sn Antonio.	2450-4080.	CV - Ofic. Empleo	[illegible]
16/03/15	Marcelino Bello.	Acaxual #2	7807-8222.		[illegible]
17/03/15	Miguel Angel Bonillas	Bo Los Cocoteros.	61825975	Copia DUI - Recomendado Don Dario	[illegible]
17/03/15	Tito Alberto Ramirez	Ciudadela	CV. 74689827	CV,	[illegible]
18/03/15	Julio Cesar Torres	Col. Alvarado.	7999-5687	CV.	[illegible]
18/03/15	Ines Santos Gomez Jacob	Col. El Milagro.	7113-2737	CV kms1.280 outlook	[illegible]
18/03/15	Kensy Marcela. Soriano	Col. Acaxual	2452-5602	CV. / Empleo	[illegible]
18/03/15.	Ricardo Sebastian Barjas.	Kilo - 5	7389-9322	CV Empleo.	[illegible]
18/3/15	Manuel de Jesús Perez.	Barrio El Campamento.	7325-1905	CV - Empleo	[illegible]
20/3/15	Milton Alexander Rivera.	Col. Sn Julia.	74297488	CV - Empleo.	M A R
20/3/15.	Jorge Mario Lopez.	Sonzacate.	2415-0488	CV - Empleo.	[illegible]
23/3/15	Antonio Morales Ramos.	Ciudadela.	6130 0422.	Consulta Inicio	[illegible]

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VISITANTES

FECHA	NOMBRE	RESIDENCIA/INSTITUCION	TELEFONO	CORREO ELECTRONICO	FIRMA
2/03/2015.	Hector Ramiro Araya	San Pedro Belén	7793-1050.	Consulta Empleo.	x H.R.A
2/03/2015	Juan Carlos Santos Anchetón	Juayua.	70613841.	CV-Empleo.	[signature]
2/03/2015.	Venancio de Jesus Vasquez	Juayua.	7432-6212	CV-Empleo.	"
2/03/2015	Israel García	Bº Campamento	6204-4997	Consulta E.	[signature]
2/03/2015.	José Adan. Avila.	Juayua.	7513-1995	CV-Empleo.	Y Aguilar
2/03/2015	Laura Cecilia Cordero.	Ciudadela...	7632-0457 ~~7607-2124~~.	CV-Empleo.	[signature]
3/03/2015	Ana Isabel Garcia Martínez	Acaxual Nº2.	7045-1071	Consulta-Empleo.	[signature]
03/03/2015.	Karen Guadalupe Flores M.	Acaxual Nº2.	7963-3203	Consulta-Empleo	[signature]
03/03/2015	Rafael. Antonio Figueroa.	Col. Alvarado	7651 4108	CV.	[signature]
03/03/2015.	Mauricio Isaías Figueroa	Col. Alvarado	7064-5787	CV.	[signature]
03/03/2015.	Rufino Cruz Galdamez.	Metalío.	6179-8842	CV.	Rufino [signature]
9/03/2015.	Edwin Giovany Herrera	~~Arma~~/Sonsonate	2929-1209	CV.	[signature]
9/03/2015	Joaquín Alessandre.	Sonsonate	7967808/2451-4857.		[signature]
2/03/2015.	Hector Ramiro. Araya.	Sn Pedro Belén	~~7793~~ 7793-1050.	CV.	H.R.A
2/03/2015.	Mariano Jeronimo Valdizon	Virtuantes/	7328-4468	CV.	MJV
11/03/2015.	Miguel Angel Martinez J.	Sonsonate	63027098.	Consulta	[signature]
11/03/2015	Ilario Sanchez.	Perra. Ciudad	7881-7407	llamada actualizado de CV	llamada
11/03/2015	Douglas Adhan Morales	Los Cobanos.	7010-6087.	Consulta. Inicio.	Douglas
11/03/2015	Jaime Alvarenga	Los Morretas.	7641-7268.	" "	[signature]
11/03/2015	José Roberto Ramos.	Sonsonate.			
11/03/2015	Julio Alfredo Alberto Zalas	Sonsonate.	2451-6210.		[signature]
11/03/2015	Uardo Ernesto Montaroza	Sonsonate/2.	7285 6610		[signature]

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VISITANTES

FECHA	NOMBRE	RESIDENCIA/INSTITUCION	TELEFONO	CORREO ELECTRONICO	FIRMA
18/2/15.	Cecilio Fidel Hernandez.	Col. Sn Francisco	7383-7182	Entregado por . Edwin Moran	[illegible]
18/2/15	José Roberto Jimenez . Martinez	Col. Sn Francisco .	11	Entregado por 11	[illegible]
18/02/15	Rafael Alfonso Arrué	INFRA DE EL SALVADOR S.A de C.V	2451-0665	rafael.arrue@oxgasa.com	[illegible]
20/02/15	Emerson Bladimir Perez	Juayua	7502-0281	Auxiliar Construccion	Hernandez.
24/02	Daniel Isais Ramos Arias	Col. Alvarado.	7066-2045	Consulta Inicio	[illegible]
	Juan Francisco Mendez	Juayúa	79746427		[illegible]
	Mario Antonio Mendoza Natividad.	Juayúa	74914804		[illegible]
	Julio Cesar Beltran M.	Juayua	71726680		[illegible]
24/02/2015	Gustavo. Alberto Vasquez	Juayua.	6301-8712	CV - Empleo.	[illegible]
	Miguel Dagoberto Castro	Ahuachapan	71252937		[illegible]
	Walter Misael Ramirez R.	Juayua Sonsonate	61165934 7053 0404	CV.	[illegible]
	José Antonio maye Rodriguez	Juayúa Sonsonate	71318679		José mayE
		El Sunzal/Acaj.	7356-4742.		
25/02/2015	Julio Alberto Sanchez.	El Sunzal.	7356-4742.		[illegible]
25/02/2015	José Mario Dubon	El Sunzal/Acaj.	7067-0006	—	[illegible]
26/02/2015	Salvador Nolasco Echavarria	El Milagro.	7016-9181.	Consulta - Inicio	M. Dubon
26/02/2015	Elmer Garcia Montorrozo	Col. Alvarado	7090-1734	Consulta - Inicio	[illegible]
26/02/2015	Mauricio Isais Figueroa	Col. Alvarado.	7064-5787	Consulta - Inicio	[illegible]
27/02/2015	Carlos Antonio Santos.	Sonsonate.	7142-5341	CV	[illegible]
27/02/2015.	Roberto Ardon Arias	Comunidad La Coquera.	73071469	CV - Empleo.	[illegible]
27/02/2015	Jorge Alonso Santos.	Vacoquera	7439-1957	Consulta	[illegible]

✓ documentos@alonsoto.com.sv
2234-8900

ENERGIA DEL PACIFICO SA DE CV

OFICINA DE INFORMACION

VISITANTES

FECHA	NOMBRE	RESIDENCIA/INSTITUCION	TELEFONO	MOTIVO		CORREO ELECTRONICO	FIRMA
				CONSULTA	CV		
13/8/15	Agustin Campos Cea	El Coyol, Sonsonate	6128-9877	X	X	—	AGCC
13/8/15.	Noe Ezequiel Aragueta	El Coyol, Acajutla	7694-5440	X	X.	—	AVEFA
13/8/15	Esdras Benjamín Pineda	El Coyol, Acajutla	7172-7465	X	X	—	[illegible]
13/8/15	Josué Angel Pineda	El Coyol, Acajutla	7164-8099	X	X.	—	[illegible]
13/8/15	Pedro Antonio Estrada	Osteros / Acajutla.	7030-4143	X			x [illegible]
14/8/15	Miguel Angel Acosta Silva	Barrio Las Atarrayas.	7644-2787	X		—	[illegible]
14/8/15	Osca Alonso Herrer	Sunza		X	X	—	X [illegible]
17/8/15	Salvador Nolasco	Col. El Milagro.	63026030	X	—	—	[illegible]
17/8/15	Felipe Danilo Alfaro Arue	Bº El Componente	2452-9727	X.	—	—	x [illegible]
17/8/15.	Rafael Mauricio Merande	Bº) Col. IVU.	7002-7712	X	—	—	x [illegible]
17/8/15.	Manuel de Jesús Cortés.	Sonzacate.	7815-6660	-X	—	—	X [illegible]
17/8/15	Nelson Jeovany Diaz	Bº Los Coquitos.	2452-6386	X	—	—	x [illegible]
17/8/15.	Mauricio Arturo Paula	Sonzacate.	7701-8083	X	—	—	x [illegible]
17/8/15	Manuel de Jesus Perez	Bº Componente	7325-1005	X	—	—	Llamada.
17/8/15	Hector Alcides Lozano	La Paz / Costa del Sol.		X		78166398	Llamada.
18/8/15	Douglas Adrian Morales.	Cantón San Julián	70108087	X	—	—	[illegible]
18/8/15	Salvador Enrique Aguilar	El Caracol	7768-1317			—	x [illegible]
18/8/15	Roberto Guillermo Hernández	Sonsonate / Sonsonate.		X		76519530	Llamada.
18/8/15.	Saúl Hernandez						
18/8/15	Oscar Baltazar Escoto.	Sonsonate / Balzamo	76687057	X	—	—	[illegible]
18/8/15	Guillermo Zetino.	Nahuizalco / Canton.	7052-9354	X	—	—	x [illegible]

CONTROL DE LLAMADAS

FECHA	NOMBRE	EMPRESA	NUMERO DE TELEFONO
19-08-15	José Manuel	-	70302827
19 08-15	Manuel Antonio Arce	-	71 70 14 98
19-08 15	Luis Alonso lopez	-	72 13 00 06
19 08-15	Victor Marcial cha-	-	61 23 55-91 / 76 23 83 82
19-08-15	Hecto Arcide Losano	-	7816 63 98
19-08-15	Alfredo Velas Areas	-	73 69 20 87.
19-08-15	Rufino Galdamez cruz	-	61 79 88 42.
19 08-15	Efrain alberto Valencia	-	79-93-21-92
20-08-15	Oscar ventura	-	-
20-08-15.	Rene alfonso polanco	-	68 97 58 82.
21.08.15	Elber pares Campos	-	71 66 78.21
21-08-15	Claudio Elias Garcia	-	7019 36 82.
24-08-15	Juan Carlos Estrada	consultor	7659-2033.
24/8/15	Arcadio de Jesus Hernandez	Sonsonate/Sn Antonio	6145-9066
26/8/15	Josué Neftaly Portillo	Santo Tomas/S.S.	7105-4142 CV

ENERGIA DEL PACIFICO SA DE CV

OFICINA DE INFORMACION

VISITANTES

FECHA	NOMBRE	RESIDENCIA/INSTITUCION	TELEFONO	MOTIVO CONSULTA	MOTIVO CV	CORREO ELECTRONICO	FIRMA
27/8/15	Julio Antonio Ramirez	Col. Calle Dos Alm.	7335-7558	✓		—	
28/8/15	Juan Antonio Galicia	Jardines de la Nueva	2227-4873		/7112-9866.		
28/8/15	Fabio Mayen	col. San Julian	7107-8875.	✓		—	
31/8/15	Balvino Contreras.	Morro Grande	7168-7172	✓	–	—	
31/8/15	Edwin Osvaldo Sanchez	El Milagro	7356-5502		.	—	
31/8/15	Miguel Angel Solis	El Milagro	76162732			—	

CONTROL DE RECEPCION D_ CV Y VISITAS
OFICINA DE INFORMACIÓN

FECHA	NOMBRE	MEDIO: Correo	MEDIO: Oficina	CORREO ELECTRONICO	PROFESION
20/01/2016	Daniel Alfredo Galicia		✓	Sensuntepeque / 6111-5115.	x
20/01/2016.	Roberto Carlos Cea Olivo		✓	Sensuntepeque. / 7589-2151	x
20/01/2016	Roberto Carranza		✓	Alvarado / 7582-3365	x
20/01/2016	Roberto Calzadilla Tadeo.		✓	Col. Acevar / 6101-9037	x.
20/01/2016	Douglas Alexander Cardona		✓	Colima - Los Cobanos / 6300-8889	x
20/01/2016	Pedro Antonio Gomez.		✓	Armenia Sonsonate / 7252-3836	x
20/01/2016	Carlos Gonzalez (Inversiones Calma)			2209-0097	Lic. Vanadaz
20/01/2016	Carlos Quiñones		✓	7737-5202	x Vlanadar
27/01/2016	Emanuel Marcio Sabrón.		✓	Nueva / 61885710	
27/01/2016.	Bladimir Enrique Tobar		✓	Col. Los Laureles. / 2434-2258	x
28/01/2016	Wilfredo Alvarado Carranza		✓	Atiquizaya / 7840-9363	x
29/01/2016.	Servin Danilo Zeteno		✓	Sacacoyo / 7018-9865	x
29/01/2016	Manuel de Jesús Mendez.		✓	Sacacoyo / 7889-0416	x MDM
29/01/2016	Jeremias Baldizon		✓	Britientes / 7328-4468	x MJVC
29/01/2016	Alexis Javier Rodriguez			Col. Atena / 24152158	V
29/01/2016.	Alexis Isaac Matozo		✓	Ahuachapan / 71774754	x
29/01/2016	Veronica Mirada Garcia		✓	Panchimalco. / 7328-8810	x
29/01/2016	Francisco Javier Pastor Ramos		✓	San Antonio / 78669815	x
29/01/2016	Rafael Rivas		✓	Alvarado / 7361-5922	x
29/01/2016	Rafael Argueta		✓	Ciudad Arce / 78323405	N Vlanader
01/02/2016	Celestino Zuniga Ramirez			Nahuizalco # 73090181	
01/02/2016	Salvador Orlando Tobar			Guaymango # 7096-4892	
01/02/2016	Mario Antonio Martinez			Acajutla # 7096-4598	
01-02 2016	Rember Adilson torres M.			Guaymango # 79669960	
01-02 2016	Carlo Alfredo Vasquez			Jujutla # 64594459	

1/02/16 . Mario Antonio Vasquez Cortez | Jayutla - 6136-5049 F. MAVC

1/02/16 Victor Manuel Rivas Lopez | Acaxual # 4 | 7235-0029 F.

1/02/16 Wilmer Maldonado Ascencio | Sto Domingo de Guzmán | 70551818 x

1/2/16. Edwin Nahum Ramirez | " | 7773-9996 x

1/2/16 Rudy Alfaro | " | 7193-8473 x

1/2/16 Alexis Javier Rodriguez. | Col. San Genaro | 7022-9829 x

ENERGIA DEL PACIFICO SA DE CV
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VISITANTES

FECHA	NOMBRE	RESIDENCIA/INSTITUCION	TELEFONO	MOTIVO		CORREO ELECTRONICO	FIRMA
				CONSULTA	CV		
1/09/15	Jorge Alberto Campos	Bº El Componente	74929389		✓	—	
1/09/15	Pedro Antonio Pineda.	Sonsonate/El Sauce.	62087484.			—	
1/09/15	Franklin Chavez	Acaxual #3	7396-3874			—	
4/09/15	Daniel Enrique Cordova	Ciudadela	70942560		-	—	
4/9/15	Pablo Aguilar.	Col. Sn Julian	74990364			Nuevo tx	
4/9/15	Rolando Ernesto Aguila.	Sonsonate/Fortuna.	7128-2163			—	
4/9/15	Oscar Baltazar Escoto	Sonsonate/Balzamar.	7668-7057		-	—	
4/9/15	Bayron Stanley Rodriguez	Com. El Milagro.	7049-9831			—	
7/9/15	Margarito Antonio Gonzales	Sn Pedro Belen.	7096-9814			—	
7/9/15	Antonio Morales Ramos	Ciudadela Cepa.	6130-0422			—	
7/9/15	Alexander Perez.	Sonsonate/Nahui-	7100-9862			—	
7/9/15	José Ramirez	Nahuizalco	7384-0057			—	
7/9/15	Ines Moran	Nahuizalco	6198-5807				
7/9/15	José Alfonso Ramos	Morro Grande	241189-08		-		
7/9/15	José Oswaldo Escobar	Morro Grande	7782-6970.				
7/9/15	Ramos Torres	Morro Grande	70646060		-		
*7/9/15	Miguel Francisco Gonzalez.	Ciudadela	73156843		.	—	
7/9/15	Noe Alberto. Ariteo	"	76177607			—	
7/9/15	Luis Alberto Reyes L.	"	79721203			—	
7/9/15	Tadeo Antonio Pacheco	Sonsonate/Sauce.	2450-4123		-	—	
7/9/15	Rolando Cruz	Nahuizalco-BA.	7128-2163.		CV.		

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FECHA	NOMBRE	RESIDENCIA/INSTITUCION	TELEFONO	MOTIVO CONSULTA	MOTIVO CV	CORREO ELECTRONICO	FIRMA
7/09/15	Juan Francisco Medrano	Punta Remedios	7758-5094			—	x
7/09/15	José Mauricio Escobar	Col. Canales	7047-9497				
7/09/15	Roberto Vasquez	Izalco	7004-0151			—	Llamada
7/09/15	Mauricio Roberto Figueroa	Costa Morro Grande	7787-5095				
8/09/15	José Amilcar Ramos	Morro Grande	7015 11-01				
8/09/15	Eduardo Enrique Rivera	Col. Acaxual	7666-8416				x
10/09/15	Luis Barillas	Guatemala	—			Llamada	—
11/09/15	Salvador Nolasco	Milagro	7617-6431				
11/09/15	Luis Roberto Perez	Guaymango	7482-1773			—	x
11/09/15	William de Jesús Cabrera	Kilo-5	7021-2839			—	
11/09/15	Nefi Eduardo Rivera	Chalchuapa	6149-8050			—	x
11/9/15	Alvaro Marin	Morro Grande	—			-	Llamada
11/9/15	Franklin Armen Chavez	Acaxual #3	73963074			—	
11/9/15	Julio Antonio Ramirez	Con. Santa Agueda	73357530			—	
11/9/15	Welmer Garcia	Santa Catarina Masahuat	79604821			—	
11/9/15	Victor Manuel Moran	"	70334331			—	
11/9/15	Manuel Antonio Moran	"	76013901			—	
14/9/15	Manuel Antonio Arce		61701498				Llamada
16/9/15	Marco Alberto Ventura	Sonsonate	7413-3107			—	
16/9/15	Santa Agueda / Rafael Sanchez		7172-4970			—	x
16/9/15	Miguel A. Cruz	Sonso/Talcomunca	7116-3968			—	Llamada
17/9/15	Alfonso Benjamin Solis Roman	El Salamo	7660-6631			-	x

Appendix 8M–

Attendance List to Acajutla Municipality Meeting 2016

LISTADO DE ASISTENCIA

Tipo de reunión: Reunión Informativa con Alcaldía Municipal de Acajutla, Proyecto "LNG TO POWER"

Fecha: Miércoles 19 de octubre de 2016.

N°	Nombre	Sexo	Institución social y Cargo	Teléfono de contacto	Correo electrónico	Firma
1	Wilber H. Soriano Mena	M	AMA concejal			[firma]
2	Hugo Antonio c Arriola		alcalde			[firma]
3	Silvia Ventura de Buruca		A.M.A. Concejal			[firma]
4	Mario Edgardo Pere		concejal			[firma]
5	Moises Mardoqueo [illegible]		Sindico			[firma]
6	Manuel Minunta		A.M.A. Consejal			[firma]
7	Silvano Madrid		consejal			[firma]
8	José Joaquín Moreira		concejal	7747-8002		[firma]
9	Saul Hdez		|			[firma]
10	José Luis Ortiz		Concejal	77444959		[firma]

LISTADO DE ASISTENCIA

Tipo de reunión: Reunión Informativa con Alcaldía Municipal de Acajutla, Proyecto "LNG TO POWER"

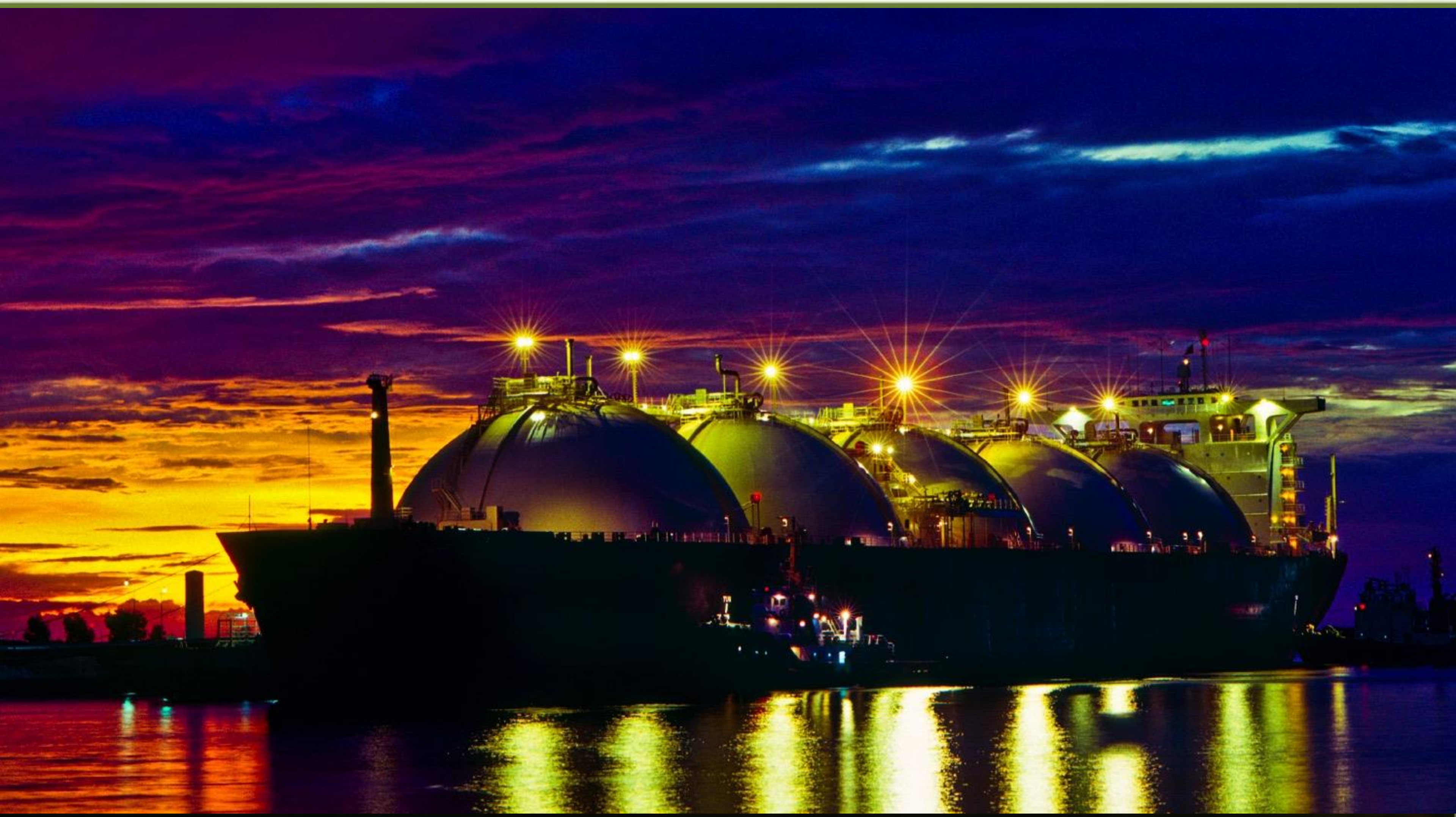
Fecha: Miércoles 19 de octubre de 2016.

N°	Nombre	Sexo	Institución social y Cargo	Teléfono de contacto	Correo electrónico	Firma
1	Dinora Mejia	F.	Alcaldia. Concejal	77441576		[firma]
2	Darlin Pineda de Mancia	F.	Secretaria Mpal.	7744-2494	darlin_rico@hotmail.com	[firma]
3	Jorge Alberto Ramirez	M	Concejal	7747-9774.		[firma]
4	Salvador Antonio Lopez	M.	Concejal	2429-7330		[firma]
5						
6						
7						
8						
9						
10						

Appendix 8N–

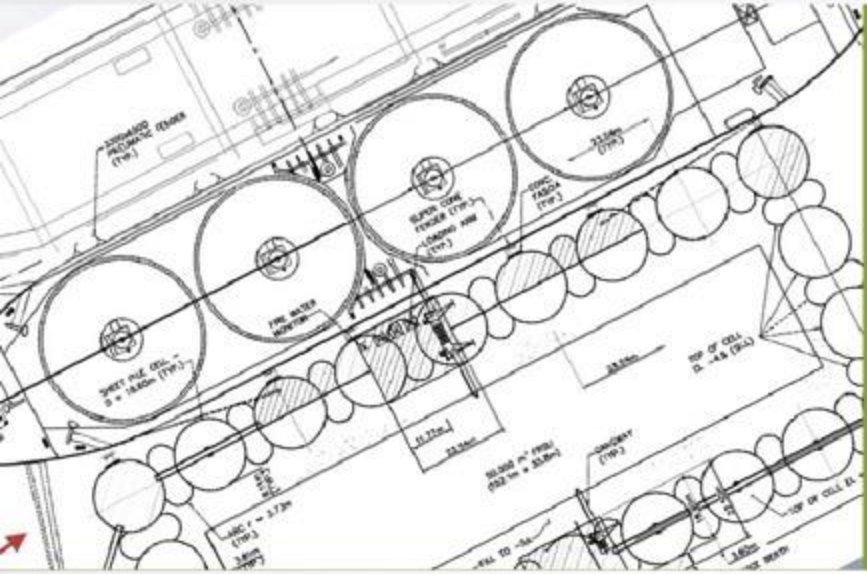
Project Presentation for 2016

Energía del Pacífico



Clean energy for our future

OBJECTIVES OF THE MEETING



Inform the popullation and the general public about the activities that have been developed and the changes in the project of ENERGY GENERATION WITH NATURAL GAS.

We have worked together

DESIGNERS – PROJECT HOLDERS– ENVIRONMENTAL CONSULTANTS

To find the optimal project settings.

INVESTMENT IN THE PROJECT

Invenergy

NATURAL GAS
11 Projects
5,833 Megawatts

EÓLICO
67 Projetcs
7,654 Megawatts

SOLAR
8 Projects
144 Megawatts

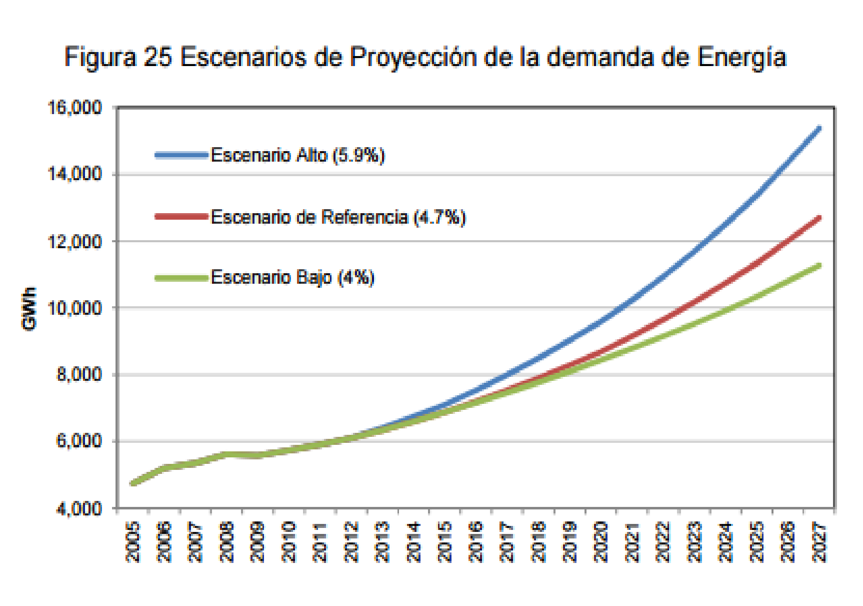
PROJECT OVERVIEW

A power plant of **380 MW will be installed.**

The plant will supply electricity to the seven distributors in El Salvador.

Natural gas will be used, the cleanest fuel available for generating electricity in thermal plants.

PROJECT NEEDS

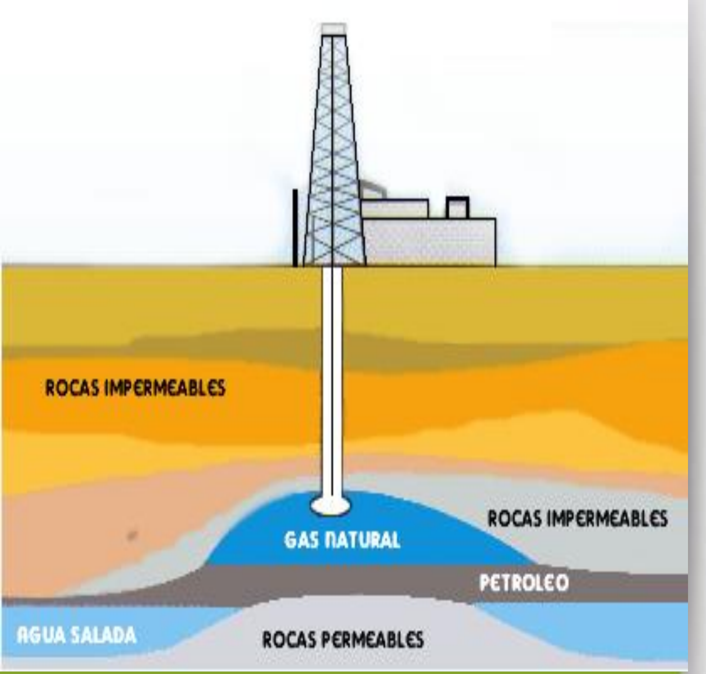


El Salvador needs to expand its production of electricity to contribute to the economic and social development that the country's growth and population demands.

Pacific Energy won a contract to generate electricity for 355 MW for 20 years.

This will help to improve the way in which electricity is generated and guarantee a supply of energy to the country and its habitants.

ADVANTAGES OF NATURAL GAS



Natural gas is a fossil fuel found in nature. It is extracted from the earth.

It is safe

It disperses easily in the environment, lighter than air.
A smaller amount is required to generate more electricity.

It is clean

It has less carbon, generating less CO_2 into the environment.
It is stored easily and its use leaves no residue on the equipment.

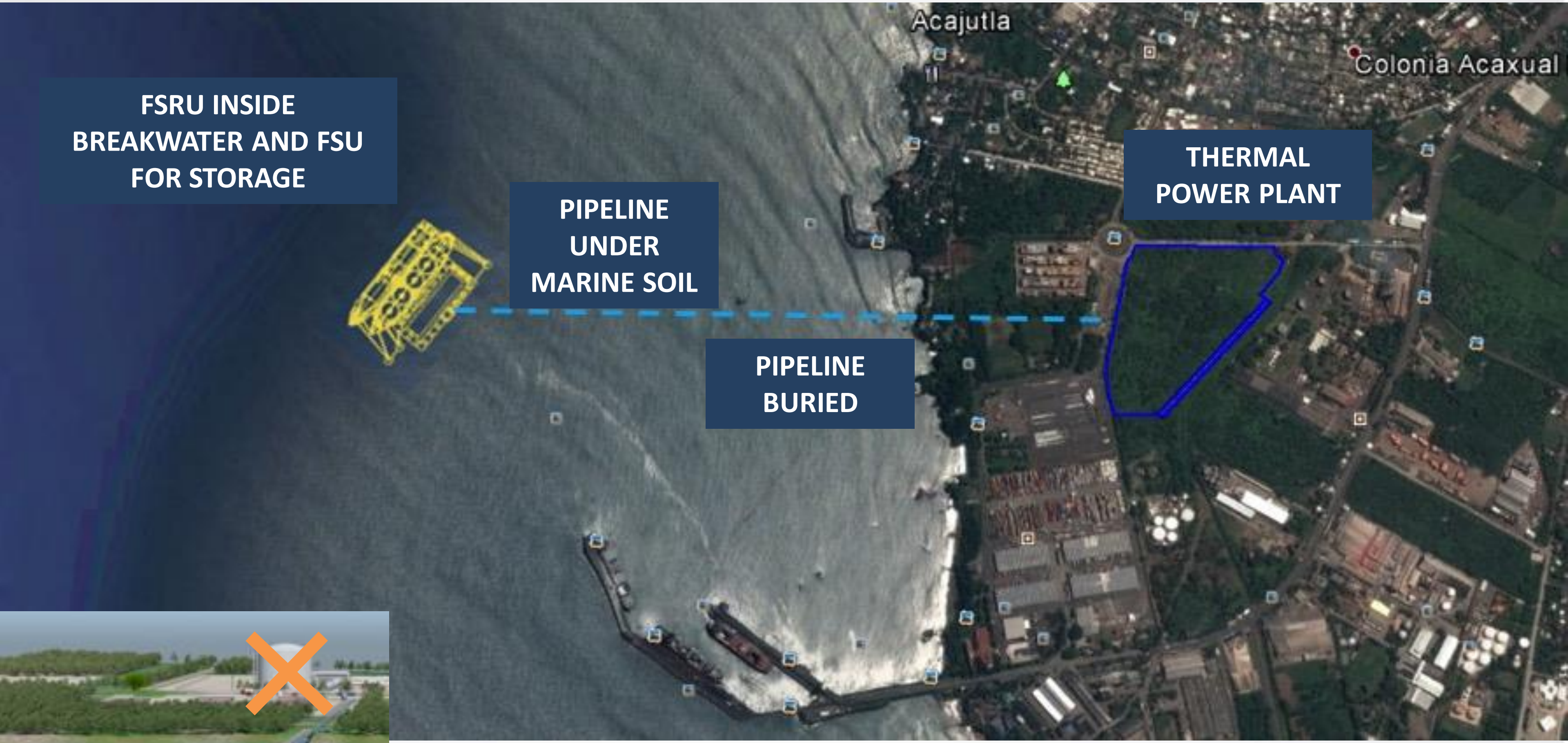
It is cheap

Its cost is lower than GLP, bunker, diesel and other fossil fuels.

PROJECT LOCATION

It is located contiguous to other plants and vacant lots of industrial use.

CONCEPT OF THE PROJECT



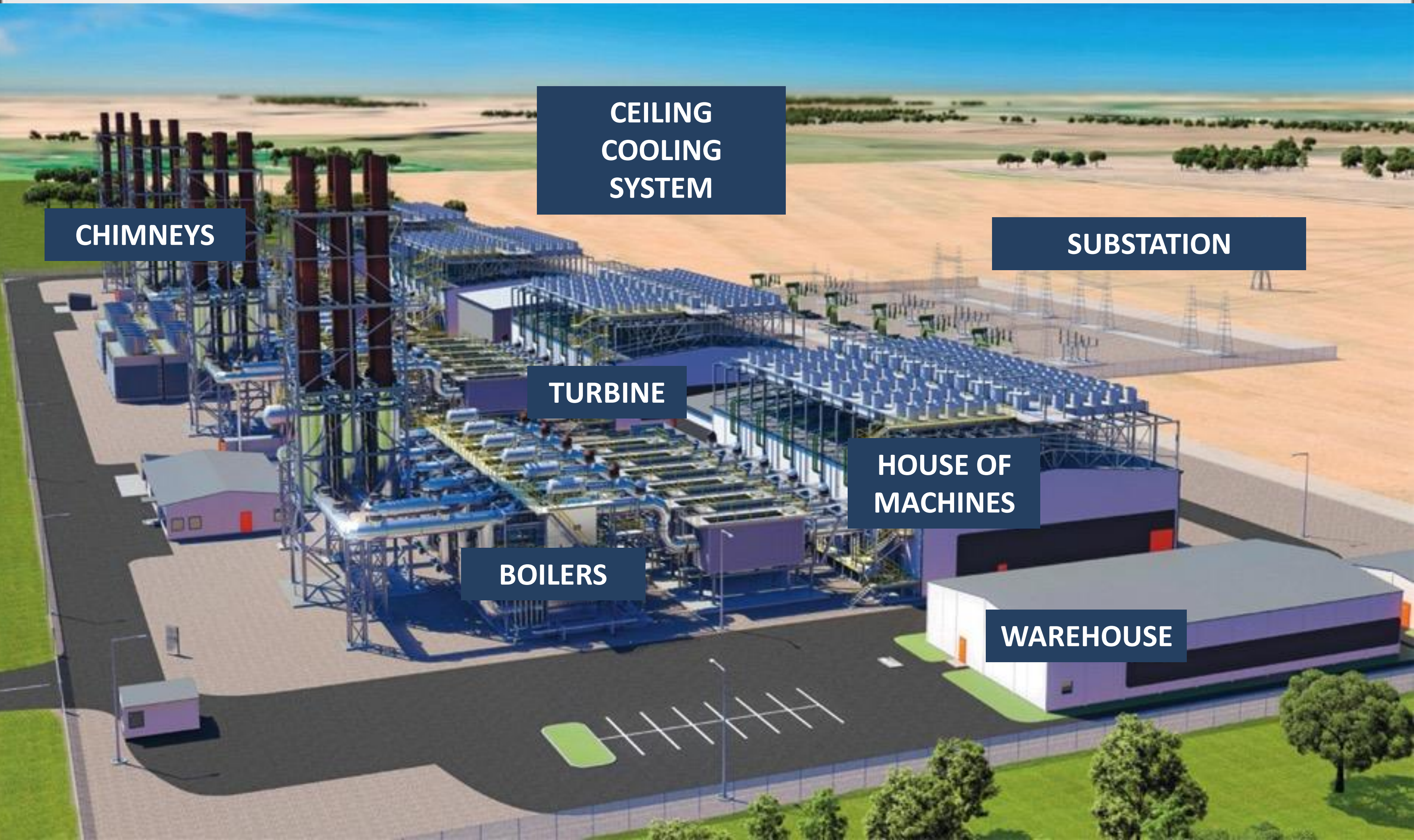
It will not be constructed:
Wharf with Liquefied Natural Gas Pipeline
Tank and regasification plant on land

THE PROJECT, ELEMENTS

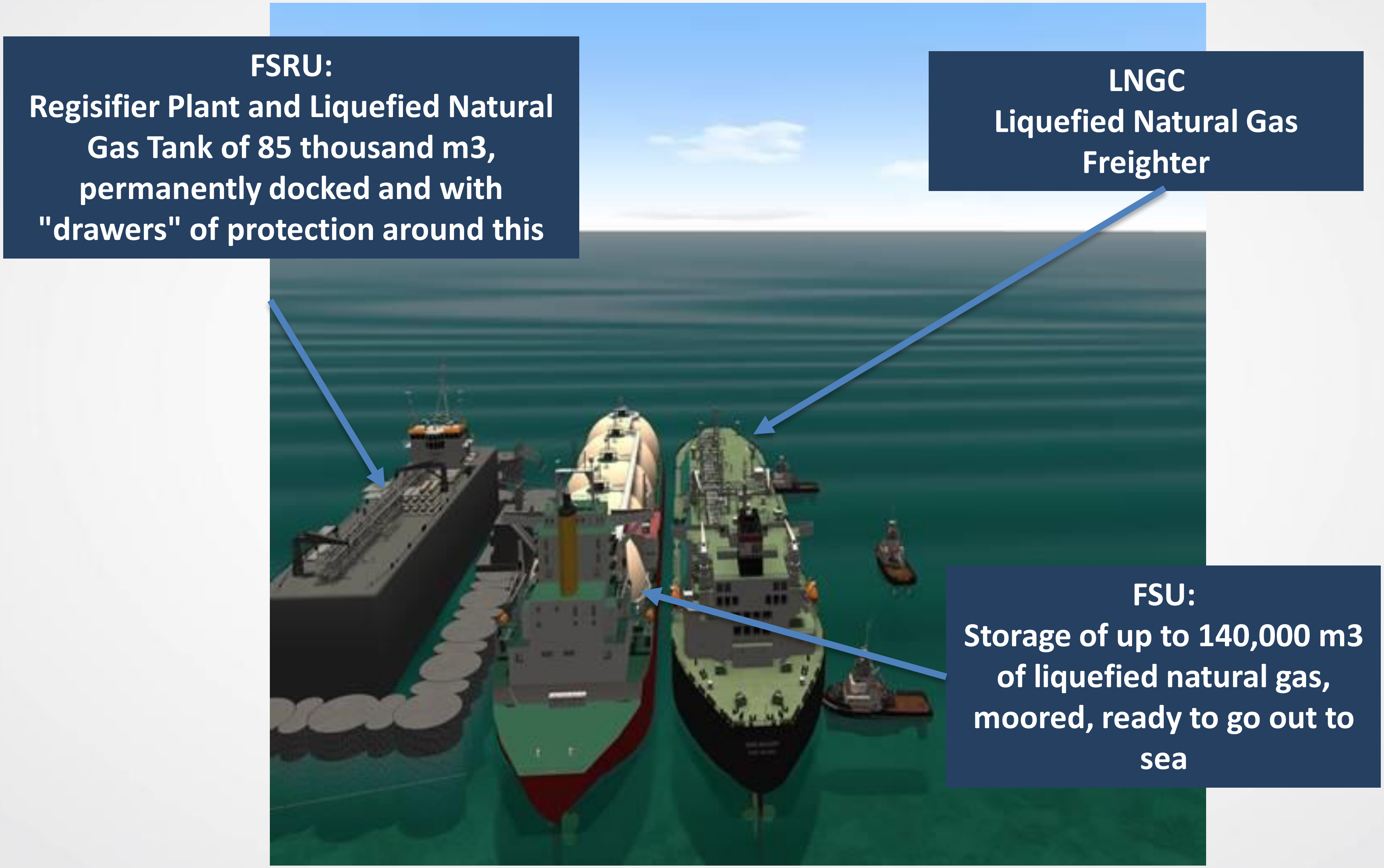
THERMAL POWER PLANT

Unit for regasification and floating storage in the sea.

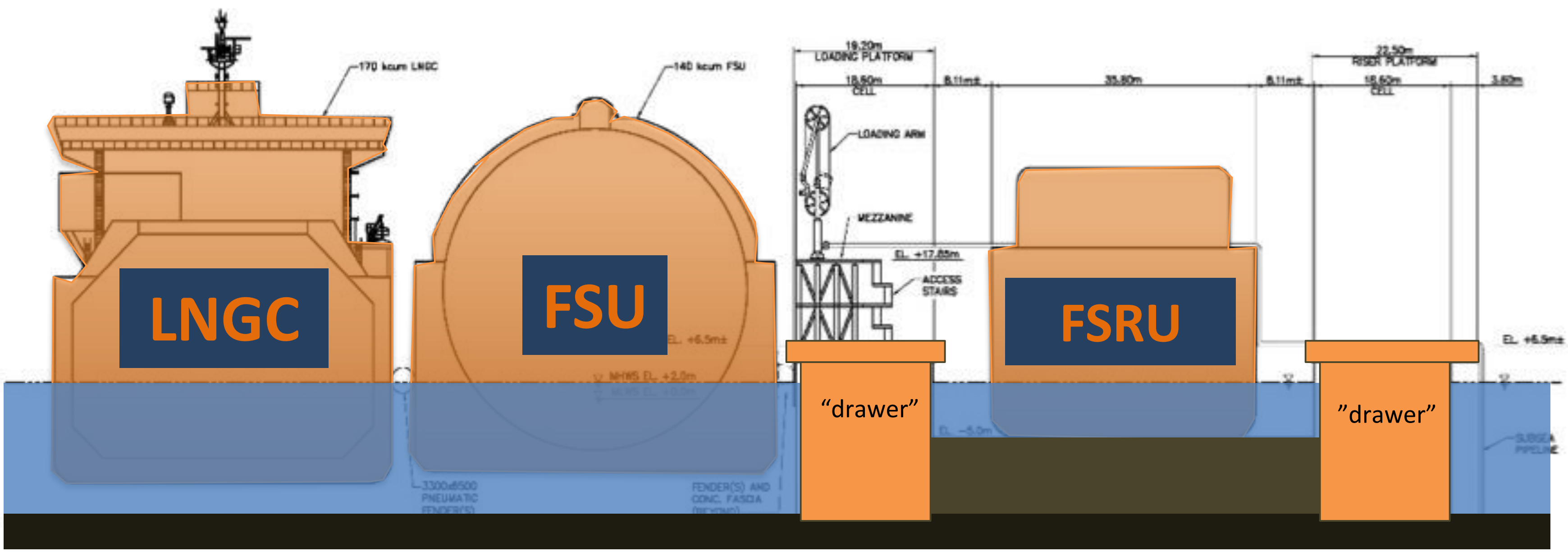
THERMAL POWER PLANT



NATURAL GAS STORAGE



DETAIL OF PROTECTION DRAWERS

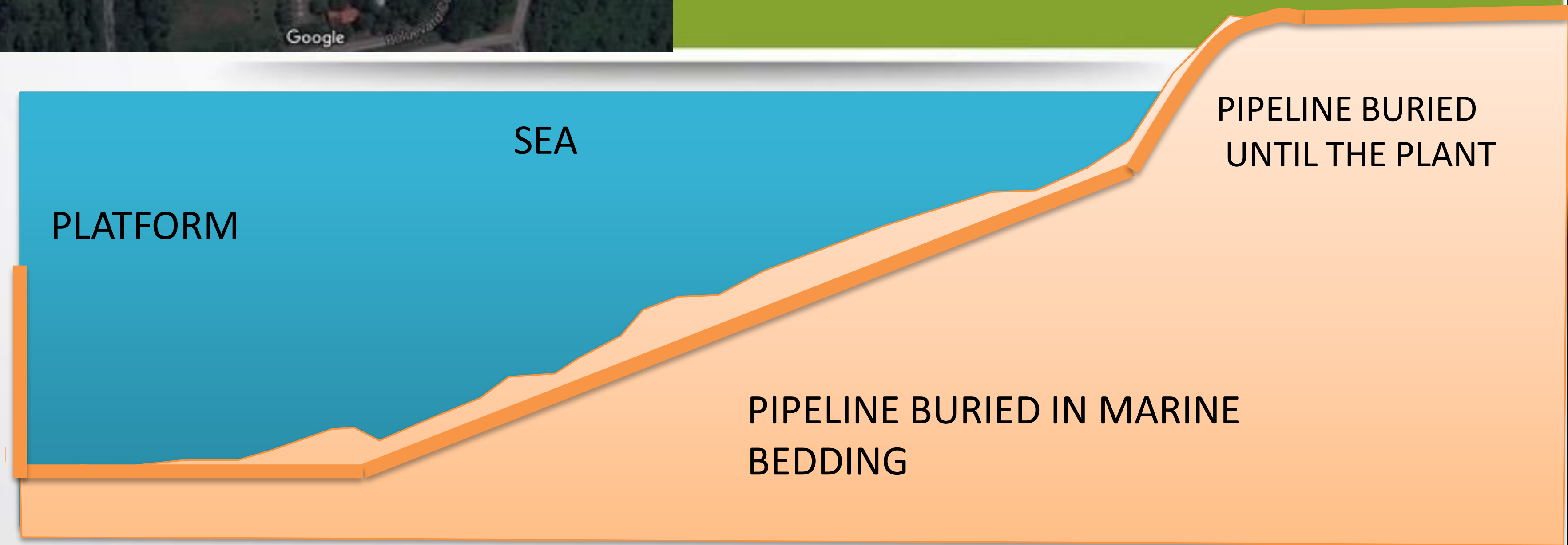


PIPE DETAIL

Approximate measurements :

1.300m buried under the seabed

500m buried under ground on land, to Plant on CEPA grounds



Energía del Pacífico

Pacific´s Central Power Generator

Environmental Permit Process

ACTIVITIES IN 2014-2015

Redesign of the project looking for the best alternative

Complementary air quality studies

Analysis of water, sediments and marine biota

Project risk study

Consultation and meetings with institutions: MARN, ANDA, MINISTERIO DE ECONIMÍA, AMP, CEPA.

Impact Assessment of the Modified Project

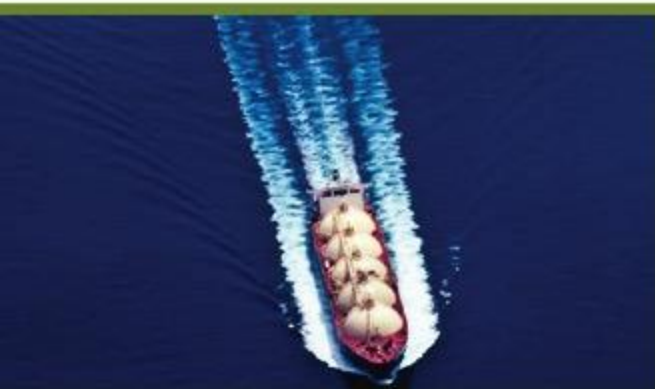
ENVIRONMENT EFFECT INVESTIGATION

A new updated document will be submitted to:

MINISTERIO DE MEDIO AMBIENTE
CORPORACIÓN FINANCIERA INTERNACIONAL (BANCO MUNDIAL)

For review and subsequent approval

Energía del Pacífico



Pacific´s Central Power Generator

POTENTIAL IMPACTS AND MITIGATION MEASURES PROPOSED

NOISE CONSTRUCTION STAGE

During construction typical noise sources are :

- ✓ Machinery, generators, traffic.

To avoid disturbing the population by noise, the following prevention measures will be applied:

- ✓ Carry out the noisiest activities during the day
- ✓ Use of mufflers in equipment
- ✓ Restrict the passage of trucks in residential areas
- ✓ Locate noisy equipment away from residential areas and barriers will be used if necessary.

Most construction noises will not be heard because in the area there are high noise levels for being an industrial zone

OPERATION STAGE: NOISE

The noise is reduced due to the installation of silencers and the engines have been located in the southern part of the land, away from the dwellings

When the existing thermal power station is operating the noise of the new Thermal Power Station will not be perceived.

The noise generated by the plant will be less than the established standard.

Low-frequency noise (which causes vibrations) will be below the standards levels and will be below the levels that make walls and windows vibrate.

Noise levels shall be measured at the start of operations and annually

AIR QUALITY - DUST AT THE CONSTRUCTION STAGE

To prevent dust discomfort, a dust control plan will be implemented, including:

- Speed limits will be set
- Truck will be covered
- Irrigation will be used
- Tire cleaning will be done before leaving
- Material that is dragged or dropped on roads will be cleaned

AIR QUALITY DURING OPERATIONS

EDP Will monitor emissions and ambient air quality during operations

Natural Gas is the cleanest compared to oil and coal (less sulfur, nitrogen dioxide and particulates) so emissions from the plant will be below the norm.

The chimneys have been grouped to improve the dispersion in groups of four chimneys.

Emissions were estimated using methods from the US Environmental Protection Agency, which indicate that they will be below the norm.

STAGE OF CONSTRUCTION - SPILLS AND WASTEWATER

Example of prevention measure

Paints, oil, fuels, and other building materials will be used.

- A spill prevention and wastewater treatment plan will be implemented
- Procedures shall be taken in case of accidental spills to protect soil and water

All wastewater will be treated in compliance with the regulations

STAGE OF OPERATION - SPILLS AND WASTEWATER

Lubricating oils are used in the operations for engines and equipment.
In less quantity other chemicals in the workshop: solvents, paints, chemicals to treat water, among others.

Spill prevention measures and cleaning plans will be implemented in case of accidental spills, to protect soil and water.

All wastewater will be treated to comply with current regulations.

WATER SUPPLY

Water consumption will be minimal because radiators will be installed instead of cooling towers on the roof of the engine room, with recirculation of water.

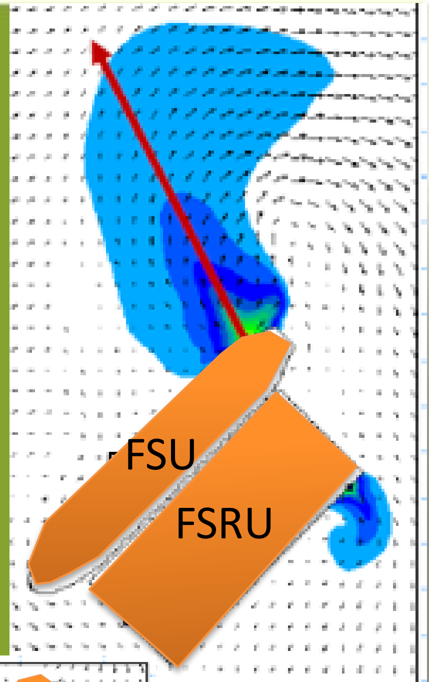
Water will be obtained from wells within the land, both for the construction and for the operation of the Project.

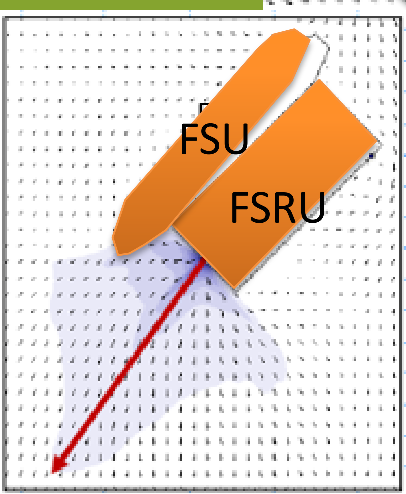
The aquifer has enough water to provide the Project without affecting other wells in the area.

We already have permission from ANDA

WATER FOR REGISTRATION

Possible dispersion of hot water





Possible Dispersion of cold water

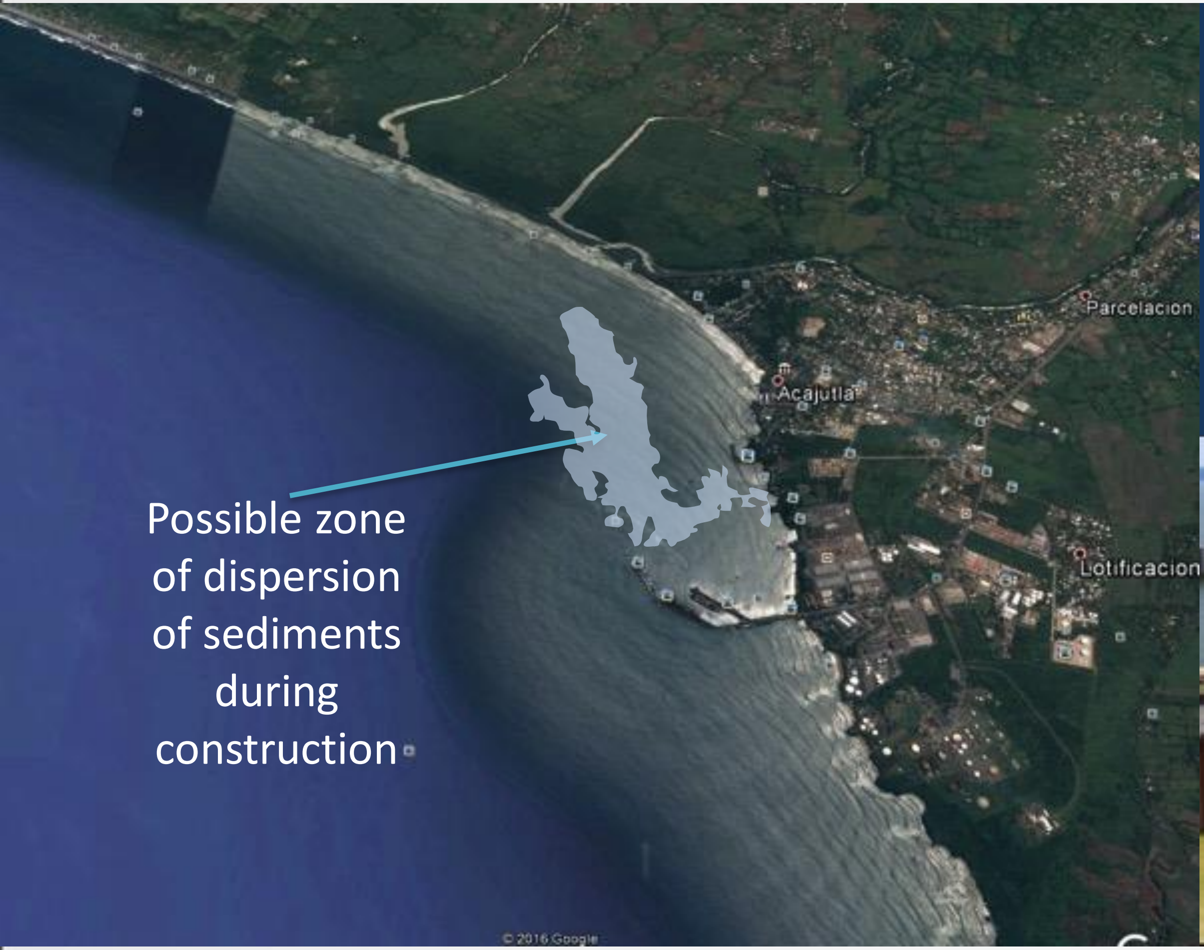
Sea water will be used. Take the water to room temperature and return 5 ° C colder as required by regulation.

For the operation of the FSU sea water is used, 5 ° C warmer is returned.

The impact of temperature change was modeled and the effects were determined as non-significant

**The images are indicative,*
The studies are in process

SEAWATER AND SEDIMENTS



The construction of the protection boxes will cause the dispersion of sediments, for a **very short period** but around the area.

** The image is indicative, the studies are in process, possibly the affected area will be smaller*

FLORA AND FAUNA

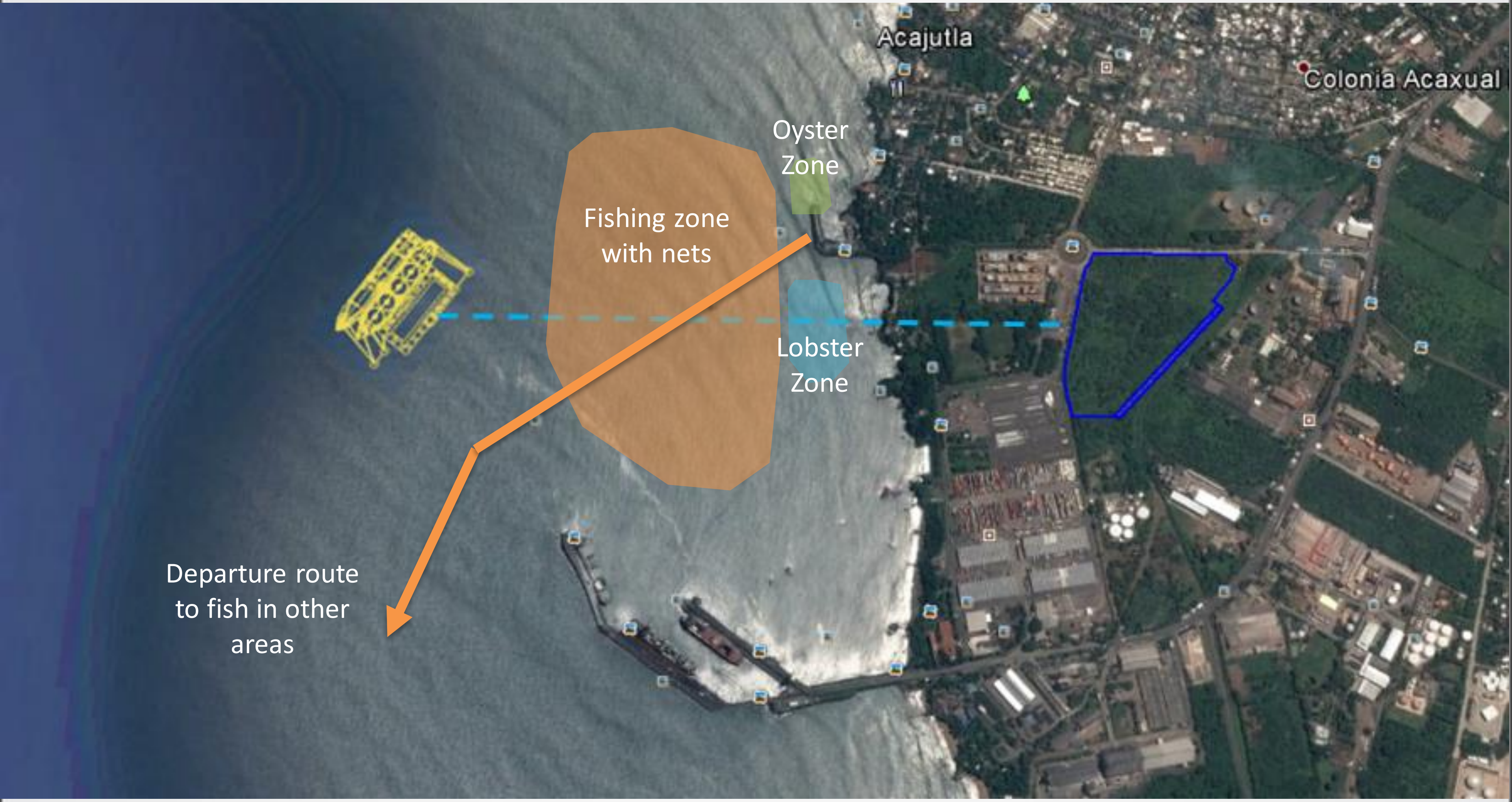
The project is located in an industrial area with very little vegetation.

A study of flora and fauna has been carried out.

Ten trees will be planted for each tree removed.

Measures are proposed for the rescue of the fauna that is found during the construction and will be planted fruit species that give food to the present fauna.

EFFECTS ON FISHING



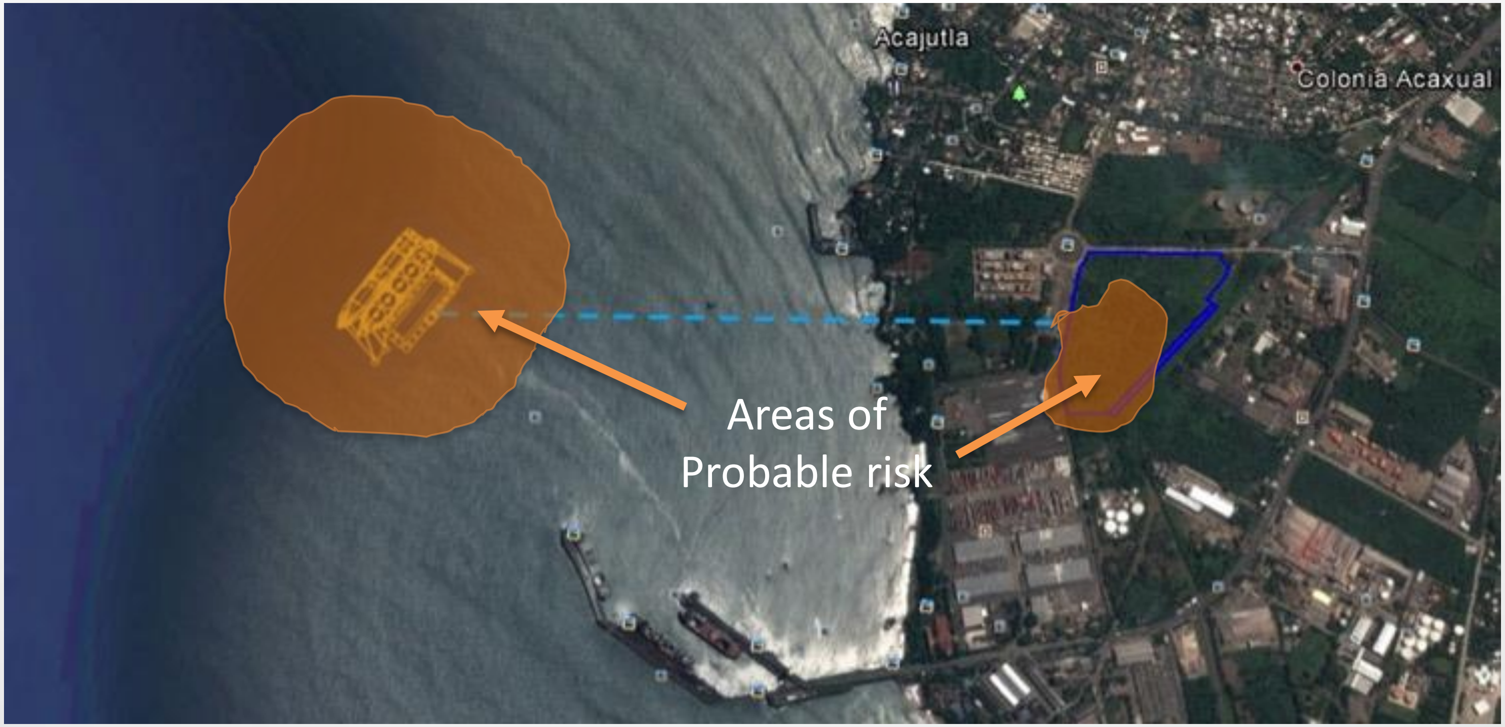
The exit route for fishing to other areas and the current fishing zones will no longer be affected by not building the pier

STUDY OF PROJECT RISKS

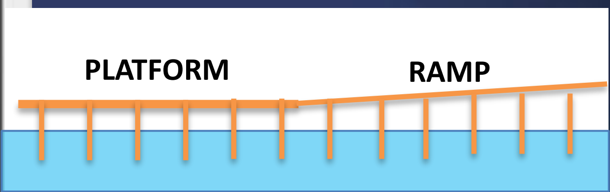
The risk of the Project will be **significantly reduced** by the storage of liquefied natural gas at sea.

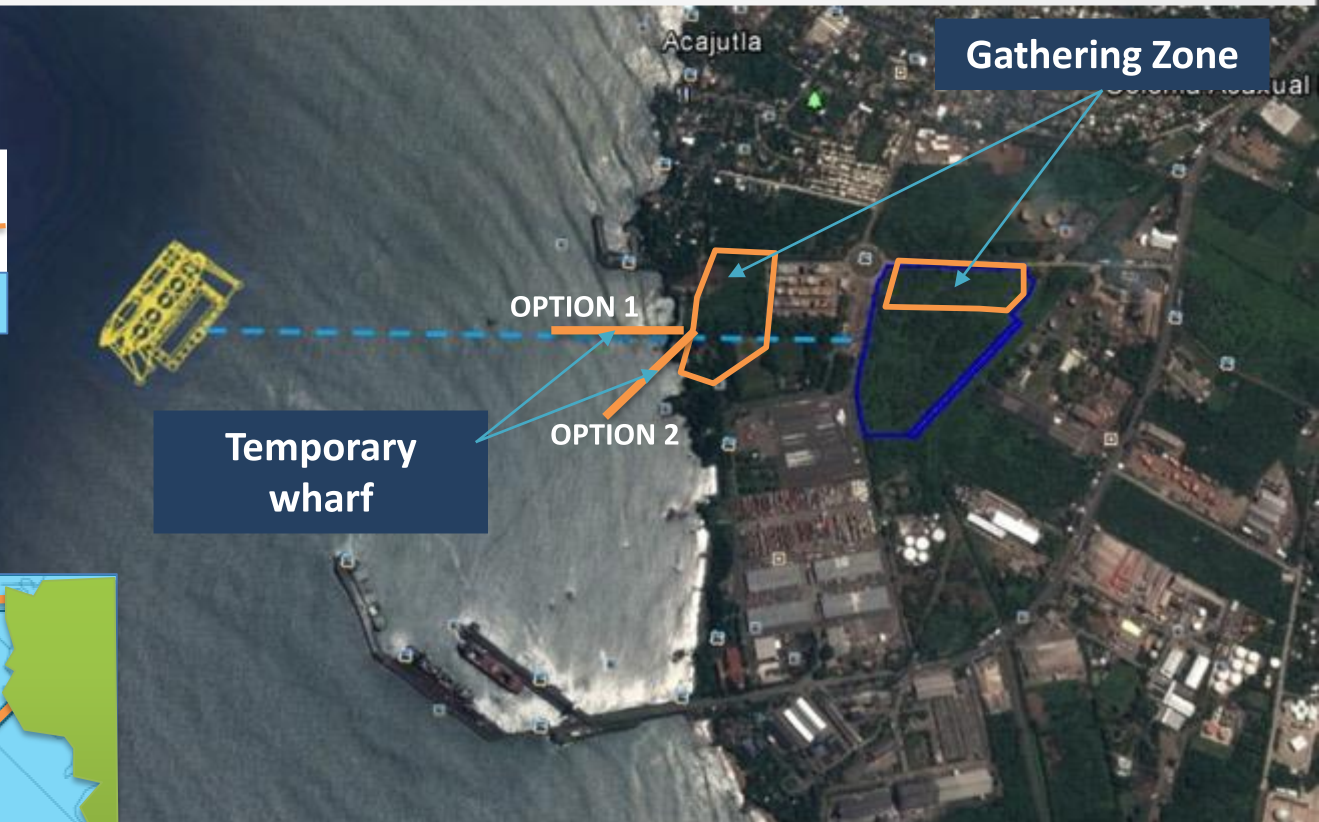
The risk study of the Project has been elaborated.

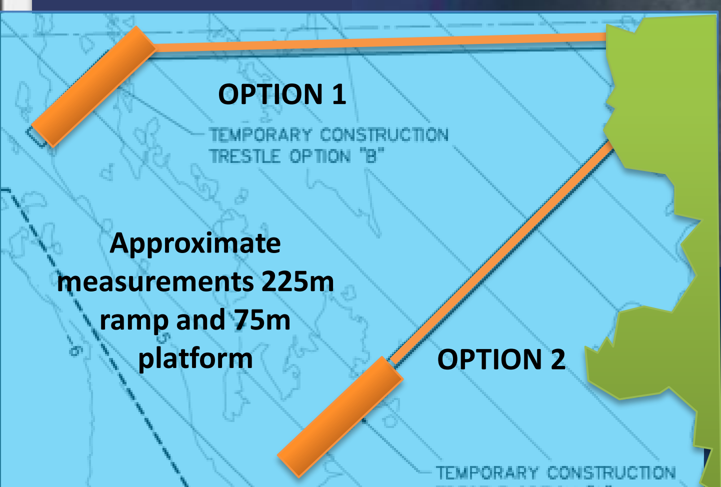
In case of **gas or fire leaks**, it has been determined that areas of potential damage **are at sea away from the population or within the project** grounds.



COOPERATION AREAS AND TEMPORARY WORKS DURING CONSTRUCTION







Detail of possible wharf location

The land of the current “Pier" will be temporarily used. If there is any affectation of the EDP infrastructure, it is committed to compensate it appropriately.

PUBLIC HEALTH AND SAFETY

EDP is aware of the concerns of the community regarding the effects of health.

Studies of noise and air quality show that the effects will be under the norm so no effect is expected on the health of the population.

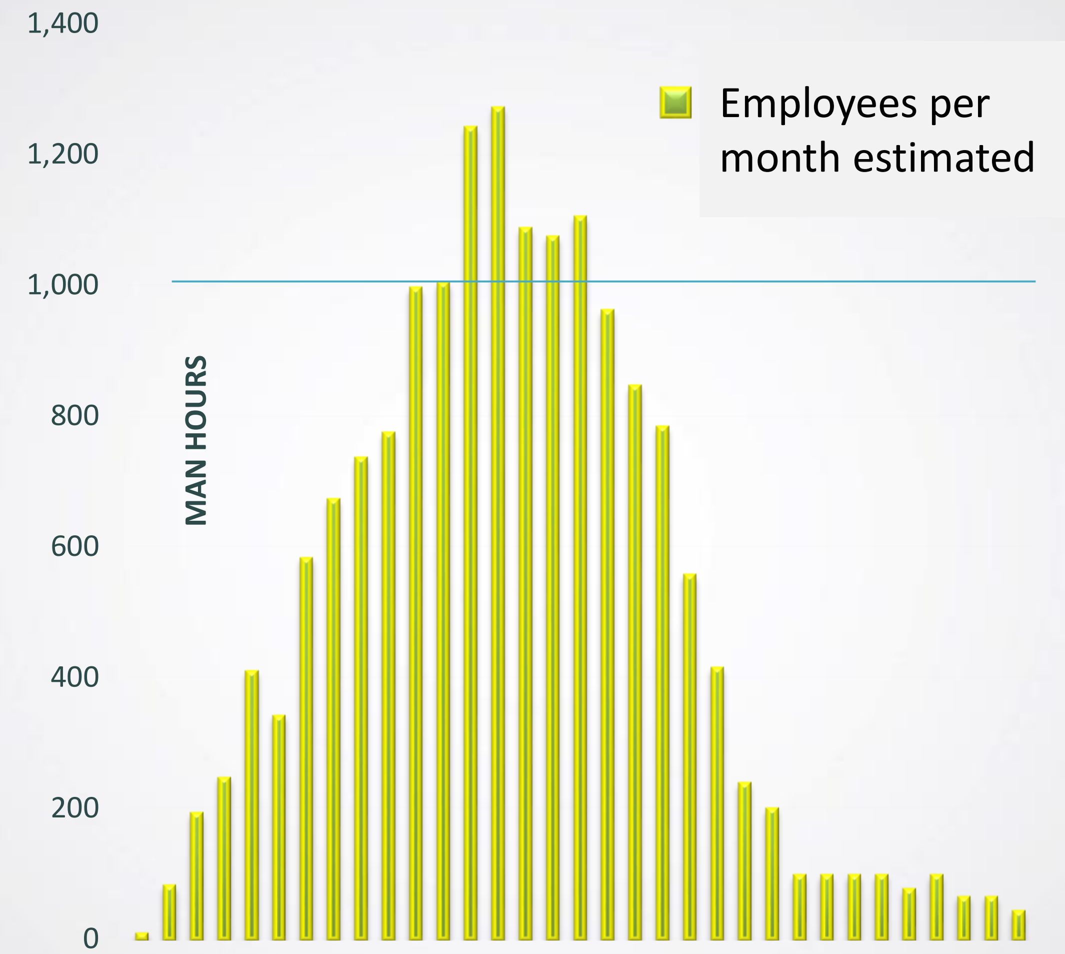
Construction traffic will use designated roads and will not pass through residential areas.

JOB

It will require a maximum approach of **1,000 construction workers** - and about 60 workers for the operations phase.

Buses will transport workers from outside the area on site

EDP is committed to **hiring local people** who have the right skills.



CITIZEN CONSULTATION

The comments of the communities have been documented and are being considered in the development of the Project.

EDP will continue to inform and listen to local communities.

CITIZEN CONSULTATION

EDP has opened a communications office in Acajutla and has established a website with information on the Project.

Anyone can come to leave their comments or report complaints regarding the execution of the Project, in the office, by phone, email or in writing.

EDP will document, review and respond to any concerns received by any means and will attempt to resolve any concerns promptly.

PROJECT BENEFITS

The Project will transmit benefits that will be presented at national, regional and local level in our country. A description of the key benefits is outlined below:

INTRODUCTION NATURAL GAS

The project will introduce natural gas (NG) to the Salvadoran market, thus reducing the country's dependence on oil use.

In addition, investing the project in an LNG receiving terminal may allow other industries to convert their engines to operate on natural gas. Such conversion can bring greater environmental and economic benefits.

Natural gas is recognized as the preferred fuel for the environment for the generation of electric energy, as compared to oil and coal.

JOB

The workforce required for the development of the project is expected to be in a high percentage, obtained from local and regional communities, depending on technical and academic requirements.

The construction phase will give temporary employment to approximately 1,000 people during the massive period.

These jobs will be required in stages because construction will extend for approximately 3 years.

JOB

The operating phase will create around 60 permanent jobs, prioritizing all employees to be nationals.

Indirect employment will rise in the area as a result of the demand created by the Project for goods and services that could include housing, food and beverage industries.

SOCIAL INVESTMENT

Energía del Pacífico

Energía limpia para nuestro futuro

Ciudad Portuaria

Acajutla

FISDL

Energía del Pacífico (EDP) is committed to contribute to the social development of the municipality of Acajutla.

The communities can present their proposals for social development projects to the Acajutla´s mayor, who, supported by FISDL, will approve and submit all projects to EDP for execution.

SOCIAL INVESTMENT

The following are the steps for the approval and execution of Social Investment Projects:

1. PROJECT EVALUATION

The works will be proposed, evaluated and prioritized, taking into account the needs of the communities, the Fondo de Inversión Social para el Desarrollo Local (FISDL) and the Mayor's Office of Acajutla

2. PROJECT APPROVAL

The works that are agreed by the FISDL and the Mayor's Office will pass to the approval of the MUNICIPAL COUNCIL

3. EXECUTION OF WORKS

Energía del Pacífico will carry out the authorized works. Investing approximately $ 530,000 each year

SOCIAL INVESTMENT

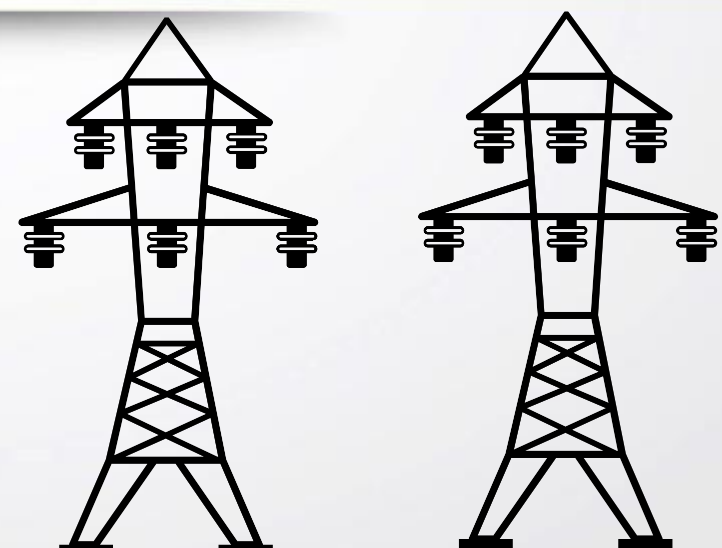
EDP will invest the amount of $ 532,500.00, annually during a period of 23 years, in SOCIAL DEVELOPMENT WORKS in the MUNICIPALITY OF ACAJUTLA, beginning in 2015

OTHER BENEFITS

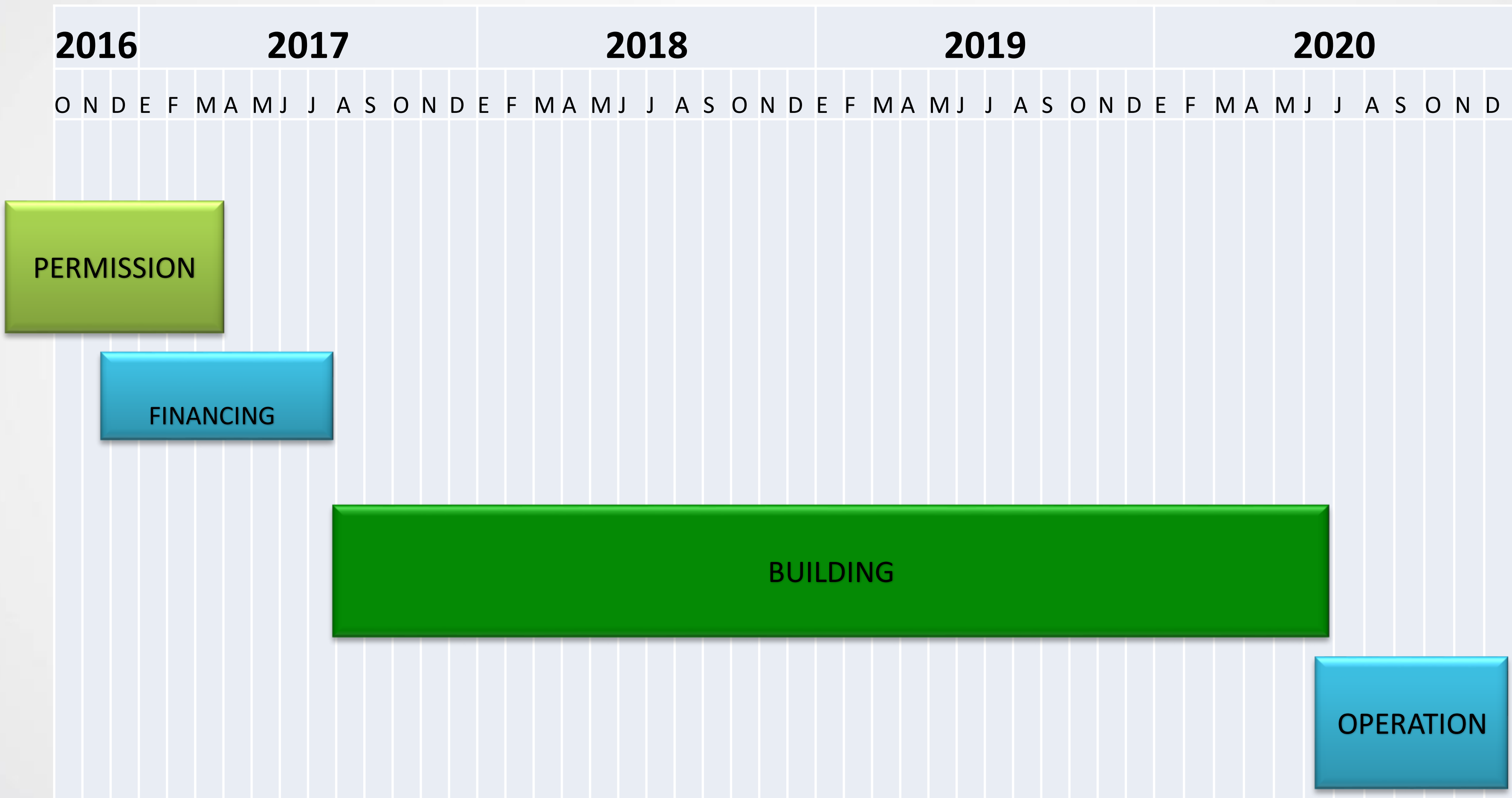
The electric energy injection generated by the Project represents about 1/3 of the current installed capacity in the country.

The project will have foreign investment. One of the benefits of foreign direct investment is that it helps in the economic development of the country where the investment is made.

The project will make capacity available to meet the expected increase in energy demand, avoiding possible outages or outages.



PROGRAM


2016
2017
2018
2019
2020
O N D E F M A M J J A S O N D E F M A M J J A S O N D E F M A M J J A S O N D E F M A M J J A S O N D
PERMISSION
FINANCING
BUILDING
OPERATION

MEANS TO OBTAIN MORE INFORMATION

Project Communications Office:

Colonia RASA 1, Calle Circunvalación, casa #44, Acajutla, Sonsonate

Telephone Attention Line:

2452-6313

Email: info@edp.com.sv
Web Page:
http://www.energiadelpacifico.com/

THANKS FOR YOUR ATTENTION

Appendix 8O–

Project Brochure 2016

PROCESO DE EVALUACIÓN DEL IMPACTO AMBIENTAL

EDP se encuentra elaborando el Estudio de Impacto Ambiental del proyecto, incluyéndose la evaluación de sus modificaciones, el cual será presentado al Ministerio de Medio Ambiente y Recursos Naturales (MARN) como un nuevo documento.

Planta de generación eléctrica

INSTALACIONES TEMPORALES

El proyecto incluye la construcción de un muelle temporal que se utilizará para la construcción de la tubería y la estructura de protección de la Unidad de Almacenamiento y Regasificación Flotante.

Imagen del muelle temporal

PARTICIPACIÓN CIUDADANA

Primera asamblea de resultados EIA

A la fecha EDP continúa con el proceso de participación ciudadana, para lo cual se han realizado varias reuniones con interesados, para darles a conocer el proyecto, sus cambios y avances.
Todas las opiniones recibidas han sido consideradas y evaluadas como parte del proceso de evaluación ambiental y social del proyecto.
El proceso continúa, si desea obtener mayor información o dar a conocer sus opiniones e inquietudes a Energía del Pacífico, Ltda, de C.V., puede hacerlo a:

Energía del Pacífico
Energía limpia para nuestro futuro

Teléfono: (503) 2133- 0700
Correo electrónico: info@edp.com.sv
Web: www.energiadelpacifico.com

Energía del Pacífico

Energía limpia para nuestro futuro

Planta de Generación de Energía Eléctrica a base de Gas Natural

LNG-TO-POWER

Avances en el desarrollo del proyecto
Octubre 2016

ANTECEDENTES Y UBICACIÓN

ANTECEDENTES

Desde sus inicios en el año 2014, el proyecto de generación de energía eléctrica de EDP ha tenido algunos cambios a fin de optimizar su diseño y lograr una mejor integración de sus elementos con el medio ambiente.
Este proceso ha involucrado tanto a los propietarios, como a los diseñadores y consultores ambientales del proyecto, buscando que su desarrollo sea exitoso en consideración de las condiciones ambientales.
El principal cambio realizado consiste en la ubicación de la Planta Regasificadora, la cual estaba localizada en tierra y ahora estará en el mar.

Los efectos derivados de este cambio son:

- Se elimina la necesidad de construir un tanque de almacenamiento en tierra.
- No se requerirá la construcción de un muelle permanente.
- La tubería de gas natural se puede instalar bajo el suelo, tanto para el tramo que atraviesa el lecho marino, como en las propiedades que ocupará el proyecto.

UBICACIÓN

El proyecto se ubicará dentro de terrenos propiedad de la Comisión Ejecutiva Portuaria Autónoma (CEPA), ubicados en la zona industrial del Puerto de Acajutla.

Plano de ubicación actualizado quitando el muelle

DESCRIPCIÓN DE LAS INSTALACIONES

EL PROYECTO CONSTA DE:

Una terminal marítima para la recepción y regasificación de Gas Natural Licuado (GNL), adecuadamente dimensionada para la recepción de buques tanqueros y el almacenamiento del combustible.

FSU/FSRU con cajones de protección

Los componentes de la terminal marítima son:

- Un FSRU (Unidad de Almacenamiento y Regasificación Flotante), consistente en una barcaza atracada de forma permanente, rodeado por un rompeolas que lo protegerá del oleaje y corrientes marinas.
- Un FSU (Unidad de Almacenamiento Flotante), consistente en un buque atracado de forma semi-permanente a la ataguía celular.
- Una tubería submarina y bajo tierra, que transportará el gas natural (regasificado) desde el FSRU a la planta de generación eléctrica.

LA PLANTA DE GENERACIÓN ELÉCTRICA DE 378 MW CONSTARÁ DE:

- 19 motores de combustión interna con una capacidad de 18.3 MW cada uno, para generar un total de 348 MW;
- Un ciclo combinado de vapor que utilizará los gases de escape de los motores para producir vapor que se utilizará en una turbina de 30.0 MW; y
- Una subestación de energía eléctrica.

Planta de generación eléctrica

Appendix 8P–

Attendance List for Meeting with Fishermen 2016

LISTA DE ASISTENCIA

Tipo de reunión: Reunión Informativa con Pescadores, Proyecto "LNG TO POWER" Acajutla
Fecha: **Martes 25 de octubre de 2016.**

N°	Nombre	Sexo	Nombre de la institución social de la cual proviene	Teléfono de contacto	Correo electrónico	Firma
	Osea Orlando Cartagena		acoopac.	71029766		
	Hernesto morales	m.	"			
	Jose ANGEL CARVAJAL GONSALES		"			
	Julian tovar		turbero	74990623		JULIANTOVAR
	JULIO NELSON JOVEL FLORES			76250928		
	José Antonio cordero		ACPPRA	73-26-41-25		
	Ana Victoria Pleitez	fm	APEBTAMAR	7421-6532		
	Rafael Antonio contreras Galbes		Apectamar	71203420		

LISTA DE ASISTENCIA						
Tipo de reunión: Reunión Informativa con Pescadores, Proyecto "LNG TO POWER" Acajutla Fecha: Martes 25 de octubre de 2016.						
N°	**Nombre**	**Sexo**	**Nombre de la institución social de la cual proviene**	**Teléfono de contacto**	**Correo electrónico**	**Firma**
	José Bonilla Triguero	M	Acoopesca	73559693		
	Margarito Antonio G.	M	Acoopesca			
	REPRESENTO - OSCAR ARMANDO -					
	Ivan Ramon ORTIS RIBERA 3-					
	Oscar ARmando GARCIA pacheco 3					
	Santos VICTOR LVE - 3					

Ma Besto SARAVIA 3-

Appendix 8Q–

Invitations Registry for Second Public Assembly 2016

Acajutla, 25 de octubre de 2016

Señor
Walter Martinez
Instituto Salvadoreño del Seguro Social
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

1. **Actualización de los avances del proyecto.**
2. **Cambios realizados al proyecto.**

La asamblea se llevará a cabo:

Día: Sábado 5 de noviembre de 2016

Hora: 9:00 A.M.

Lugar: Liceo de Acajutla

Si desea obtener más información puede visitar nuestra oficina ubicada en la Colonia RASA 1, Calle Circunvalación, casa #44, Acajutla, Sonsonate, llamar al teléfono 2452-6313 o escribirnos al correo electrónico info@edp.com.sv

Energía del Pacifico, Ltda. de C.V. reitera la importancia de su participación y sus comentarios en esta **"Segunda Asamblea General Informativa"**, ya que todas las opiniones recibidas serán consideradas y analizadas como parte del proceso de evaluación ambiental y social.

Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

UNIDAD MEDICA ACAJUTLA
SECRETARIA DE DIRECCION
ISSS

27-10-16
9:25am

Acajutla, 25 de octubre de 2016

Señora

Susana Beatriz de Matinez

Comunidad La Rana N° 1

Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señor
Juan Carlos Mejía. (Comunidad La Raza #1)
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Día: Sábado 5 de noviembre de 2016

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Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señora
Karla Mejía de Estrada. Comunidad La Raza #1
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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2. **Cambios realizados al proyecto.**

La asamblea se llevará a cabo:

Día: Sábado 5 de noviembre de 2016

Hora: 9:00 A.M.

Lugar: Liceo de Acajutla

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Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señora
Yolanda Isabel Avalos Comunidad La Raza #1
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señor
Jorge Orellana   Comunidad La Obrera
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señor
Rafael Martinez   Cruz Roja de Acajutla
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señor
Felix Aguirre
Presente

Iglesia Santuario del Dios de Elias

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Rosicel Aguirre Menjivar

Acajutla, 25 de octubre de 2016

Señor
Walter Montoya. Alcaldía Medio Ambiente
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

UNIDAD DE MEDIO AMBIENTE
REPUBLICA DE EL SALVADOR EN LA AMERICA CENTRAL
ALCALDIA DE ACAJUTLA

26-10-2016
3:36 p.m.

Acajutla, 25 de octubre de 2016

Señor
Hugo Arriola
Alcalde Municipal
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

ALCALDIA MUNICIPAL ACAJUTLA SONSONATE
DESPACHO
ALCALDE

Recibido.
26/10/16
3:35 pm.

Acajutla, 25 de octubre de 2016

Señor
Carlos Antonio Tobar
Alcaldía - Turismo
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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Hora: 9:00 A.M.

Lugar: Liceo de Acajutla

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Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Olman portillo
3:39 PM
26/10/16

Acajutla, 25 de octubre de 2016

Señor
Sub Inspector Gustavo Neftalí Perez PNC
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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Agradecemos su atención a la presente.

POLICIA NACIONAL CIVIL
SUBDELEGACION ACAJUTLA
DOCUMENTOS RECIBIDOS
COMANDACIA DE GUARDIA
FECHA: 26-10-2016.
HORA: 15:15.
NOMBRE: Virgilio Ramos

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señor
Moises Bonilla. Alcaldía - Proyección Social
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Recibido
15:33 pm
26/10/2016.

Acajutla, 25 de octubre de 2016

Señor
Napoleon García
Presente

Iglesia Sn. Francisco de Asís

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Recibido

PARROQUIA SAN FRANCISCO DE ASIS DIOCESIS DE SONSONATE. ACAJUTLA.

Acajutla, 25 de octubre de 2016

Señora
Margot Soriano
Presente

Colonia Brisas de Acajutla 2

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señor

Israel Henrrquez tapas

Presente

CE. Comunidad Alvarado

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Recibido

Jesus Cruz Cardoza

Acajutla, 25 de octubre de 2016

Señor

Luis Arturo Diego

Bomberos Sonsonate

Presente

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

BOMBEROS ESTACION SONSONATE EL SALVADOR, C.A.

26-10-2016
11:15

Acajutla, 25 de octubre de 2016

Señor
Will antonio Alavarro. Ciudadela CEPA
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señor
Ronco Alfonso Argueta.
Presente

Ciudadela CEPA

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señora
Silvia Estela Henriquez   Comunidad El Barquito
Presente

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señora
Celia Hernandez
Presente

Barrio La Playa

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señora
Marlene Canjura   Barrio La Playa
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señor
Jose Edid Cortez Henriquez
Fuerza Naval
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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Agradecemos su atención a la presente.

FUERZA NAVAL DE EL SALVADOR
CAPITANÍA DE PUERTO DE ACAJUTLA
COMANDANCIA
PATRIA, LEALTAD Y VALOR

Atentamente,

Mario Walter Sandoval

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señora
Reina Rodríguez
Presente

Comunidad San Roque

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señora
Ana Ruth Flores
Presente

Comunidad San Roque

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señora
Ana Cecilia Guillen de Molina ADESCOMAR Los Morritos

Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

m de I G

Acajutla, 25 de octubre de 2016

Señora
Maria de Jesus Galeas
Presente

ADESCOMAR Acaxual

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

m de J G

Acajutla, 25 de octubre de 2016

Señor
Omar Esau de la O   ADESCOMAR La Reina
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

m de I G

Acajutla, 25 de octubre de 2016

Señor
Nelson David Alvarado Rivera Com. Zona Industrial
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señor

Boanerges Armendaris Lotificación Alvarado

Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Boanerges A. Armendariz

Acajutla, 25 de octubre de 2016

Señora

Maria Julia Cerna

Comunidad Obelisco

Presente

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

maria Julia Cerna

Acajutla, 25 de octubre de 2016

Señora
Yanet Saraí Portillo Comunidad Obelisco
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Maura Guevara

Acajutla, 25 de octubre de 2016

Señora
Maura Guevara
Presente

Comunidad Obelisco

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Maura Guevara

Acajutla, 25 de octubre de 2016

Señora
Yesenia Carolina Zelaya   Comunidad Obelisco
Presente

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Energía del Pacífico, Ltda. de C.V.

Maura Guevara

Acajutla, 25 de octubre de 2016

Señora
Delsy Noemi Ramirez.
Red de Mujeres de Acajutla
Presente

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señora
Maritza Elizabeth Hernández   Red de Mujeres de Acajutla
Presente

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

27-10-2016

Acajutla, 25 de octubre de 2016

Señora
Daysi Beatriz Espinoza
Presente

Red de Mujeres de Acajutla

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Energía del Pacífico, Ltda. de C.V.

27-10-2016

Acajutla, 25 de octubre de 2016

Señora
Maria Moura Castro Red de Mujeres de Acajutla
Presente

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señora
Vilma Noemy Santos
Presente

Red de Mujeres de Acajutla

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

27-10-2016.

Acajutla, 25 de octubre de 2016

Señora
Doctora Iris Godoy. Unidad de Salud Acajutla

Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Recibido 27/10/16 11:16 am Dra Godoy

Acajutla, 25 de octubre de 2016

Señor
Dr. Perez
Presente

AGAPE Acajutla

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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2. **Cambios realizados al proyecto.**

La asamblea se llevará a cabo:

Día: Sábado 5 de noviembre de 2016

Hora: 9:00 A.M.

Lugar: Liceo de Acajutla

Si desea obtener más información puede visitar nuestra oficina ubicada en la Colonia RASA 1, Calle Circunvalación, casa #44, Acajutla, Sonsonate, llamar al teléfono 2452-6313 o escribirnos al correo electrónico info@edp.com.sv

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Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Recibido 27/10/16 11.16 Dra Godoy

Acajutla, 25 de octubre de 2016

Señor
Edgar Leonel Guzman
Unidad de Salud Acajutla
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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Lugar: Liceo de Acajutla

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Agradecemos su atención a la presente.

Recibido 27/10/16
11:15 am

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señora
Carolina de Mendoza Paola   Colonia Brisas de Acajutla 1
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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Lugar: Liceo de Acajutla

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Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Carolina de Mendoza
Recibido 27/10/16

Acajutla, 25 de octubre de 2016

Señora
Susana Jeannette Ruiz
Presente

Colonia Brisas de Acajutla 1

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Carolina de Mendoza
Recibido 27/10/16

Edificio Avante, Oficina 709, Calle Llama del Bosque,
Antiguo Cuscatlán, La Libertad, El Salvador.
(503) 2133-0700

Acajutla, 25 de octubre de 2016

Señora
Evelyn Carlolina Roduquez de Mendoza
Presente

Colonia Brisas de Acajutla 1

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Carolina de Mendoza
Recibido 27/10/1

Acajutla, 25 de octubre de 2016

Señora
Lorena Antonia Flores de Lara Lotificación Alvarado
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señor

Francisco Calzadilla. Comunidad La Raza N° 2

Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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Día: Sábado 5 de noviembre de 2016

Hora: 9:00 A.M.

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Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Recibido 27/10/16 11:17

Acajutla, 25 de octubre de 2016

Señores
Bomberos Sonsonate
Tte. Damián Alfonso Rivas
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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2. **Cambios realizados al proyecto.**

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Día: Sábado 5 de noviembre de 2016

Hora: 9:00 A.M.

Lugar: Liceo de Acajutla

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Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

BOMBEROS
ESTACION SONSONATE
EL SALVADOR, C.A.

26-10-2016
11:15

Acajutla, 25 de octubre de 2016

Señora
Ana Isabel Salazar
Colegio Católico de Acajutla
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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2. **Cambios realizados al proyecto.**

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Día: Sábado 5 de noviembre de 2016

Hora: 9:00 A.M.

Lugar: Liceo de Acajutla

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Agradecemos su atención a la presente.

Atentamente,

Recibido

Energía del Pacífico, Ltda. de C.V.

Acajutla, 25 de octubre de 2016

Señor
Guillermo Cordero. Ciudadela CEPA
Presente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a la **"Segunda Asamblea General Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 20 de octubre de 2016

Señores
ACOPESCA
Presente

Con Atención a:
José Bonilla Trigueros
Representante de ACOPESCA

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a usted y a 4 representantes de su sector, a la **"Reunión Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

3. **Actualización de los avances del proyecto.**
4. **Cambios realizados al proyecto.**

La asamblea se llevará a cabo:

Día: Martes 25 de octubre de 2016

Hora: 9:00 A.M.

Lugar: Salón de Conferencias Restaurante Acajutla.

Si desea obtener más información puede visitar nuestra oficina ubicada en la Colonia RASA 1, Calle Circunvalación, casa #44, Acajutla, Sonsonate, llamar al teléfono 2452-6313 o escribirnos al correo electrónico info@edp.com.sv

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Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 20 de octubre de 2016

Señores
Cooperativa Doraderos
Presente

Con Atención a:
Rafael Antonio Contreras
Representante de Doraderos

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a usted y a 4 representantes de su sector, a la **"Reunión Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

5. **Actualización de los avances del proyecto.**
6. **Cambios realizados al proyecto.**

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Hora: 9:00 A.M.

Lugar: Salón de Conferencias Restaurante Acajutla.

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Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 20 de octubre de 2016

Señores
Sector Ostreros de Acajutla
Presente

Con Atención a:
Oscar Armando García Pacheco
Representante de Ostreros

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a usted y a 4 representantes de su sector, a la **"Reunión Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Energía del Pacífico

Acajutla, 20 de octubre de 2016

Señores
Sector Tuberos de Acajutla
Presente

Con Atención a:
Raúl Escobar
Representante de Tuberos

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

JULIAN TOVAR

Energía del Pacífico

Acajutla,20 deoctubre de 2016

Señores ACOOPPAC
Presente

Con Atención a:
Oscar Orlando Córtez
Presidente

Reciban un cordial saludoen nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitarlos a usted y a 4 representantes de su sector, a la **"Reunión Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 20 deoctubre de 2016

Señores ACPPRA
Presente

Con Atención a:
José Antonio Cordero
Presidente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

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Atentamente,

Energía del Pacífico, Ltda. de C.V.

Edificio Avante, Oficina 709, Calle Llama del Bosque,
Antiguo Cuscatlán, La Libertad, El Salvador.
(503) 2133-0700

Appendix 8R–

Attendance List for Second Public Assembly 2016

LISTA DE ASISTENCIA

SEGUNDA ASAMBLEA GENERAL INFORMATIVA.

Planta de Generación de Energía Eléctrica a base de Gas Natural LNG-to-POWER

Fecha: Sábado, 5 de noviembre de 2016

No.	Nombre	Sexo	Teléfono de contacto	Nombre de la institución social de la cual proviene	Firma
	José Alberto Gomez Martinez	M	74498774	B- La playa	[firma]
	Marlene Canjura	F	7032-6993	B- La playa	[firma]
	José Israel Chávez	M.	7071-1209	UES - Biología	[firma]
	Nancy canjura	F	7768-7269	UES - Biología	[firma]
	D. Ernesto Avelar	M	77500309	UES - MAGA.	[firma]
	Nazario Martinez Guzm	M	24525911	Col. Obrera	[firma]
	Guillermo Amilcar Sandoval	M	77168103	canton Kilo 5	[firma]
	William Balmore Flores	M	71832365	cant. San Kilo 5"	[firma]
	Joze Eugenio Gaitan	M	71963780	canton. Kilo 5.	[firma]
	Astor Vladimir Chavez Q.	M	7667-1844	col. Acaxual #3	[firma]
	José Angel Carbajal Gonzalez	M		ACOPAC	[firma]
	Erick Osman Mazariego	M	6104-4025	col. El Barquito	Emazariego
	Nelson Arnulfo Rivera	M	71186683	Col. santa Agueda.	[firma]
	Omar Esau De la O	M	2452-6558	ADESCOMAR	[firma]
	Angel Rivera	M	74805926	San julian	[firma]

Energía del Pacífico

LISTA DE ASISTENCIA

SEGUNDA ASAMBLEA GENERAL INFORMATIVA.

Planta de Generación de Energía Eléctrica a base de Gas Natural LNG-to-POWER

Fecha: Sábado, 5 de noviembre de 2016

No.	Nombre	Sexo	Teléfono de contacto	Nombre de la institución social de la cual proviene	Firma
	Carlos Humberto Ochoa M	M	2452-6200	Acajutla	[firma]
	Celia Hernandez.	M.	70809959	B° La Playa Acajutla	[firma]
	Alma Sanchez	F	76238388	Ecoing.	[firma]
	Kevin Mejía	M	79312344	UES	[firma]
	William Ernesto Galán	M	77446989	UES	[firma]
	Sofía Paniagua	F	71446645	UES	[firma]
	Rolando William Hernández	M	7270-3608	UES	[firma]
	Juan Nela González	M	70284547	ACPETAMAR	[firma]
	Mauricio Guandique Nativí	M	79757722	col. Obrera	[firma]
	Miguel Angel Acosta	M	24526945	B. Atarrayas. Acajutla	[firma]
	Miguel Angel Polanco	M	6424-7904	B Rosco quitos	[firma]
	Alfredo Santos Orellana	M	77654288	Comunidad 12 Octubre	A. A. Orellana
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	Julio Antonio Ramirez	M	7335 7530	Comunidad C. Sta Ageda	[firma]
	Ana Cecilia Guillen	F	70355522	ADESCOMAR	[firma]

LISTA DE ASISTENCIA

SEGUNDA ASAMBLEA GENERAL INFORMATIVA.

Planta de Generación de Energía Eléctrica a base de Gas Natural LNG-to-POWER

Fecha: Sábado, 5 de noviembre de 2016

No.	Nombre	Sexo	Teléfono de contacto	Nombre de la institución social de la cual proviene	Firma
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	Saúl Avelar	M	2210-1973	UES.	[illegible]
	Brenda Marcela Tovar	F	7873-0774	UES	[illegible]
	Raphael Alexander Cuellar	M	2452-30-82	UCSFI de Acajutla	[illegible]
	Moisés Castro	M	7469-8433	Urb. Brisas de Acajutla	[illegible]
	DAVID AMAYA	M	73193455	COL. SAN JULIAN	[illegible]
	Ana Victoria Pleitez	F	7421-6532	Apectamar	[illegible]
	Cecilio Alejandro Contreras	M	74623828	Mov. Cultural Atonal.	[illegible]
	José Roberto Rivas Moreno	M.	78892698	Acaxual Nº 4	[illegible]
	maria de Jesus Galcas	F	77107354	Adescomar	m de J G
	Jose Marenco	M	7642-4061	RASA 1	[illegible]
	Francisco Rodriguez	M	7512-6756	ESFE/ACAPE	[illegible]
	William Enmanuel Vanega	M	7649-6899	Col. nueva Acajutla	[illegible]
	Tomas Rolando Mejia	M	7375-5087	Col. San Roque	[illegible]

Energía del Pacífico

LISTA DE ASISTENCIA

SEGUNDA ASAMBLEA GENERAL INFORMATIVA.

Planta de Generación de Energía Eléctrica a base de Gas Natural LNG-to-POWER

Fecha: Sábado, 5 de noviembre de 2016

No.	Nombre	Sexo	Teléfono de contacto	Nombre de la institución social de la cual proviene	Firma
	Jorge A. Mejía	M	2452-3120	ATONAL CULTURAL ACAJUTLA	[signature]
	José Bonilla Iraheta	M	73559693	Acoopesca.	[signature]
	Boanerges R. Alvarado	M	77688132	Col. ALVARADO	[signature]
4	Juan José Salazar	M	76216365	Col. I.V.O	[signature]
	Rafael Sanchez	M	7172 49 70	Col. Sta Aguila.	[signature]
	Ingrid Estefany Aguilar	F	7976-0529	B° la Playa	[signature]
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	Odin Hugo Zamora	M	78654552	B° Los Peñas	[signature]
	Jacqueline Magdalena Sanchez	F	7375 4012	Col. El Milagro	[signature]
	Maura Guevara	F	6308 6040	Com. El Ovelisco.	[signature]
	Erick Alexander Guzmán	M	72810701	Caton Punta Remedios	[signature]
	Walter Montoya C.	M	73765723	Ala. Acajutla.	[signature]
	Js CAR AX mon DO L. ASIL	M	76894637	COLONIALVE	[signature]
	Carlos antonio lopez	M	71499565	acajutra	[signature]
	Leonardo Lopez	M	7850 4173	MARAI	[signature]

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Planta de Generación de Energía Eléctrica a base de Gas Natural LNG-to-POWER

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No.	Nombre	Sexo	Teléfono de contacto	Nombre de la institución social de la cual proviene	Firma
	Oscar Orlando Cortez R.	M	-	Acoopac.	[firma]
	Mauricio Alexander Jovel	M	-	ACOPAC	[firma]
	Nelson David Alvarado	M	-	Zona Industrial	[firma]
	Rene Eduardo Torres	M	-	Bº Atarrallas	[firma]
	José Alberto Roman	M	-	Atarrallas	[firma]
	Hector Francisco Ayala	M	7322-3198	Col. Alvarado	[firma]
	Oscar David Romos	M	76141893	Sn Julián	[firma]
	Josué Alexander Recinos	M	70838636	La Coquera	J.A.R
	Margarito Antonio Guardado	M	7881-7727	ACOPesca	[firma]
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	Hugo Stanley Viana	M	70299778	Sonsonate	[firma]
	Ernesto Ramirez Hernandez	M	7053 9739	Alcaldía Acajutla	[firma]
	Maria Yesenia Blanco Valdez	F	73964125	ciudadela	[firma]
	Dumarcy Juárez	M	78125943	Col. El Barquita	[firma]
	Danilo Alexander Juan	M	71548965	Acajutla	[firma]

LISTA DE ASISTENCIA

SEGUNDA ASAMBLEA GENERAL INFORMATIVA.

Planta de Generación de Energía Eléctrica a base de Gas Natural LNG-to-POWER

Fecha: Sábado, 5 de noviembre de 2016

No.	Nombre	Sexo	Teléfono de contacto	Nombre de la institución social de la cual proviene	Firma
	Hilton Alcir Aguilar	M	79590443	Proteccion civil	[firma]
	Olga Yamileth Sanchez	F	7620-6252	Col. El milagro	[firma]
	Gustavo Adolfo Diaz	M		col. la Cagueva	Gustavo A Diaz
	Juan Aleman	M	—	col. Caracol.	[firma]
	Jonathan fernando Navarro	M	—	Col. Caracol.	[firma]
	Guillermo Manuel Perez A	M	7943-5277 7815-3319	Nahuizalco Bº Trinidad	[firma]
	Bill Nelson Morán	M	70708241	ACAJUTLA VOLLEY	[firma]
	José Antonio Lozano	M	73264725	ACPPRA	[firma]
	Avelino del Carmen Aquino	M	2432-2523	Caserio El Ovelisco	[firma]
	Karina Rosales	F	7053-3996	CMAI	[firma]
	Carlos Ayala	M	—	Ciudadela CEPA	[firma]
	Julio Cesar Lopez Bonilla	M	7668-7168	lotificación Canales	J.C.L.B
	Julian Tovar	M	7499-0623	Asocion de tuberos	Julian TOVAR

LISTA DE ASISTENCIA

SEGUNDA ASAMBLEA GENERAL INFORMATIVA.

Planta de Generación de Energía Eléctrica a base de Gas Natural LNG-to-POWER

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No.	Nombre	Sexo	Teléfono de contacto	Nombre de la institución social de la cual proviene	Firma
	Julio Cesar Lopez bonilla	M	7668-7168	lotificación canales	[firma]
	Julian Tovar	M	7499-0623	Asocion de tuberos	JULIAN TOVAR

Appendix 8S–

Photographs of Second Public Assembly 2016

REGISTRATION OF GUESTS IN THE EVENT


AVAILABLE MATERIAL FOR THE EVENT

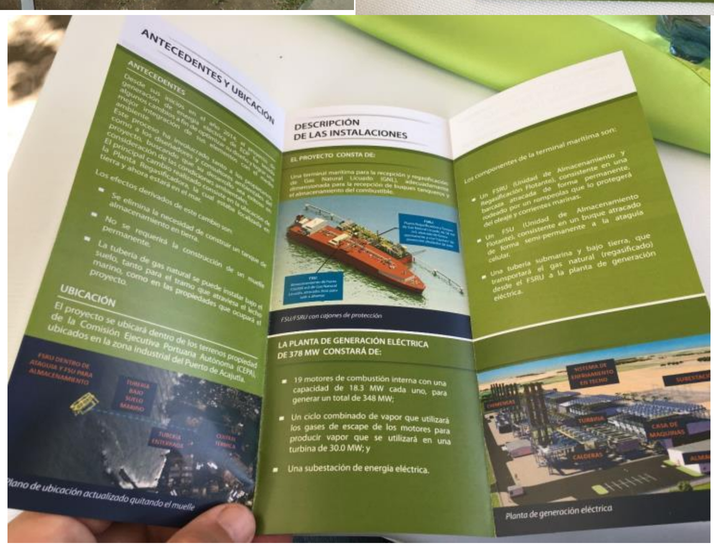



"ACAJUTLA LNG-TO-POWER"
ENERGÍA DEL PACÍFICO

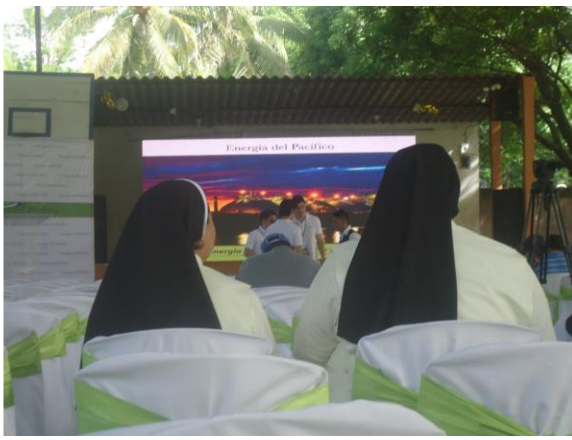

Energía del Pacífico
Energía limpia para nuestro futuro

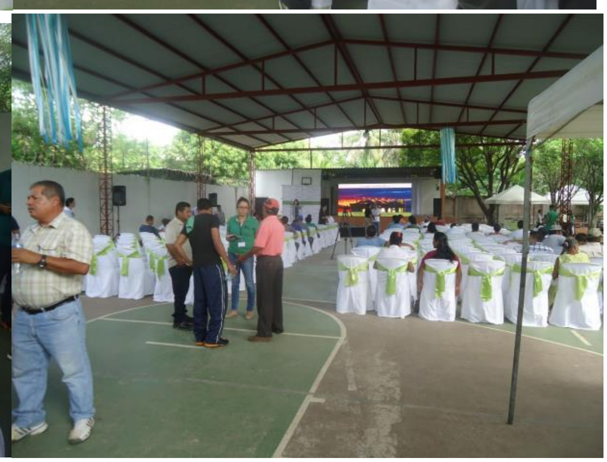

Energía del Pacífico
Energía limpia para nuestro futuro
¡BIENVENIDOS!
"SEGUNDA ASAMBLEA GENERAL INFORMATIVA"
sobre los avances del proyecto de generación de energía eléctrica que se ejecutará en la ciudad de Acajutla.


Energía del Pacífico
Energía limpia para nuestro futuro
Planta de Generación de Energía Eléctrica a base de Gas Natural
LNG-to-POWER
Avances en el desarrollo del proyecto
Octubre 2016


ANTECEDENTES Y UBICACIÓN
ANTECEDENTES
UBICACIÓN
DESCRIPCIÓN DE LAS INSTALACIONES
EL PROYECTO CONSTA DE:
LA PLANTA DE GENERACIÓN ELÉCTRICA DE 378 MW CONSTARÁ DE:
19 motores de combustión interna con una capacidad de 18.3 MW cada uno, para generar un total de 348 MW;
Un ciclo combinado de vapor que utilizará los gases de escape de los motores para producir vapor que se utilizará en una turbina de 30.0 MW; y
Una subestación de energía eléctrica.
Planta de generación eléctrica

PLACING GUEST AT THE EVENT



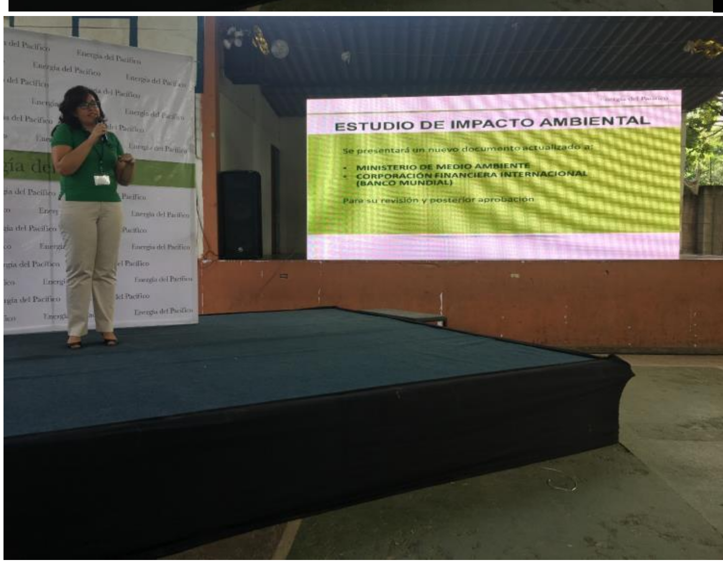


SUPPORT IN FILLING OUT INFORMATION




START OF THE PRESENTATION ACTIVITIES

PRESENTATION MADE BY THE CONSULTANT



GUESTS PAYING ATTENTION TO THE PRESENTATION



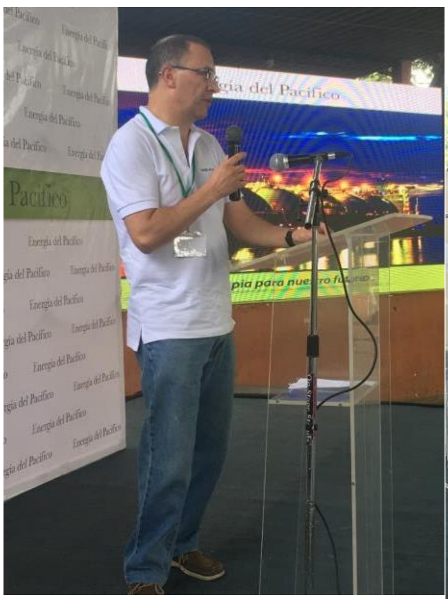


COLLECTION AND CLASSIFICATION OF QUESTIONS



QUESTIONS ASKED USING A MICROPHONE

ANSWERS TO GUESTS' QUESTIONS



GUESTS OBSERVING THE SUPPORT MATERIAL


Energía del Pacífico
TERMINAL MARITIMA DE GAS NATURAL LICUADO
El proyecto incluye la instalación de una Terminal marítima para la recepción y regasificación de gas natural licuado (GNL), la cual está dimensionada para la recepción de buques tanqueros y el almacenamiento de combustible.

Energía del Pacífico

Apendix Chapter 9

December 2016 16-3489

ECO INGENIEROS
LÍDERES EN CONSULTORÍA AMBIENTAL

DILLON CONSULTING

Appendix 9A–

Assistance List of First High-Level Risk Identification Workshop

ASSISTANCE LIST OF FIRST HIGH LEVEL RISK INDUCTION WORKSHOP

The first workshop was held on October 21, 2015 at the offices of Invenergy, Chicago. The workshop was attended by experienced staff from Invenergy, Moffat & Nichol (M & N), Exmar, Dillon Consulting and Lloyd's Registry. The list of participants is presented below:

Table 1- Assistance List of First High-Level Risk Identification Workshop

#	Name	Company	Discipline
1	Ron Heffron	Moffatt & Nichol	Vice President, Marine Engineering
2	Eric Smith	Moffatt & Nichol	Associate Vice President, Marine Engineering
3	Diego Cana	Invenergy	Engineer
4	Chandra Bettadapur	Invenergy	Vice President, Engineering and Project Management
5	Horacio Larios	Invenergy	Project Management
6	Matthew Olive	Invenergy	Development
7	Joel Schroeder	Invenergy	Engineering
8	Jessica Wright	Dillon Consulting	Environmental
9	Jonathan Raes	Exmar	Business Development (FSRU)
10	Therese L. Baas	Lloyd´s Register	HAZID Facilitator, Risk and Safety
11	Danielle Chrun	Lloyd´s Register	HAZID Scribe, Risk and Safety

Appendix 9B–

HAZID Marine Report

Lloyd's Register
Energy

Working together
for a safer world

Invenergy Power to Shore Project, La Paz, El Salvador

Marine HAZID Report

Report for
Invenergy LLC

Report: US4122.2, Rev: Final

Date: 03 March 2016

Summary

Invenergy Power to Shore Project, La Paz, El Salvador

Marine HAZID Report

Security classification of this report: Distribute only after client's acceptance

Report:	Revision:	Report date:
US4122.2	Final	03 March 2016

Prepared by:	Reviewed by:	Approved by:
Danielle Chrun / Susan Guo Senior Consultants	Therese L. Baas Center of Excellence	Kyle Wingate Consulting Manager

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Our contact:
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Document History

Revision	Date	Description/changes	Changes made by
Draft	12 February 2016	Draft report issued for comments. HAZID worksheet was sent out on 29 January 2016 to HAZID workshop participants for comments. Comments received have been implemented in the worksheet attached in Appendix A and in this draft report.	Danielle Chrun
Final	03 March 2016	Draft report issued to workshop participants for comments. No comments were received. Ship collision risk analysis is added as Appendix C.	Danielle Chrun and Susan Guo

Executive Summary

A marine hazard identification analysis (HAZID) covering the marine risks for the Invenergy Power to Shore Project in El Salvador was carried out at the Hilton Hotel in San Salvador, El Salvador, on 18 and 19 January 2016. The objectives of the HAZID were to identify the major marine hazards and simultaneous operations to be taken into account in the design development of the project.

In the risk industry HAZID, workshops are widely used to incorporate local knowledge and main focus areas into risk assessments and projects. The main objective of the HAZID is to identify the major credible accident hazards associated with the marine project, potential cause/consequences, frequency, possible risk-reducing measures, and recommendations.

Key regulatory bodies, stakeholders and project participants from the Maritime Port Authority, Ministry of the Environment, Port of Acajutla, Invenergy, Moffatt & Nichol, Exmar, Shell, Energía del Pacífico, and Lloyd's Register were present during the workshop.

HAZID Results Overview

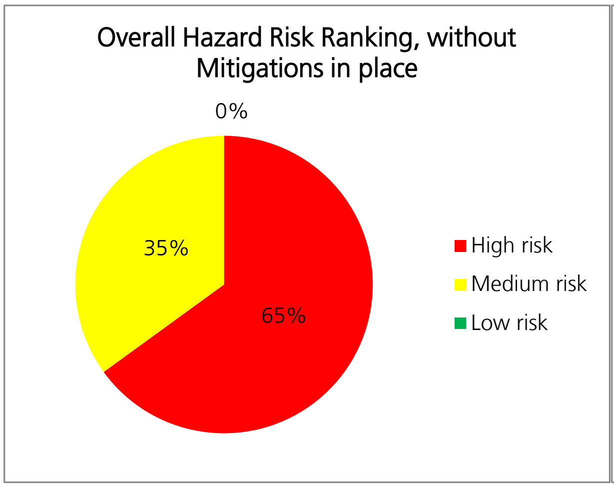
A total of 26 hazards were discussed in the HAZID, 20 of which were risk ranked. The remaining six items were not identified as major hazards but were discussed in the workshop and captured in the worksheet without risk ranking. The charts below show high-level summaries of the total hazard risk distribution results based on risk ranking category, without and with mitigations in place. Sixty-five percent (65%) of the items were identified as high-risk hazards without mitigation in place, while 35% of the items were identified as medium-risk hazards. When taking into account the mitigations, the items were identified as medium- and low-risk hazards.

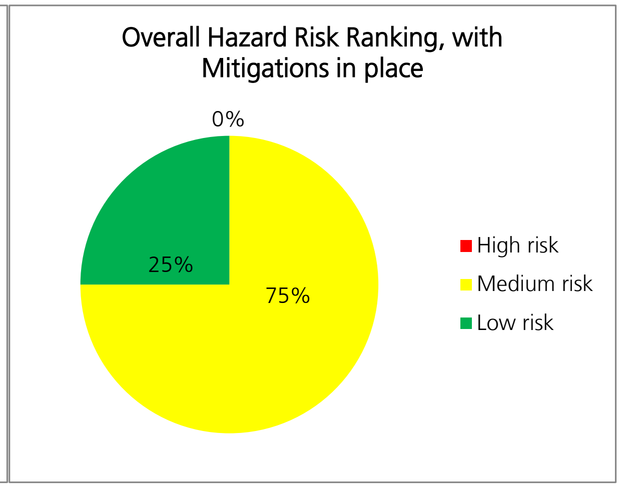
Besides the typical hazards found at most LNG import terminals worldwide, specific findings, taking into account the local conditions and the location of Sea Island, were identified, such as

- location of the shipping lane, proximity to the Port of Acajutla, Cenérgica mooring area, and ship traffic coming in and out of the Port of Acajutla, increasing the potential for ship collisions;
- ship traffic in the area, which can result in dropped or dragged anchors on the proposed subsea pipeline;
- possible local external threats;

- extreme weather from swells and tsunamis due to seismic activity from the Middle American Trench subduction zone outside the coast of El Salvador;
- possible limitation in the available resources to handle two simultaneous major accidents;
- no major hazards were identified related to the specific operation of transferring liquid natural gas (LNG) from a floating storage unit (FSU) to a floating storage and regasification unit (FSRU), maneuvering and mooring during nighttime, underkeel clearance, coastal communities, and visibility; and
- no major hazard caused by LNG Terminal was identified to impact Albapetroleos Terminal and Rasa Terminal or vice versa.

Safeguards will, however, be in place to mitigate these risks. Safeguards include, but are not limited to, inherently safe design, safety zone perimeter, reduced speed around the import terminal, pilot on board and vessel assisted by two tugs, Automatic Identification System (AIS), marine traffic control tower regulation, and no anchoring area above the subsea pipeline.



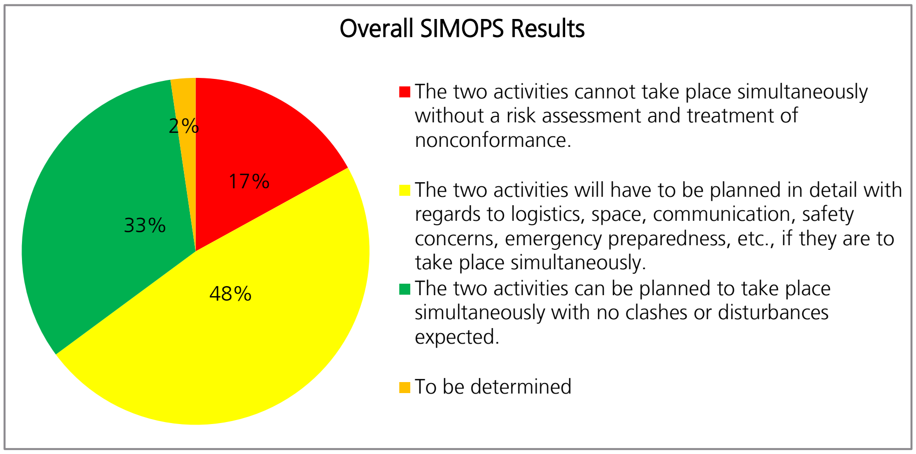


SIMOPS Results Overview

A total of 270 simultaneous operations (SIMOPS) were discussed in the session. Overall results are shown in the chart below.

Findings from the SIMOPS include, but are not limited to, the following:

- With the current available resources (pilot and tugs) and the requirement to assist oil tanker/LNG carrier (LNGC) inbound from the pilot boarding area with a pilot and two tugs, oil tankers will not approach or depart the Cenérgica area while the LNGC is in transit to the pilot boarding area or to Sea Island;
- Normal operations at the Port of Acajutla can be performed at the same time as LNGC movement or as normal operations at the LNG Terminal.
- If an LNG leak or fire occurs on Sea Island, all inbound and outbound traffic should be stopped. It is identified that operations at the Port of Acajutla will have to be planned in detail if they are to continue in the event of an LNG leak or fire on Sea Island.



Twenty-six recommendations were identified in the HAZID, and five recommendations were identified in the SIMOPS. They should be followed up and closed out by the party assigned the responsibility. Detailed results are provided in Section 6.

Table of Contents

Page

1 Introduction

1.1 Scope of Work

The marine HAZID of the Invenergy Power to Shore Project in El Salvador was carried out at the Hilton Hotel in San Salvador, El Salvador, on 18 and 19 January 2016. Key regulatory bodies, stakeholders, and project participants from the Maritime Port Authority, Ministry of the Environment, Port of Acajutla, Invenergy, Moffatt & Nichol, Exmar, Shell, Energía del Pacífico, and Lloyd's Register were present during the workshop.

In the risk industry, HAZID workshops are widely used to incorporate local knowledge and main focus areas into risk assessments and projects. A HAZID is a broad review of possible hazards and sources of accidents with particular emphasis on ensuring that relevant hazards with the potential for major accidents are not overlooked and further mitigated as low as reasonably practical in the design and operational procedures.

The objectives of the marine HAZID were to identify the major marine hazards and simultaneous marine port operations to be taken into account in the design development for the marine part of the project.

Lloyd's Register was engaged as an independent subcontractor to prepare, facilitate/scribe, and document the HAZID workshop.

1.2 Assumptions

- The HAZID was based on the offshore concept 3.b that was selected in the meeting on 20 October 2015 with personnel from Moffatt & Nichol, Exmar, Invenergy, and Lloyd's Register.
- The HAZID has addressed the normal operation phase for the installation and does not include the construction phase.

1.3 Abbreviations and Definitions

AIS	Automatic Identification System
AMP	Autoridad Marítima Portuaria
CAMS	Central American Marine Services
CEPA	Comisión Ejecutiva Portuaria Autónoma
EDP	Energía del Pacífico
EIA	Environmental impact assessment
ESD	Emergency shutdown system
FSRU	Floating storage and regasification unit
FSU	Floating storage unit
GPS	Global positioning system
HAZID	Hazard identification
HP	High pressure
LNG	Liquefied natural gas

LNGC	LNG carrier
M&N	Moffatt & Nichol
MARN	Ministerio de Medio Ambiente y Recursos Naturales (Ministry of Environment and Natural Resources)
mmscfd	Million standard cubic feet per day
mtpa	Metric ton per annum
MW	Megawatt (million watts)
QRA	Quantitative risk analysis
RPT	Rapid phase transition
SIMOPS	Simultaneous operations
STS	Ship to ship
VTS	Vessel Traffic Service

Sea Island = The LNG Import Terminal is located at "Sea Island." Sea Island comprises the LNGC (when present for offloading), FSU, FSRU, and the marine structures. The gas is exported to shore through riser and subsea pipeline.

2 System Description

2.1 Overview

Invenergy plans to build an LNG import terminal to supply natural gas to an adjacent 355 MW power plant and to other energy consumers in the area of Acajutla Port, in El Salvador (see Figure 2.1). The LNG demand for the power plant is estimated to be 0.5 mtpa, with a maximum throughput of 600 MMSCFD and a typical demand of 400 MMSCFD. The following operations will be performed:

- An LNGC will offload LNG to an FSU on a frequent basis (frequency to be decided based on FSU/FSRU storage capacity).
- The FSU will transfer LNG to an FSRU where LNG will be processed into high pressure (HP) natural gas.
- The natural gas will be transferred from the FSRU to the onshore plant via riser and pipeline at 6–7 barg.

The normal operation is estimated to occur over a 6-week cycle, with one day for LNGC offloading.

Figure 2.1: Site location.

2.2 Terminal Facility

The Terminal facility is shown in Figure 2.2, with LNGC (ship-to-ship transfer), FSU, grounded FSRU barge, and subsea pipeline to shore. The main pre-FEED characteristics are provided in Table 2.1.

Conventional LNGC mooring will be used for the FSU. As part of the concept, the FSU will stay moored at the LNG import terminal unless environmental conditions, such as swells or tsunamis, exceed safe mooring loads. The FSRU barge will have LNG buffer storage and perform the regasification of LNG into natural gas. The FSRU will be safely moored at the import terminal at all times and can withstand all identified environmental loads (inherently safe design). Transfer of LNG between LNGC and FSU will be performed via ship-to-ship (STS) transfer. LNG will also be transferred between the FSU and FSRU on a continuous basis for regasification. The send-out rate to the onshore power plant is estimated to be 70 MMSCFD.

Figure 2.2: LNG import terminal (Sea Island).

Table 2.1: Pre-FEED Assets/Infrastructure Characteristics

Assets/Infrastructure	Characteristics
LNGC	165,000 m^3
FSU	125,000–140,000 m^3
FSRU	Yearly production 70 MMSCFD LNG buffer storage capacity, 50,000–55,000 m^3
Riser and pipeline	20 inches, subsea pipeline approx.1,250 m long

2.3 Marine Activity in the Area

2.3.1 Pilot Boarding Area

All vessels sailing to the Cenérgica mooring area, Port of Acajutla, Albapetroleos Terminal or Rasa Terminal inbound will pass the pilot boarding area, located approximately 3 km west from the LNG Terminal. Vessels will wait and be escorted by a pilot and two tugs to their destination. Five vessels can wait in the staging/anchoring area until resources are available to escort them to their destination. Figure 2.3 shows the locations of the port and terminals.

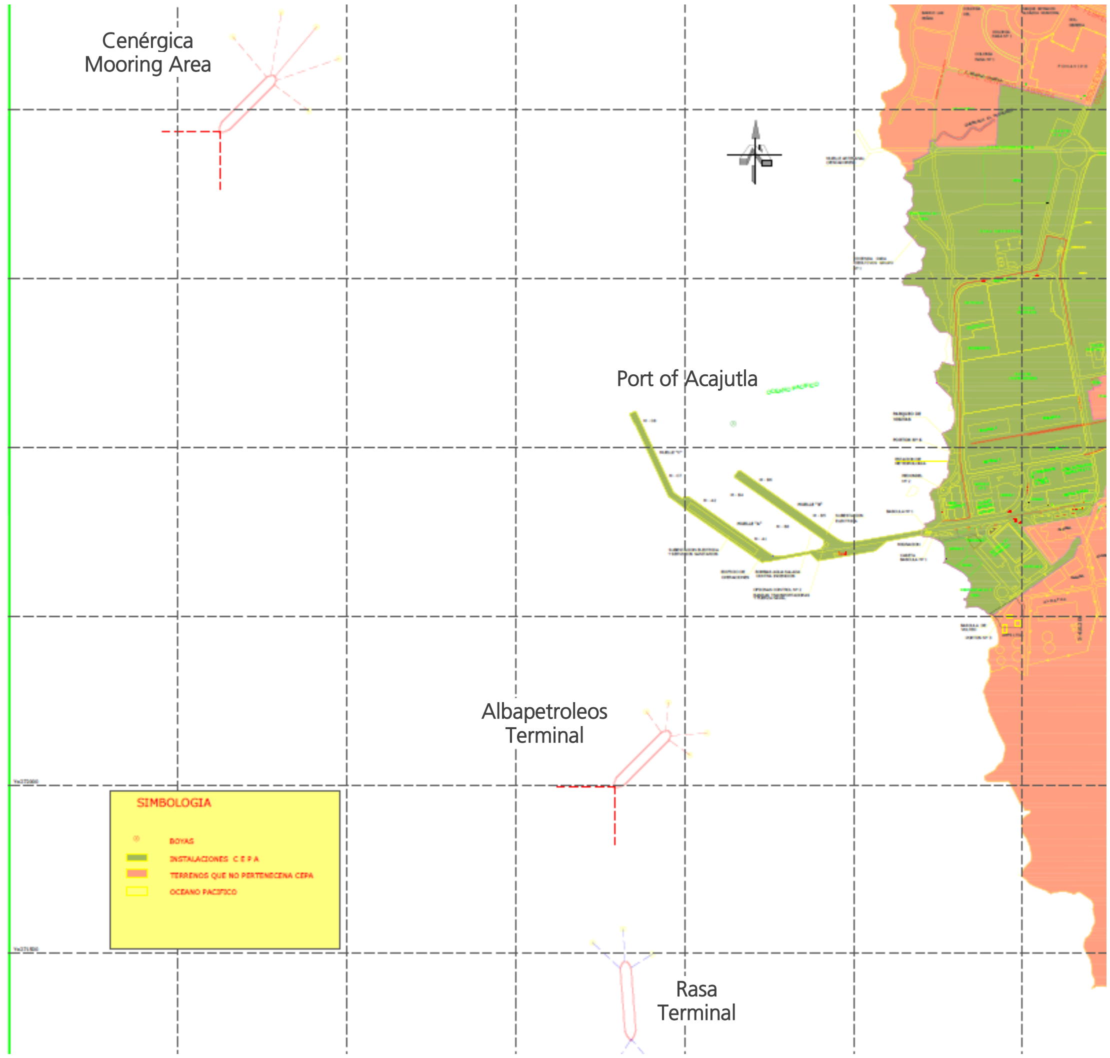


Figure 2.3: Terminals in the Port of Acajutla area.

Currently, two pilots on rotation and two tugs are available; hence, only one vessel can be escorted at one time. Entrance to and operations in Cenérgica mooring area, Albapetroleos terminal and Rasa terminal are only possible during daytime. However, normal departure (vs. emergency departure) from existing terminals is possible during nighttime.

All vessels are equipped with Automatic Identification System (AIS). The control tower regulates the traffic in the area and communicates with the vessels via Vessel Traffic Services (VTS).

2.3.2 Cenérgica Mooring Area

The Cenérgica Mooring Area is located at approximately 600 m northwest of the terminal facility.

Approximately 31 oil tankers visit the Cenérgica mooring area per year. Oil tankers are escorted by a pilot and two tugs from the pilot boarding area to the Cenérgica Mooring Area.

2.3.3 Port of Acajutla

Approximately 742 entries (341 unique vessels) to the Port of Acajutla are recorded per year (Ref. /1/). The vessel distribution is provided in Figure 2.4. Approximately four cruise ships enter the port per year, with approximately 500 people on board, up to 1,200 people.

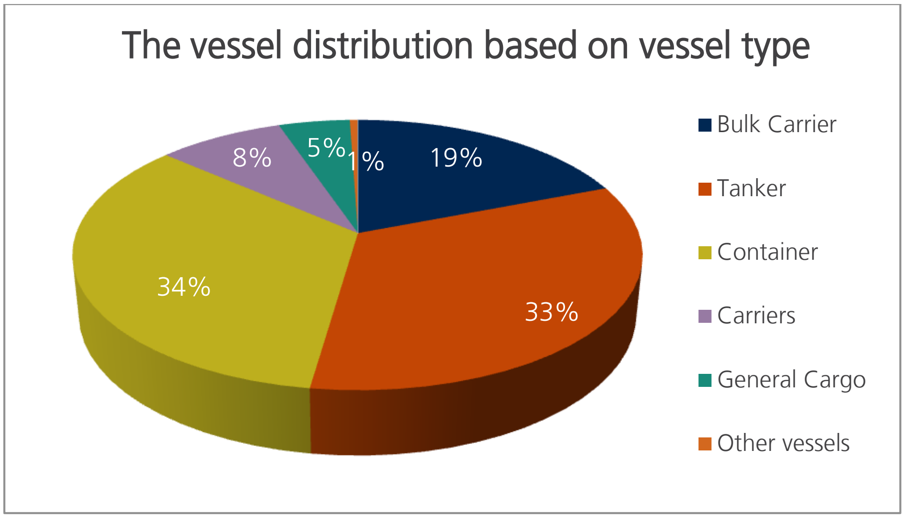


Figure 2.4: Distribution of vessels to Acajutla port based on vessel type.

Port traffic is shown in Figure 2.5. A 400 m wide approach channel is defined by the Comisión Ejecutiva Portuaria Autónoma (CEPA). The channel is currently not marked with visual indicators such as buoys.

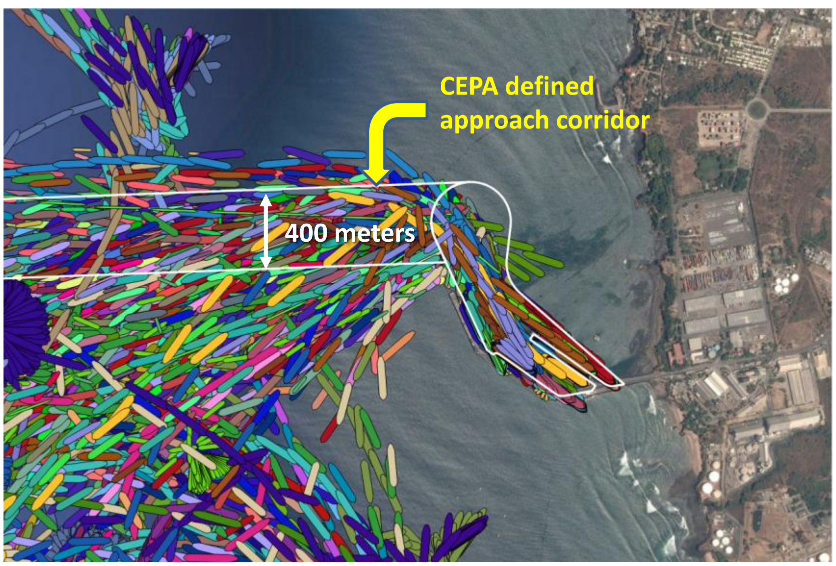


Figure 2.5: Port traffic.

2.3.4 Albapetroleos and Rasa Terminals

The Albapetroleos and Rasa terminals are located approximately 500 m and 1 km respectively south of the port. These terminals are used for offloading fuels/hydrocarbons from tankers.

2.4 Shell LNG Tanker

Shell will most likely use a chartered LNGC to transport LNG from Shell's facility in Perú to Sea Island.

2.5 Project Status

At the time of the marine HAZID, the project is at the pre-FEED stage. The project has already submitted an Environmental Impact Assessment (EIA) to the El Salvador Ministry of the Environment and Natural Resources (MARN). The Project EIA description included a 150,000 m^3 FSU, a 1.25 km jetty and trestle, a 50,000 m^3 full containment onshore storage tank, two 100% vaporizers, three 60% LNG pumps, and ancillary regasification equipment. Given the design has been slightly changed (addition of the FSRU with no onshore regasification), the EIA will be resubmitted. The permit for marine studies (geophysical study) has been approved and is scheduled to start in the spring 2016.

Operations are scheduled to start in the first quarter of 2020.

3 Workshop Participants

The HAZID workshop was conducted at the Hilton Princess Hotel in San Salvador, El Salvador, on 18 and 19 January 2016. Key regulatory bodies, stakeholders, and project participants from the Maritime Port Authority, Ministry of the Environment, Port of Acajutla, Invenergy, Moffatt & Nichol, Exmar, Shell, Energía del Pacífico, and Lloyd's Register were present during the workshop. The expertise of the team, both with respect to technical engineering and maritime operational experience, was considered appropriate and adequate for the HAZID.

Table 3.1: HAZID Participants

#	Name	Company	Discipline	Email address	01/18	01/19
1	Horacio Larios	EDP/Invenergy	Project Management	hlarios@invenergyllc.com	x	x
2	Marcos Vasquez R	CEPA	Infrastructures	marcos.vasquez@cepa.gob.sv	x	x
3	René Hernández	AMP	Presidente	rhernandez@amp.gob.sv	x	
4	Julio Melhado	EDP	Marine Engineer	jmelhado2002@yahoo.com	x	x
5	Fernando Gonzalez Chana	M&N	Project Engineering	fgchana@moffattnichol.com	x	x
6	Arturo Jimenez	M&N	Coastal Engineering	ajimenez@moffattnichol.com	x	x
7	Emmanuel Aguirre	Exmar	Maritime Operations	Emmanuel.aguirre@exmar.be	x	x
8	Javier Mina	EDP	Engineering	lmina@edp.com.sv	x	x
9	Lorena Arriola	AMP	Port infrastructures	larriola@amp.gob.sv	x	x
10	Tatiana Chacón	AMP	Port infrastructures	echacon@amp.gob.sv	x	x
11	José Roberto Escalante	AMP	Operations, Safety, Security	jescalante@amp.gob.sv	x	x
12	Chester Urban	Shell	Marine Facilities LNG Shipping and Maritime	chester.urban@shell.com	x	x
13	Alejandro Alle	EDP	Director	aalle@edp.com.sv	x	x
14	Diego Canal Saéz	Invenergy	Project Engineering/ Development	dcanalsaez@invenergyllc.com	x	x
15	John E. Keon	CAMS	Marine Advisor	elsalmar1@msn.com	x	x
16	Roberto Mendoza	CEPA	Acajutla Port Manager	roberto.mendoza@cepa.gob.sv	x	x
17	Yid Lai Zelada Quán	MARN	Environmental Evaluation	yzelada@marn.gob.sv	x	x
18	José Alberto Fabran	MARN	Environmental Evaluation	afabran@marn.gob.sv	x	x
19	Therese L. Baas	Lloyd's Register	HAZID Facilitator, Risk and Safety	therese.baas@lr.org	x	x
20	Danielle Chrun	Lloyd's Register	HAZID Scribe, Risk and Safety	danielle.chrun@lr.org	x	x

4 Supporting Documentation

The HAZID was based on the documentation listed in Table 4.1.

Table 4.1: Supporting Documentation

Document Number	Document Title	Date
901700C-403-EXHB-PLAN-OPTION 3	Invenergy LNG Import Terminal	15 Dec. 2015
-	Incoming Vessel Anchoring Area	15 Jan. 2016 (Email)
OS-SPT-0470-ESD-0003, Issue A00	Option A – Site Plan – Double Banked Jetty LNG Offloading Arms	30 May 2014
-	Terminals Map	15 Jan. 2016 (Email)
-	PowerPoint presentation by M&N	18 Jan. 2016
-	General Approach Tracks into the 3 Private Moorings Off Acajutla Port Facility, John Keon	20 Jan. 2016

5 Methodology

5.1 Marine HAZID Methodology

The marine HAZID was reported and performed on a combined accident type and area basis, as shown in Table 5.1. Due to the early phase of the project, a set of marine risk aspects were identified and discussed for each accident/area in the workshop. A HAZID presentation was used by the facilitator to present the risk aspects and engage the team in discussions.

Table 5.1: Hazards Covered in the HAZID

No.	Hazard Description
1	LNGC sailing to Sea Island
2	LNGC approaching Sea Island
3	LNGC moored at Sea Island for offloading or only FSU
4	LNG transfer from FSU to FSRU (no LNGC present)
5	LNG transfer to shore through subsea pipeline
6	Navigational issues
7	Security and other hazards
8	Emergency situations
9	Weather conditions
10	Albapetroleos Terminal
11	Rasa Terminal

5.1.1 Risk Ranking

A simple risk ranking was used to qualitatively assess the risk for each identified credible scenario, as shown in Table 5.2. Items ranked as a medium or high risk will be considered for further analysis, such as the quantitative risk assessment (QRA) and/or emergency planning study, as opposed to low risk items.

Table 5.2: Risk Ranking Definition

Risk	Description
High Risk	Actions required to reduce risk as a matter of priority
Medium Risk	Need to assess whether further risk reduction would be beneficial
Low Risk	Mitigations/safeguards are in place according to a reasonable level

5.1.2 HAZID Worksheet

The HAZID worksheet is attached as Appendix A. The worksheet column fields are described in Table 5.3.

Table 5.3: HAZID Worksheet Column Fields Description

Worksheet Field	Description
ID	For identification purposes, it is necessary that all items are independent and given a unique identifier number.
Type of hazard	Hazards represent deviation from the normal operation.
Hazard cause	All reasonable causes for the hazard should be stated here. This information will assist in evaluating the probability of occurrence, hence the risk and means of detecting the occurrence as well as possible corrective actions to take.
Hazard consequence	The consequences of the occurrence of the hazard should be described here. This information will assist in evaluating the risk.
Risk ranking (without mitigation)	Each hazard is qualitatively assessed in terms of risk level, defined as a combination of frequency of occurrence of the hazard and consequence of the hazard, in the absence of the mitigation measures.
Existing barriers/mitigation measures	Mitigation measures involve measures that can reduce or prevent the consequence of a hazard. For example, they include existing systems to detect the hazard, operational procedures, and personnel experience.
Risk ranking (with mitigation)	Each hazard is qualitatively assessed in terms of risk level, defined as a combination of frequency of occurrence of the hazard and consequence of the hazard, taking into account the mitigation measures.
Recommendations/ comments	Possible recommendations and comments are stated in this column.

5.2 SIMOPS Methodology

A SIMOPS review is a high-level analysis of risks related to performing several activities at the same time. The review does not go into detail on each activity and is based on the plans and documentation of activities that are available at the time of the SIMOPS review. Important findings from the review are recorded as actions/recommendations in a worksheet similar to the HAZID worksheet, called the SIMOPS worksheet.

It was assessed whether other operations, such as another vessel approaching or loading/offloading, can be carried out at the same time as the LNG Terminal operations. The operations that are considered for the LNG Terminal operations are listed in Table 5.4, while the other operations are listed in Table 5.5.

Table 5.4: LNG Terminal Operations

ID	LNG Terminal Operation
1	LNGC approach to pilot boarding area
2	LNGC departure from pilot boarding area and approach to Sea Island
3	LNGC fully loaded and moored at Sea Island
4	LNG transfer from LNGC to FSU
5	LNGC departure from Sea Island
6	LNG transfer from FSU to FSRU
7	High-pressure gas transfer to shore through subsea pipeline
8	LNG leak
9	Natural gas release due to overpressurization of tanks
10	Fire on Sea Island

Table 5.5: Other Operations

Node	ID	Operation
Transit inbound/outbound	A.1	Vessel (oil tanker, merchant vessel, fishing or recreational vessel) approaching pilot boarding area
	A.2	Other ship moored in anchoring/staging area
	A.3	Vessel (oil tanker, merchant vessel, fishing or recreational vessel) departing pilot boarding area inbound
	A.4	Inbound cruise ship
	A.5	Outbound cruise ship
Cenérgica mooring area	B.1	Loaded oil tanker approaching Cenérgica mooring area
	B.2	Oil tanker offloading HFO/diesel buoy
	B.3	Empty oil tanker departing Cenérgica mooring area
	B.4	Hydrocarbon leakage from oil tanker in Cenérgica mooring area
	B.5	Fire on board oil tanker in Cenérgica mooring area
LNG Terminal	C.1	LNG transfer from LNGC to FSU
	C.2	LNG transfer from FSU to FSRU
	C.3	High-pressure gas transfer to shore through subsea pipeline

Node	ID	Operation
	C.4	LNG leak
	C.5	Fire on Sea Island
Approach to Port of Acajutla	D.1	Vessel (oil tanker, merchant vessel, fishing or recreational vessel) approaching Port of Acajutla
Port of Acajutla	E.1	Crane operations in Port of Acajutla
	E.2	Vessel (oil tanker, merchant vessel, fishing or recreational vessel) berthed in Port of Acajutla
	E.3	Cruise ship berthed in Port of Acajutla
	E.4	Fertilizer handling
	E.5	Bulk handling
	E.6	Granular hydrocarbons (oil, gasoline, diesel) handling
	E.7	Flammable cargo handling
	E.8	Truck/car traffic (incoming and outgoing) at berths
	E.9	Fire on ship berthed in Port of Acajutla
Albapetroleos Terminal	F.1	Albapetroleos unloading of hydrocarbons
Rasa Terminal	G.1	Rasa unloading of hydrocarbons

The major product of the SIMOPS review is a color-coded matrix (SIMOPS worksheet) listing all the activities to be performed simultaneously. The colors in the matrix represent the evaluation of risk of performing two given activities at the same time, as defined in Table 5.6.

Table 5.6: Assessment of Simultaneous Operations

The two activities cannot take place simultaneously without a risk assessment and treatment of nonconformance.
The two activities will have to be planned in detail with regards to logistics, space, communication, safety concerns, emergency preparedness, etc., if they are to take place simultaneously.
The two activities can be planned to take place simultaneously, with no clashes or disturbances expected.

The complete SIMOPS worksheet is attached in Appendix B.

6 Results

6.1 HAZID Results

Twenty-six hazards were discussed in the HAZID, 20 of which were risk ranked. The remaining six items were not identified as major hazards but were discussed in the workshop and captured in the worksheet without risk ranking. The marine HAZID worksheet can be found in Appendix A. Figure 6.6 shows the number of items per risk ranking category without and with mitigation in place. The medium- and high-risk items with mitigation in place will be considered for further analysis such as the quantitative risk assessment (QRA) and/or emergency planning study, as opposed to low-risk items.

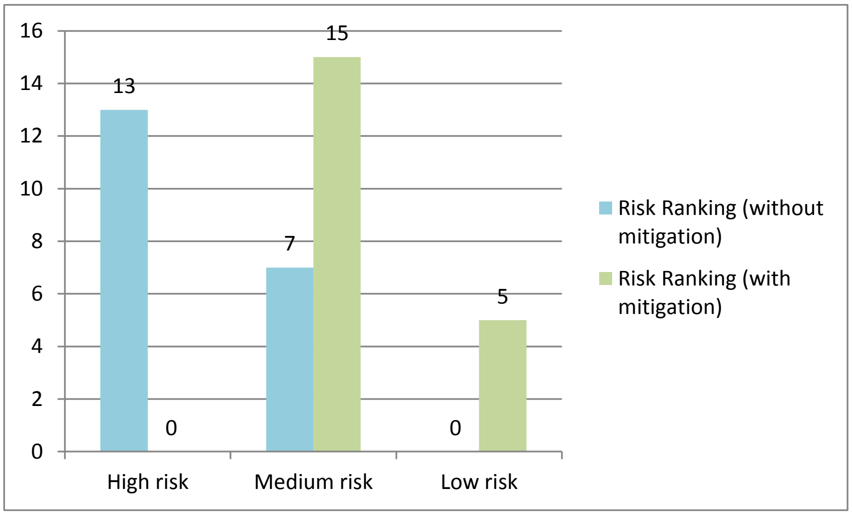


Figure 6.6: Number of items per risk ranking category.

The distribution of risk ranking items per hazard without and with mitigation measures in place is shown in Figure 6.7 and Figure 6.8 respectively. The following conclusions are drawn:

- The short distance between the import terminal and the Acajutla port and the proximity of the shipping lane to the import terminal for inbound and outbound traffic to the port increase the risk for ship collisions with the import terminal. In addition to the inherently safe design (double hull LNGC and FSU), mitigation measures include AIS on ships, marine traffic control tower, vessel traffic system (VTS), reduced speed in the area (less than 3 knots), and assistance by a pilot and two tugs to and from pilot boarding area. Currently, only two tugs are available; as a result, only one ship movement at a time is possible in the area, which reduces the risk of ship collisions. An analysis has been performed on the risk of ship collisions; results can be found in Appendix C.
- The shipping channel is currently not visually marked (Figure 2.5) and it is recommended to consider defining a formal shipping lane.
- Another risk related to the presence of other ships nearby the installation is the occurrence of a dropped or dragged anchor on the subsea pipeline. This can lead to gas release to the environment but is mitigated by the design of the pipeline to withstand shock from foreign objects and the definition of a no-anchoring zone on the pipeline route, which will be depicted on the nautical charts.

- There is a security risk related to the location of Sea Island as local threats are present. A patrol/security vessel will be present to mitigate the risk and to restrict traffic around the installation.
- No major hazards were identified related to the specific operation of transferring LNG from FSU to FSRU, maneuvering and mooring during nighttime, underkeel clearance, coastal communities, and visibility.
- No major hazards caused by LNG Terminal were identified to impact Albapetroleos Terminal and Rasa Terminal or vice versa.

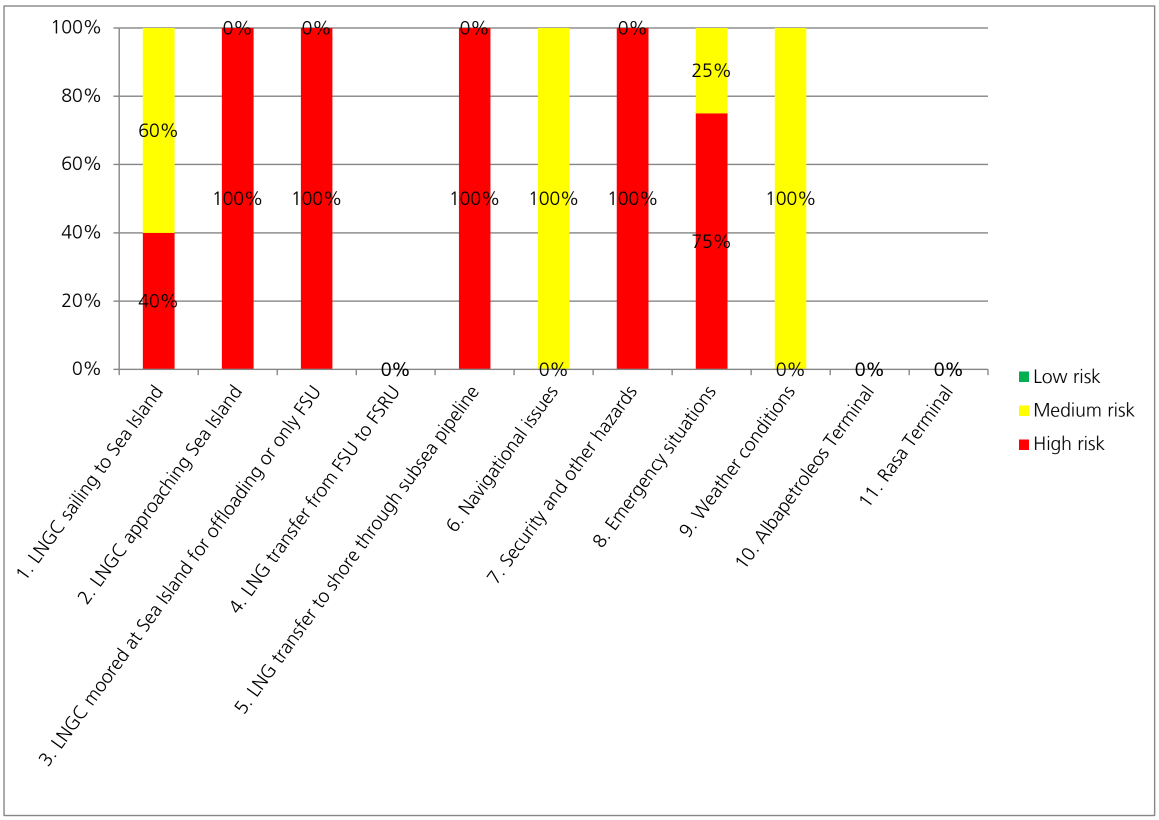


Figure 6.7: Distribution of risk ranking items per hazard, without mitigation measures.

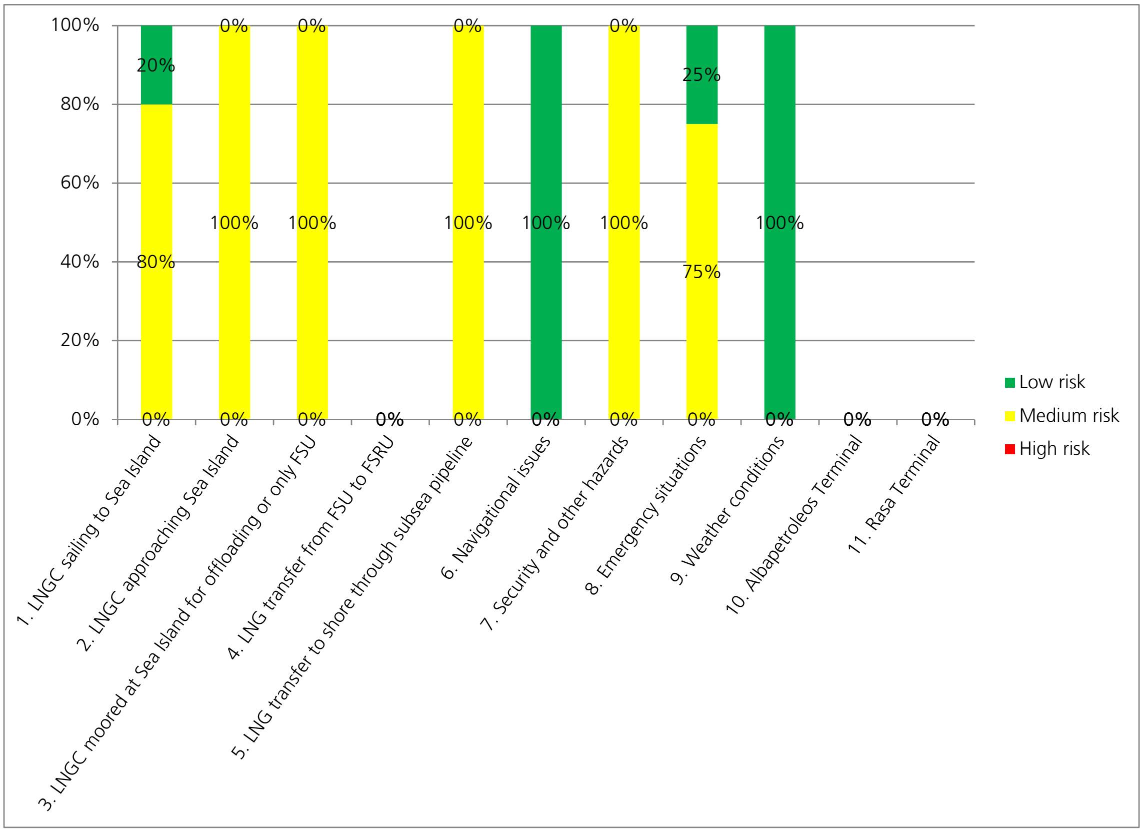


Figure 6.8: Distribution of risk ranking items per hazard, with mitigation measures.

6.2 HAZID Recommendations

Twenty-six recommendations were identified in the HAZID and are listed in Table 6.1. The recommendations shall be followed up and closed out by the party assigned the responsibility. Comments are provided in Table 6.2.

Table 6.1: Recommendations from HAZID

ID	Recommendations	Responsible	Risk Ranking (after mitigation)
1.1	Consider operational procedures to ensure proper pilotage and tug assistance for approaching LNGC to avoid clashes and/or collisions.	Invenergy	M
1.1	Establish points where tug assistance needs to be in place before proceeding further to final destination.	Invenergy	M
1.1	Identify needs for navigational aids.	Port of Acajutla	M
1.5			L
3.1			M
3.2			M
3.3			M
1.2	Investigate exclusion and/or security/safety zone for	Invenergy	M

ID	Recommendations	Responsible	Risk Ranking (after mitigation)
2.1 8.2	LNGC transit.		M L
1.2	Establish by procedure the requirement of having tug escort for LNGC.	Invenergy	M
1.2	Consider establishing designated pilot boarding area(s).	Port of Acajutla	M
1.2	Consider regulating a formal shipping lane for ships sailing to/from Port of Acajutla to Southwest and validate in marine simulations. Ensure that the formal proposal has sufficient supporting documentation (e.g., marine simulations) when submitted to Marine Administration. It is recommended to conduct a meeting to involve all stakeholders impacted by the channel (shipping lane) location change (AMP, CEPA pilots, Cenérgica mooring master). It is recommended to mark the shipping lane with visual markers. Ensure that the approach to other terminals remains safe under the new scheme.	Invenergy	M
1.2 2.1	Identify turning circle for LNGC maneuvering and approaching Sea Island and coordinate with AMP and Port Authority. Consider PIANC and SIGTTO regulations to determine turn radius.	Invenergy	M M
1.4 3.5	It is recommended to conduct bathymetry studies for navigation areas.	Invenergy	M M
1.5	Consider assessing operational procedures to ensure proper pilotage and tug assistance for approaching LNGC and prevent collision.	Invenergy	L
3.1 3.2 3.3	Evaluate tug requirements (e.g., technical requirements, procedures) for passing vessels to Sea Island or vessels entering/exiting port.	Invenergy	M M M
3.4 5.1	Develop pipeline protection as part of the design. It is recommended to include a restriction zone around the pipeline route.	M&N	M M
3.4	Develop riser protection as part of the design.	Exmar and M&N	M
3.5	Investigate sea bottom composition in the geophysical study.	M&N	M
5.1	Consider visual marker to indicate physical location of pipeline. Ensure that proper markers are in place to avoid fishing vessels anchoring in the pipeline area (indication on nautical charts and communication directly with the fishermen). Ensure security tugs enforce no anchoring zone in the pipeline area.	Invenergy	M
6.1	Consider limiting approach/departure of one vessel at a time to or from the Cenérgica mooring area or Port of Acajutla or LNG Terminal.	Invenergy and Port of Acajutla	L
6.1	It is recommended to provide local pilots and tugboat operators the required familiarization and training to	Invenergy	L

ID	Recommendations	Responsible	Risk Ranking (after mitigation)
	handle the LNGC.		
6.2	It is recommended to start mooring operations and maneuvering operations for LNG Terminal in daytime. Nighttime departures will be simulated to determine preliminary acceptability.	Invenergy	-
6.3	Underkeel clearance needs to be analyzed for moored vessel.	M&N	-
7.1	When the terminal is in operation and lit, fishing activity will be attracted to the terminal. Ensure security/safety and exclusion zones are proposed and instituted regarding fishing and traffic near the terminal.	Port of Acajutla	M
7.1	International Ship and Port Security (ISPS) plan for the terminal needs to take into account local security concerns.	Invenergy	M
7.1	It is recommended that the project engages with the national government in order to ensure that the government provides security measures for external threats to this international investment project.	Invenergy	M
7.2	The quantified risk analysis (QRA) for the project will address risk to third parties and coastal communities (nearby populations).	LR	-
9.1 9.2	Consider pausing LNG transfer from LNGC to FSU and from FSU to FSRU in the occurrence of chubascos.	Invenergy	L L
9.1 9.2	Include chubascos in the marine simulations scenarios.	M&N	L L
9.2	It is recommended to clearly define environmental limits.	Invenergy	L

Table 6.2: Comments from HAZID

ID	Comment
1.1 1.5	Currently, maneuvering/approaching/departing operations may be stopped when wind speed exceeds 12 knots, based on pilot's judgment, in the Port of Acajutla. However, such operations with up to 18 knots wind speed have been conducted to date. Wind speed criteria will be adjusted based on the marine simulations.
1.2	Currently, anchoring/staging area can host up to eight vessels. Up to five anchored vessels have been seen at a time.
1.3	There are approximately four cruise ships per year visiting the Port of Acajutla with, on average, 500 passengers on board and up to 1,200 passengers.
1.4	There is no known structure that the LNGC can collide with in the seaway.
1.4	LNGC approaching speed will be determined based on simulations. Typically, 3 knots is the maximum speed in the area.
1.5	At the HFO or diesel buoy located in Cenérgica Mooring Area, there is approximately 40 barrels maximum of oil in each flexible hose (two hose streams). Hoses are connected to the shore pipeline. A check valve and manual isolation valve are located on the pipeline at the Pipeline End Manifold (PLEM). Opening/closing of isolation valve is performed by diver for the oil tanker offloading operations.

ID	Comment
2.1	The FSU will be nearly empty upon LNGC arrival (only 10% LNG in tanks to keep cool). Power plant will be fed by buffer storage tank on FSRU during this period of time.
3.1	Existing mitigation: LNG vessel design to meet IMO IGC Code 2G standards. This comment applies across the worksheet.
6.1	When considering the appropriate distance of the pilot boarding area, ample sea room should be available after the pilot boards and is familiarized on the bridge to make fast the tugs to aid in slowing down the vessel and maneuvering.
6.2	No night operations for existing terminals in the area. Currently, departure at night is possible for existing terminals.
7.2	Coastal communities: - Acajutla at north of Port of Acajutla (approximately 60,000 habitants) - Metalío at north of Acajutla (approximately 28,000 habitants) - Los Cobanos at South of Port of Acajutla (approximately 12,000 habitants), with protected area
8.1	Refer to report for HAZID performed in October 2015 for other emergency situation events at Sea Island.
8.1 8.2 8.3 8.4	The emergency events at Sea Island, Port of Acajutla, or Cenérgica are further addressed in the SIMOPS for how they may affect the different operations in this area.
8.1	The design should be consistent with NFPA 59A.
8.2	A vapor release does not usually have any hazardous consequences since the gas quickly disperses into air; however the frequency is slightly higher than for large LNG leakages.
8.2	Exmar commented that Exmar is currently operating 12 FLNGs/FSRUs around the world and has in the last 10 years not had any known vapor release.
9.2	Optimized mooring configuration will be developed as part of dynamic mooring analysis.
9.3	Visibility guideline will be included in operations manual. The visibility is very good in this area.
10.1	Albapetroleos Terminal is also further addressed in the SIMOPS.
11.1	Rasa Terminal is also further addressed in the SIMOPS.

6.3 SIMOPS Results

Two hundred and seventy (270) simultaneous operations were discussed in the SIMOPS workshop. Figure 6.9 shows the number of items per ranking category. The following conclusions are drawn:

- With the current available resources (pilot and tugs) and the requirement to assist oil tankers/LNGCs inbound from the pilot boarding area with a pilot and two tugs, oil tankers will not approach or depart the Cenérgica area while an LNGC is in transit to the pilot boarding area or to Sea Island.
- Normal operations at the Port of Acajutla can be performed at the same time as the LNGC movement or as the normal operations at the LNG Terminal. As an example, while the LNGC approaches or departs Sea Island or LNG is transferred through the pipeline to shore, the normal Port of Acajutla operations, such as material offloading or handling, can continue.

- If an LNG leak or fire occurs on Sea Island, all inbound and outbound traffic should be stopped. It is identified that operations at the Port of Acajutla will have to be planned in detail if they are to continue in the event of an LNG leak or fire on Sea Island.
- Unloading of hydrocarbons at Albapetroleos terminal or Rasa terminal can be performed at the same time as the normal operations at Sea Island and at the same time as an LNGC approach or departure.

All results from the SIMOPS can be found in Appendix B.

Table 6.3 presents the recommendations and comments captured during the workshop. All recommendations should be followed up and closed out by those given the responsibility for the respective actions.

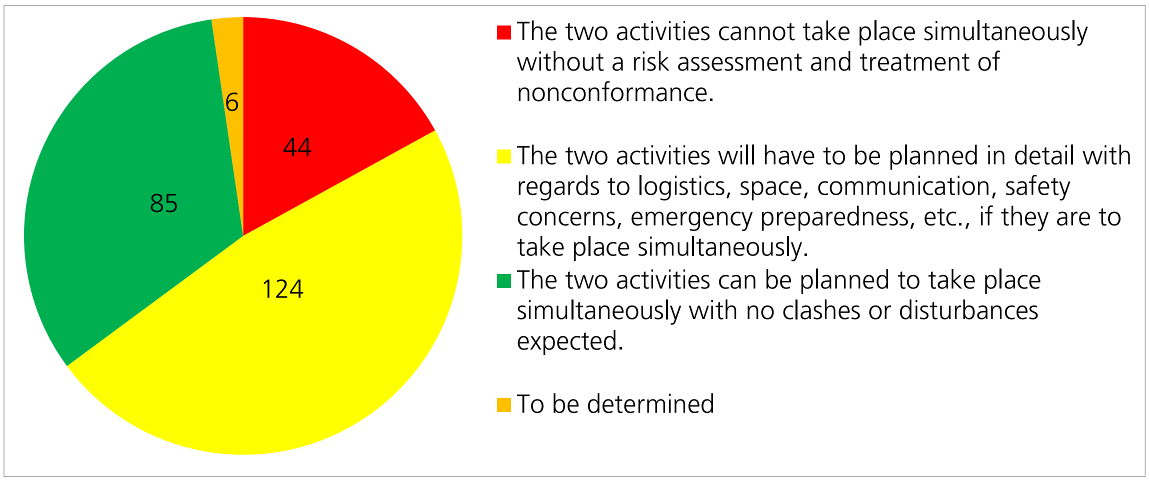


Figure 6.9: Distribution of rankings of items evaluated in SIMOPS.

Table 6.3: Recommendations and Comments from SIMOPS

ID	Recommendations [R]/Comments [C]	Responsible
1	[C] In the future, if additional tugs and pilots are available for simultaneous movements of ships, the marine control tower in the Port of Acajutla can handle these movements.	-
1	[C] There are approximately four cruise ships per year in the Port of Acajutla, with, on average, 500 passengers on board and up to 1,200 passengers.	-
2	[C] Incoming vessels can anchor in the anchoring/staging area based on approval of marine control tower (exact location is communicated via coordinates). Vessels will wait until the marine control tower approves movement of the vessel to the pilot boarding area. Currently, anchoring/staging area can hold up to 8 vessels.	-
2	[R] It is recommended for the project to determine if there is a need to increase the anchoring/staging area or to assign specific anchoring areas prior to when LNGC enters the area.	Invenergy

ID	Recommendations [R]/Comments [C]	Responsible
3	[R] It is recommended that the project obtains the operations manual and emergency preparedness procedures from port and other terminals.	Invenergy
8	[R] It is recommended to determine if resources in the Port of Acajutla are sufficient in terms of emergency response capacity for occurrence of two accidents at the same time, e.g., 1) LNG leak at LNG Terminal and oil leak at Cenérgica mooring area, or 2) LNG leak at LNG Terminal and fire at Port of Acajutla). Mitigating measures could be to stop transfer and production to prevent two accidents at the same time.	Invenergy
9	[R] It is recommended to run a simulation in the QRA to cover the consequences of a vapor vent release of natural gas.	LR
10	[R] It is recommended to evaluate the frequency of scenarios that have a consequence on the port operations and potentially determine contingency planning for these situations.	Invenergy

7 References

/1/ http://www.sadfiweb.gob.sv:8090/ConsultasEnLinea/HistoricoBuques/index.php

Appendix A

HAZID Worksheet

ID	Type of hazard	Hazard cause	Hazard consequence	Risk Ranking (without mitigation)	Existing barriers/mitigation measures	Risk Ranking (with mitigation)	Recommendations [R]/Comments [C]
1	**LNGC sailing to Sea Island**						
1.1	Collision of LNGC with oil tanker moored in Cenérgica mooring area as LNGC approaches Sea Island	- Fail to observe and reduce the speed in time - Loss of power (blackout) - Environmental (weather, sea) conditions - Human error	- Loss of containment of Heavy Fuel Oil (HFO) and diesel - Potential leak of LNG to the environment - Worst case scenario: T-bone powered collision of LNGC with moored oil tanker	H	- Reduced speed while sailing to Sea Island (3-1.5 knots) - LNGC assisted by tugs while sailing to Sea Island which can recover the vessel in case of loss of position - Pilot onboard LNGC - Double-hull oil tanker - Double-hull LNGC - Operational procedure to prevent leaving pilot boarding area without proper pilotage and tug assistance (captain's decision) - Frequency of having both oil tanker and LNGC in the area is low - Marine simulations to develop environmental and operational criteria - Automatic Identification System (AIS) to automatically provide updates on vessel positions in the area and other relevant ship voyage data. - Port of Acajutla marine traffic control tower and VTS with radar capacity to ensure traffic management and marine safety communications incl. coordination with rescue resources	M	**[R]** Consider operational procedures to ensure proper pilotage and tug assistance for approaching LNGC to avoid clashes and/or collisions. [Invenergy] **[C]** Currently, maneuvering / approaching / departing operations may be stopped when wind speed exceeds 12 knots, based on pilot's judgment, in the Port of Acajutla. However, such operations with up to 18 knots wind speed have been conducted to date. Wind speed criteria will be adjusted based on the marine simulations. **[R]** Establish points where tug assistance needs to be in place before proceeding further to final destination. [Invenergy] **[R]** Identify needs for navigational aids. [Port of Acajutla]
1.2	Collision of LNGC with another vessel (merchant vessel, fishing boat etc.) when LNGC is departing/leaving pilot boarding area	- Fail to observe and reduce the speed in time - Loss of power (blackout) - Environmental (weather, sea) conditions - Human error - Shipping lane to and from pilot boarding area is close to the LNG Import Terminal/Sea Island	- Loss of containment of cargo to environment - Potential injury or fatality (fishing boat) if LNGC collides with fishing boat	M	- Reduced speed while sailing to Sea Island (3-1.5 knots) - LNGC assisted with tugs while sailing to Sea Island - Pilot onboard LNGC - Double-hull LNGC - Operational procedure to prevent leaving pilot boarding area without proper pilotage and tug assistance (captain's decision) - Procedure to ensure only one vessel is moving in the pilot boarding area at a time; all other vessels are anchored - Automatic Identification System (AIS) to automatically provide updates on vessel positions in the area and other relevant ship voyage data. - Port of Acajutla marine traffic control tower and VTS with radar capacity to ensure traffic management and marine safety communications incl. coordination with rescue resources	M	**[R]** Investigate exclusion and/or security/safety zone for LNGC transit. [Invenergy] **[R]** Establish by procedure the requirement of having tug escort for LNGC. [Invenergy] **[R]** Consider establishing designated pilot boarding area(s). [Port of Acajutla] **[C]** Currently, anchoring / staging area can host up to 8 vessels. Up to 5 anchored vessels have been seen at a time. **[R]** Consider regulating a formal shipping lane for ships sailing to/from Port of Acajutla to Southwest and validate in marine simulations. Ensure that the formal proposal has sufficient supporting documentation (e.g. marine simulations) when submitted to Marine Administration. It is recommended to conduct a meeting to involve all stakeholders impacted by the channel (shipping lane) location change (AMP, CEPA pilots, Cenérgica mooring master). It is recommended to mark the shipping lane with visual markers. Ensure that the approach to other terminals remains safe under the new scheme. [Invenergy] **[R]** Identify turning circle for LNGC maneuvering and approaching Sea Island and coordinate with AMP and Port Authority. Consider PIANC and SIGTTO regulations to determine turn radius. [Invenergy]

1.3	Collision of LNGC with cruise ship when LNGC is departing/leaving pilot boarding area	- Fail to observe and reduce the speed in time - Loss of power (blackout) - Environmental (weather, sea) conditions - Human error	- Loss of containment of LNG to environment - Potential injury or fatality	H	- Reduced speed while sailing to Sea Island (3-1.5 knots) - LNGC/cruise ship assisted by tugs - Pilot onboard LNGC and cruise ship - Operational procedure to prevent leaving pilot boarding area without proper pilotage and tug assistance (captain's decision) - Procedure to ensure only one vessel is moving in the pilot boarding area at a time; all other vessels are anchored - Automatic Identification System (AIS) to automatically provide updates on vessel positions in the area and other relevant ship voyage data. - Port of Acajutla marine traffic control tower and VTS with radar capacity to ensure traffic management and marine safety communications incl. coordination with rescue resources	M	**[C]** There are approximately 4 cruise ships per year visiting the Port of Acajutla with on average 500 passengers onboard, and up to 1,200 passengers.
1.4	Collision of LNGC with obstacle in the seaway	Unknown underwater formations	- Grounding - Hull rupture - Leak of LNG to the environment	M	- Reduced speed while sailing to Sea Island (3-1.5 knots) - Double hull LNGC - Marine studies (geophysical) will confirm any obstacles	M	**[C]** There is no known structure that the LNGC can collide with in the seaway. **[C]** LNGC approaching speed will be determined based on simulations. Typically, 3 knots is the maximum speed in the area. **[R]** It is recommended to conduct bathymetry studies for navigation areas. [Invenergy]
1.5	Collision of LNGC with HFO or diesel buoy located in Cenérgica mooring area	- Fail to observe and reduce the speed in time - Loss of power (blackout) - Environmental (weather, sea) conditions - Human error	Loss of containment of HFO or diesel	M	- Reduced speed while sailing to Sea Island (3-1.5 knots) - LNGC assisted with tugs while sailing to Sea Island - Pilot onboard LNGC - Operational procedure to prevent leaving pilot boarding area without proper pilotage and tug assistance (captain's decision) - Marine simulations to develop environmental and operational criteria	L	**[R]** Consider assessing operational procedures to ensure proper pilotage and tug assistance for approaching LNGC and prevent collision. [Invenergy] **[C]** Currently, maneuvering / approaching / departing operations may be stopped when wind speed exceeds 12 knots, based on pilot's judgment, in the Port of Acajutla. However, such operations with up to 18 knots wind speed have been conducted to date. Wind speed criteria will be adjusted based on the marine simulations. **[C]** At the HFO or diesel buoy located in Cenérgica mooring area there is approximately 40 barrels maximum of oil in each flexible hose (2 hose streams). Hoses are connected to the shore pipeline. A check-valve and manual isolation valve are located on the pipeline at the Pipeline End Manifold (PLEM). Opening/closing of isolation valve is performed by diver for the oil tanker offloading operations. **[R]** Identify needs for navigational aids. [Port of Acajutla]

2	**LNGC approaching Sea Island**						
2.1	LNGC colliding with FSU when LNGC is approaching FSU for LNG offloading	- Fail to observe and reduce the speed in time - Loss of power (blackout) - Environmental (weather, sea) conditions - Human error	- Collision with FSU leading to FSU structural damage and puncture of LNG storage tank and/or structural damage to LNGC - Localized impact. It is assumed that FSU will be nearly empty upon LNGC approach - LNGC will be full with LNG upon arrival. Loss of containment, gas dispersion, fire if gas cloud is ignited - No impact foreseen for FSRU, as it will be protected by the fixed marine structure	H	- A number of tugs to escort LNGC to FSU - Reduced speed at LNG terminal entrance and approaching the facility - Sufficient power and redundancy in tugs to maintain LNGC safely positioned at all times during berthing - Double hull LNGC/FSU - Safety zone around installation - Fender system for FSU - Docking aid system	M	**[C]** The FSU will be nearly empty upon LNGC arrival (only 10% LNG in tanks to keep cool). Power plant will be fed by buffer storage tank on FSRU during this period of time. **[R]** Investigate exclusion and/or security/safety zone for LNGC transit. [Invenergy] **[R]** IIdentify turning circle for LNGC maneuvering and approaching Sea Island and coordinate with AMP and Port Authority. Consider PIANC and SIGTTO regulations to determine turn radius. [Invenergy]
3	**LNGC moored at Sea Island for offloading or only FSU**						
3.1	Collision of vessel approaching/departing Cenérgica mooring area or Port of Acajutla into LNGC at Sea Island	- Fail to observe the speed limit - Loss of power (blackout) - Environmental (weather, sea) conditions - Human error	- Loss of primary containment from LNGC and other vessel - Potential spill of oil - Flammable environment, potential fire if ignited	H	- Reduced speed while sailing/departing to Cenérgica area or Port of Acajutla - Tug assistance - Pilot onboard inbound/outbound ship - Operational procedure to prevent leaving pilot boarding area without proper pilotage and tug assistance (captain's decision) - Patrol/security vessel will be present to restrict traffic around installation. - Automatic Identification System (AIS) to automatically provide updates on vessel positions in the area and other relevant ship voyage data. - Port of Acajutla marine traffic control tower and VTS with radar capacity to ensure traffic management and marine safety communications incl. coordination with rescue resources	M	**[R]** Identify needs for navigational aids. [Port of Acajutla] **[R]** Evaluate tug requirements (e.g. technical requirements, procedures) for passing vessels to the Sea Island or vessels entering/exiting Port. [Invenergy] **[C]** Existing mitigation: LNG vessel design to meet IMO IGC Code 2G standards. This comment applies across the worksheet.
3.2	Collision of other vessels with moored FSU	- Fail to observe the speed limit - Loss of power (blackout) - Environmental (weather, sea) conditions - Human error	- Loss of primary containment from FSU and other vessel - Potential spill of oil - Flammable environment, potential fire if ignited	H	- Reduced speed while sailing/departing to Cenérgica area or Port of Acajutla - Tug assistance - Pilot onboard inbound/outbound ship - Operational procedure to prevent leaving pilot boarding area without proper pilotage and tug assistance (captain's decision) - Patrol/security vessel will be present outside the Sea Island to restrict traffic around installation. - Automatic Identification System (AIS) to automatically provide updates on vessel positions in the area and other relevant ship voyage data. - Port of Acajutla marine traffic control tower and VTS with radar capacity to ensure traffic management and marine safety communications incl. coordination with rescue resources	M	**[R]** Identify needs for navigational aids. [Port of Acajutla] **[R]** Evaluate tug requirements (e.g. technical requirements, procedures) for passing vessels to the Sea Island or vessels entering/exiting Port. [Invenergy]

3.3	Collision of other vessels with structure	- Fail to observe the speed limit - Loss of power (blackout) - Environmental (weather, sea) conditions - Human error	Loss of containment from colliding vessel	H	- Reduced speed while sailing/departing to Cenérgica area or Port of Acajutla - Tug assistance - Pilot onboard inbound/outbound ship - Operational procedure to prevent leaving pilot boarding area without proper pilotage and tug assistance (captain's decision) - Patrol/security vessel will be present outside the Sea Island to restrict traffic around installation.	M	**[R]** Identify needs for navigational aids. [Port of Acajutla] **[R]** Evaluate tug requirements (e.g. technical requirements, procedures) for passing vessels to the Sea Island or vessels entering/exiting Port. [Invenergy]
3.4	Collision of other vessels in riser	- Rupture on riser due to ship collision in riser - Pipeline rupture due to another vessel's dragged anchor	- Damage to riser/pipeline - Gas release to the environment - Flammable environment	H	- Reduced speed while sailing/departing to Cenérgica area or Port of Acajutla - Tug assistance - Pilot onboard inbound/outbound ship - Operational procedure to prevent leaving pilot boarding area without proper pilotage and tug assistance (captain's decision) - ESD - Patrol/security vessel will be present at berth to restrict traffic around installation. - No anchoring zone on the pipeline route (shown on nautical charts) - Pressure monitoring - Physical protection of riser	M	**[R]** Develop pipeline protection as part of the design. It is recommended to include a restriction zone around the pipeline route. [M&N] **[R]** Develop riser protection as part of the design. [Exmar and M&N]
3.5	LNGC grounding ashore	- Fail to observe the speed limit - Loss of power (blackout) - Environmental (weather, sea) conditions - Human error	- Local structural damage to LNGC - Possible loss of containment	H	- Tug assistance - Pilot onboard inbound/outbound ship - Reduced speed at LNG terminal entrance and approaching the facility - Sufficient power and redundancy in tugs to maintain LNGC safely positioned at all times during berthing - Double hull LNGC	M	**[R]** Investigate sea bottom composition in the geophysical study. [M&N] **[R]** It is recommended to conduct bathymetry studies for navigation areas. [Invenergy]
4	**LNG transfer from FSU to FSRU (no LNGC present)**						
4.1	Refer to hazards covered in Section 3 - LNGC moored at Sea Island for offloading						
5	**LNG transfer to shore through subsea pipeline**						
5.1	Other vessel grounding in the proximity of the subsea pipeline or dropped anchor on pipeline	- Fail to observe the speed limit - Loss of power (blackout) - Environmental (weather, sea) conditions - Human error - Dropped anchor	- Damage to riser/pipeline - Gas release to the environment - Flammable environment	H	- Reduced speed while sailing/departing to Cenérgica area or Port of Acajutla - Tug assistance - Pilot onboard inbound/outbound ship - Operational procedure to prevent leaving pilot boarding area without proper pilotage and tug assistance (captain's decision) - ESD - No anchoring zone on the pipeline route (shown on nautical charts) - Pressure monitoring - Physical protection of pipeline or buried pipeline - Port of Acajutla marine traffic control tower and VTS with radar capacity to ensure traffic management and marine safety communications incl. coordination with rescue resources. Ensure safe anchoring and anchoring locations.	M	**[R]** Develop pipeline protection as part of the design. It is recommended to include a restriction zone around the pipeline route. [M&N] **[R]** Consider visual marker to indicate physical location of pipeline. Ensure that proper markers are in place to avoid fishing vessels anchoring in the pipeline area (indication on nautical charts and communication directly with the fishermen). Ensure security tugs enforce no anchoring zone in the pipeline area. [Invenergy]

6	**Navigational issues**						
6.1	Maneuvering	- Present turning circle size for LNGC less than 2-ship lengths - Environmental (weather, sea) conditions - Other ship traffic in the area	Ship grounding, collision and/or allision with possible loss of containment	M	- Reduced speed while sailing/departing to/from Cenérgica area or Port of Acajutla - Tug assistance - Pilot onboard inbound/outbound ship - Operational procedure to prevent leaving pilot boarding area without proper pilotage and tug assistance (captain's decision) - Automatic Identification System (AIS) to automatically provide updates on vessel positions in the area and other relevant ship voyage data. - Port of Acajutla marine traffic control tower and VTS with radar capacity to ensure traffic management and marine safety communications incl. coordination with rescue resources	L	**[R]** Consider limiting approach/departure of one vessel at a time to or from the Cenérgica mooring area or Port of Acajutla or LNG Terminal. [Invenergy and Port of Acajutla] **[C]** When considering the appropriate distance of the pilot boarding area, ample sea room should be available after the pilot boards and is familiarized on the bridge to make fast the tugs to aid in slowing down the vessel and maneuvering. **[R]** It is recommended to provide local pilots and tug boat operators the required familiarization and training to handle the LNGC. [Invenergy]
6.2	Maneuvering and mooring night operations for LNG Terminal	-	-	-	-	-	**[R]** It is recommended to start mooring operations and maneuvering operations for LNG Terminal in day time. Night time departures will be simulated to determine preliminary acceptability. [Invenergy] **[C]** No night operations for existing terminals in the area. Currently, departure at night is possible for existing terminals.
6.3	Underkeel clearance	-	-	-	-	-	**[R]** Underkeel clearance needs to be analyzed for moored vessel. [M&N]
7	**Security and other hazards**						
7.1	Security issues in Acajutla	Local security threats for Sea Island installation	- Impact on safety of personnel - Impact on assets and production	H	Patrol/security vessel will be present to restrict traffic around installation.	M	**[R]** When the terminal is in operation and lit, fishing activity will be attracted to the terminal. Ensure security/safety and exclusion zones are proposed and instituted regarding fishing and traffic near the terminal. [Port of Acajutla] **[R]** International Ship and Port Security (ISPS) plan for the terminal needs to take into account local security concerns. [Invenergy] **[R]** It is recommended that the project engages with the National Government in order to ensure that the Government provides security measures for external threats to this international investment project. [Invenergy]
7.2	No identified hazards related to the proximity of coastal communities in the proximity of the Terminal (too far away)	-	-	-	-	-	**[C]** Coastal communities: - Acajutla at north of Port of Acajutla (approximately 60,000 habitants) - Metalío at north of Acajutla (approximately 28,000 habitants) - Los Cobanos at South of Port of Acajutla (XX habitants), with protected area **[R]** The quantified risk analysis (QRA) for the project will address risk to third parties and coastal communities (nearby populations). [LR]

8	Emergency situations						
8.1	LNG leak or fire on Sea Island	- Leakage in cargo transfer lines due to dropped objects - Puncture of largest storage tank due to ship collision - Equipment failure	- Damage to cargo transfer line - Leakage of LNG to the environment (spill on water), gas dispersion and fire if ignited - LNG in liquid form can cause frostbite of contact with skin - Fatalities	H	- Protect cargo transfer line or limit any lifting above the transfer line to avoid dropped objects - Double hull LNGC/FSU - ESD and segmentation - Break-away coupling on transfer line, stop transfer immediately - Fire and Gas detection - Fire plan, fire drills - Active fire protection on jetty (hydrants) - Active and passive fire protections on ship - Smoking controlled area - Water curtain while transferring - Clearance radius - Training - Certifications - Policies and procedures - Lightning protection system	M	**[C]** Refer to report for HAZID performed in October 2015 for other emergency situation events at Sea Island. **[C]** The emergency events at Sea Island, Port of Acajutla or Cenérgica are further addressed in the SIMOPS for how they may affect the different operations in this area. **[C]** The design should be consistent with NFPA 59A.
8.2	Vapor release (smaller natural gas release) due to over pressurization of tanks	- Cold release, which is visible (some expansion). Typically a small amount is vented into the air. - Malfunction and/or failure of pressure control system (both primary and secondary) - Human error	- Cold gas is vented. Depending on the wind conditions it will most likely disperse into air quickly and not pose a threat. - Smaller amount of gas	M	- Pressure control system, incl. Emergency Shut Down System (ESD) and Process Shut Down System (PSD) (primary and secondary controls) - Tank over pressurization will result in tank protection vents opening (known of in the industry) - Alarm and monitoring systems - Operational procedures that shall prevent such events. If boil-off gas pressure is high in tank, more boil-off gas will typically be sent to the burner etc. This is regulated by the operator.	L	**[C]** The emergency events at Sea Island, Port of Acajutla or Cenérgica are further addressed in the SIMOPS for how they may affect the different operations in this area. **[C]** A vapor release does usually not have any hazardous consequences as the gas quickly disperse into air; however the frequency is slightly higher than for large LNG leakages. **[C]** Exmar commented that Exmar is currently operating 12 FLNGs/FSRUs around the world and have in the last 10 years not had any known vapor release. **[R]** Investigate exclusion and/or security/safety zone for LNGC transit. [Invenergy]
8.3	Leak of hydrocarbons or fire from ship berthed in Port of Acajutla	Leakage of hydrocarbons from ships in Port of Acajutla	- Leakage of hydrocarbons to the environment - Potential fire if ignited - Fatalities	H	- Clearance radius - Active and passive fire protections on ship - Fire and Gas detection - Fire plan, fire drills - Smoking controlled area - Training - Certifications - Policies and procedures	M	**[C]** The emergency events at Sea Island, Port of Acajutla or Cenérgica are further addressed in the SIMOPS for how they may affect the different operations in this area.
8.4	Leak of hydrocarbons/oil or fire from oil tanker in Cenérgica mooring area	Leakage of hydrocarbons from the Cenérgica oil tanker	- Leakage of hydrocarbons to the environment - Potential fire if ignited - Fatalities	H	- Clearance radius - Active and passive fire protections on ship - Fire and Gas detection - Fire plan, fire drills - Training - Certifications - Policies and procedures	M	**[C]** The emergency events at Sea Island, Port of Acajutla or Cenérgica are further addressed in the SIMOPS for how they may affect the different operations in this area.

9	**Weather conditions**							
9.1	Electrical storms	Chubascos (rain squall, short duration, strong intensity, occasional downburst and waterspout)	- Damage to infrastructure - Potential fatalities	M	- Weather forecast - Early warning system (Sistemas de Alerta Temprana - SAT) - Sonsonate X band radar of the Ministry of Environment - Infrastructure designed to withstand such event - Operational procedures - Port is considering adding a meteorological radar - A specific weather station will be installed on site to verify meteorological conditions - Port of Acajutla marine traffic control tower and VTS with radar capacity to ensure traffic management and marine safety communications incl. coordination with rescue resources	L	**[R]** Consider pausing LNG transfer from LNGC to FSU and from FSU to FSRU in the occurrence of chubascos. [Invenergy] **[R]** Include chubascos in the marine simulations scenarios. [M&N]
9.2	High wind	Chubascos (rain squall, short duration, strong intensity, occasional downburst and waterspout)	Breakage of mooring lines	M	- Weather forecast - Early warning system (Sistemas de Alerta Temprana - SAT) - Sonsonate X band radar of the Ministry of Environment - Infrastructure designed to withstand such event for mooring - Operational procedures - Port is considering adding a meteorological radar - A specific weather station will be installed on site to verify meteorological conditions - Port of Acajutla marine traffic control tower and VTS with radar capacity to ensure traffic management and marine safety communications incl. coordination with rescue resources	L	**[R]** Consider pausing LNG transfer from LNGC to FSU and from FSU to FSRU in the occurrence of chubascos. [Invenergy] **[R]** Include chubascos in the marine simulations scenarios. [M&N] **[R]** It is recommended to clearly define environmental limits. [Invenergy] **[C]** Optimized mooring configuration will be developed as part of dynamic mooring analysis.
9.3	No identified hazard impacting visibility	-	-	-	-	-	**[C]** Visibility guideline will be included in operations manual. The visibility is very good in this area.
10	**Albapetroleos Terminal**							
10.1	No major hazards caused by LNG Terminal identified to impact Albapetroleos Terminal or vice versa	-	-	-	-	-	**[C]** Albapetroleos Terminal is also further addressed in the SIMOPS.
11	**Rasa Terminal**							
11.1	No major hazards caused by LNG Terminal identified to impact Rasa Terminal or vice versa	-	-	-	-	-	**[C]** Rasa Terminal is also further addressed in the SIMOPS.

Appendix B

SIMOPS Worksheet

		A.1	A.2	A.3	A.4	A.5	B.1	B.2	B.3	B.4	B.5	C.1	C.2	C.3	C.4	C.5	D.1
		Vessel (oil tanker, merchant vessel, fishing or recreational vessel) approaching pilot boarding area	Other ship moored in anchoring/staging area	Vessel (oil tanker, merchant vessel, fishing or recreational vessel) departing pilot boarding area inbound	Inbound cruise ship	Outbound cruise ship	Loaded oil tanker approaching Cenérgica mooring area	Oil tanker offloading HFO/Diesel buoy	Empty oil tanker departing Cenérgica mooring area	Hydrocarbon leakage from oil tanker in Cenérgica mooring area	Fire onboard oil tanker in Cenérgica mooring area	LNG transfer from LNGC to FSU	LNG transfer from FSU to FSRU	High pressure gas transfer to shore through subsea pipeline	LNG leak	Fire on Sea Island	Vessel (oil tanker, merchant vessel, fishing or recreational vessel) approaching Port of Acajutla
1	LNGC approach to pilot boarding area											N/A					
2	LNGC departure from pilot boarding area and approach to Sea Island											N/A					
3	LNGC fully loaded and moored at Sea Island											N/A					
4	LNG transfer from LNGC to FSU											N/A					
5	LNGC departure from Sea Island											N/A					
6	LNG transfer from FSU to FSRU												N/A				
7	High pressure gas transfer to shore through subsea pipeline													N/A			
8	LNG leak									TBD	TBD				N/A	N/A	
9	Natural gas release due to over pressurization of tanks																
10	Fire on Sea Island									TBD	TBD				N/A	N/A	

		E.1	E.2	E.3	E.4	E.5	E.6	E.7	E.8	E.9	F.1	G.1	
		Crane operations in Port of Acajutla	Vessel (oil tanker, merchant vessel, fishing or recreational vessel) berthed in Port of Acajutla	Cruise ship berthed in Port of Acajutla	Fertilizer handling	Bulk handling	Granular hydrocarbons (oil, gasoline, diesel) handling	Flammable cargo handling	Truck/car traffic (incoming and outgoing) at berths	Fire on ship berthed in Port of Acajutla	Albapetroleos unloading of hydrocarbons	Rasa unloading of hydrocarbons	Recommendations (R) /Comments (C)
1	LNGC approach to pilot boarding area												**[C]** In the future, if additional tugs and pilots are available for simultaneous movements of ships, the marine control tower in the Port of Acajutla can handle these movements. **[C]** There are approximately 4 cruise ships per year in the Port of Acajutla with on average 500 passengers onboard, and up to 1,200 passengers.
2	LNGC departure from pilot boarding area and approach to Sea Island												**[C]** Incoming vessels can anchor in the anchoring/staging area based on approval of marine control tower (exact location is communicated via coordinates). Vessels will wait until the Marine control tower approves movement of the vessel to the pilot boarding area. Currently, anchoring/staging area can hold up to 8 vessels. **[R]** It is recommended for the project to determine if there is a need to increase the anchoring/staging area or to assign specific anchoring areas prior LNGC enters the area. [Invenergy]
3	LNGC fully loaded and moored at Sea Island												**[R]** It is recommended that the project obtains the operations manual and emergency preparedness procedures from Port and other Terminals. [Invenergy]
4	LNG transfer from LNGC to FSU												
5	LNGC departure from Sea Island												
6	LNG transfer from FSU to FSRU												
7	High pressure gas transfer to shore through subsea pipeline												
8	LNG leak									TBD			**[R]** It is recommended to determine if resources in the Port of Acajutla are sufficient in terms of emergency response capacity for occurrence of two accidents at the same time (e.g. 1) LNG leak at LNG terminal and oil leak at Cenérgica mooring area, or 2) LNG leak at LNG terminal and fire at Port of Acajutla). Mitigating measures could be to stop transfer and production to prevent two accidents at the same time. [Invenergy]
9	Natural gas release due to over pressurization of tanks												**[R]** It is recommended to run a simulation in the QRA to cover the consequences of a vapor vent release of natural gas. [LR]
10	Fire on Sea Island									TBD			**[R]** It is recommended to evaluate the frequency of scenarios that have a consequence on the Port operations and potentially determine contingency planning for these situations. [Invenergy]

Appendix C

Ship Collision Risk Analysis

Table of Contents

Page

1 Introduction

Invenergy LLC plans to build a liquefied natural gas (LNG) import terminal to supply natural gas to an adjacent 378 MW power plant and to other energy consumers in the area of Acajutla Port, in El Salvador. Lloyd's Register (LR) has been engaged by Invenergy LLC to perform a ship collision risk analysis for the proposed LNG import terminal design.

1.1 Objectives

The objectives of this study are the following:

- Quantify the risks associated with ship collisions and identify the main risk contributors.
- Propose risk-mitigating measures (if applicable).

1.2 Scope of work

Based on the HAZID, the following ship collision scenarios involving Sea Island (FSU and FSRU installation) have been identified for further analysis:

1. The potential collision of the LNGC with Sea Island
2. The potential collision of an oil tanker en route to the Cenérgica mooring area with Sea Island
3. The potential collision of merchant vessels to/from the port of Acajutla with Sea Island

1.3 Glossary/Abbreviations

AIS	Automatic Identification System
ARPA	Automatic Radar Plotting Aid
B.V.	Bad visibility
CEPA	Comisión Ejecutiva Portuaria Autónoma (Autonomous port Executive Committee)
DWT	Deadweight tonnage
G.V.	Good visibility
FSU	Floating Storage Unit
FSRU	Floating Storage And Regasification Unit
LNGC	Liquefied Natural Gas Carrier (LNGC)
LR	Lloyd's Register
MMSCFD	Million Standard Cubic Feet Per Day
M&N	Moffatt and Nichol
NFPA	National Fire Protection Association
RABL	Risk Assessment of Buoyancy Loss
SD	Standard Deviation
UDM	Uncontrolled Drifting Movement

UM	Uncontrolled Movement
UPM	Uncontrolled Powered Movement
VLCC	Very Large Crude Carrier

2 System and Operation Description

2.1 Operation Overview

Invenergy LLC is planning to develop a new marine terminal for the unloading and supply of LNG to a new power plant in Acajutla, El Salvador (see Figure 2.1). The LNG demand for the power plant is estimated to be 0.5 mtpa, with a maximum throughput of 600 MMSCFD and a typical demand of 400 MMSCFD. The following operations will be performed:

- An LNG carrier (LNGC) will offload LNG to a floating storage unit (FSU) on a frequent basis (frequency to be decided based on FSU/FSRU storage capacity).
- The FSU will transfer LNG to a floating storage and regasification unit (FSRU) where LNG will be processed into high pressure (HP) natural gas.
- The natural gas will be transferred from the FSRU to the onshore power plant via riser and pipeline at 6–7 barg.

As part of the concept, the FSU will stay moored at the LNG import terminal unless environmental conditions, such as swells or tsunamis, exceed safe mooring loads. The FSRU barge will have LNG buffer storage and perform the regasification of LNG into natural gas. The FSRU will be safely moored at the import terminal at all times and can withstand all identified environmental loads (inherently safe design). Transfer of LNG between LNGC and FSU will be performed via ship-to-ship (STS) transfer. LNG will also be transferred between the FSU and FSRU on a continuous basis for regasification. The send-out rate to the onshore power plant is estimated to be 70 MMSCFD.

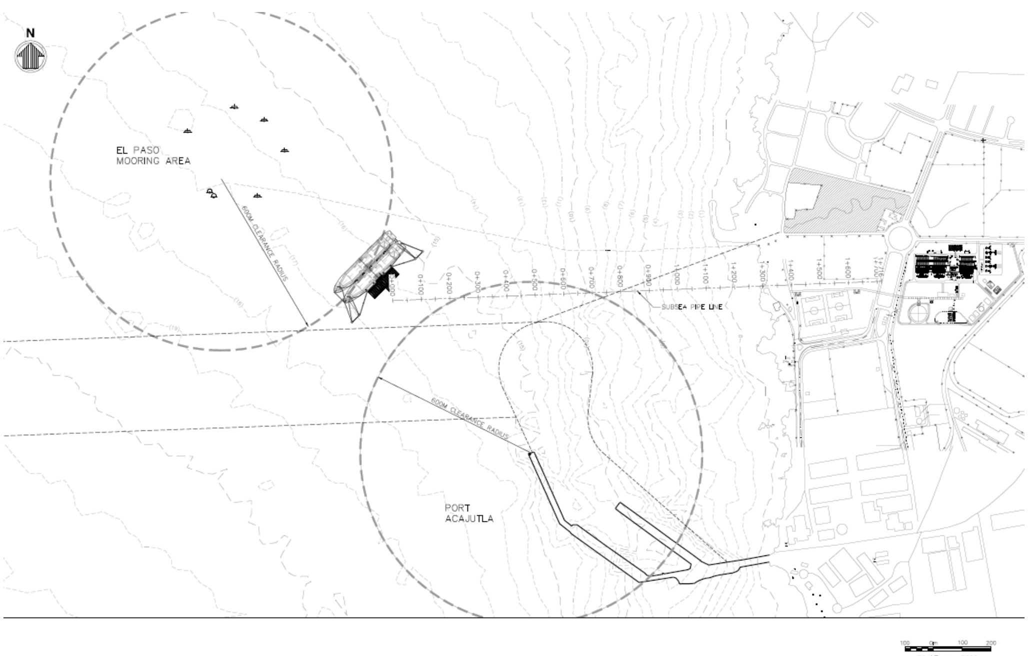


Figure 2.1: Proposed LNG import terminal.

2.2 Weather Data

Weather information used in this study is obtained from the Metocean report prepared by Moffatt & Nichol (M&N), Ref. /1/.

Temperature

The ambient temperature is assumed to be 27°C, which is the annual average temperature for Acajutla port, Ref. /2/.

Humidity

The average ambient relative humidity is assumed to be 80%, Ref. /2/.

Wind speed and wind direction

The wind rose is shown in Figure 2.2. The dominating wind direction is the wind from north to northeast sector, followed by winds from the south.

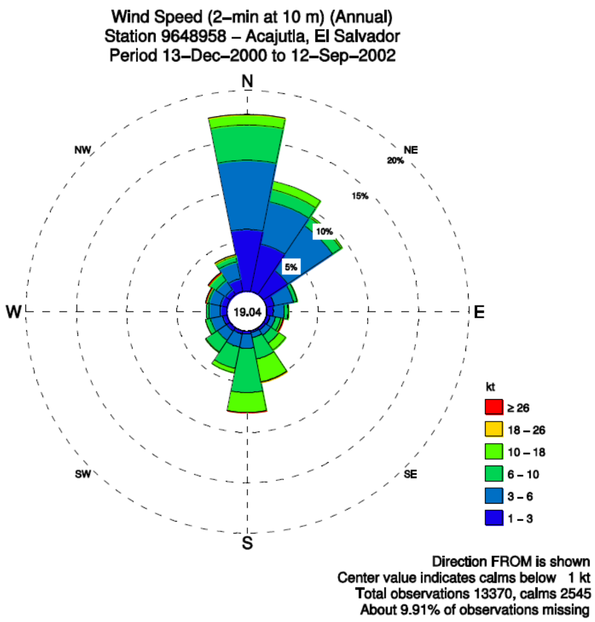


Figure 2.2: Wind rose data at Acajutla.

Stability class

Pasquill stability class is a measure of turbulence in the atmosphere and defined in Table 2.1, Ref. /3/. It is dependent on wind speed, time of day, and other conditions, as shown in Table 2.2.

Table 2.1: Pasquill Stability Classes

Pasquill Class	Stability
A	Extremely unstable
B	Moderately unstable
C	Slightly unstable
D	Neutral
E	Slightly stable
F	Moderately stable

Table 2.2: Stability Class from Wind Speed and Solar Radiation

Wind Speed (m/s)	Daytime Insolation			Nighttime Conditions	
	Strong	Moderate	Slight	Thin Overcast or > 4/8 Low Cloud	<=4/8 Cloudiness
0–2	A	A-B	B	E	F
2–3	A-B	B	C	E	F
3–5	B	B-C	C	D	E
5–6	C	C-D	D	D	D
>6	C	D	D	D	D

For this study, it is assumed that the stability class at Sea Island is 5D (wind speed is 5 m/s with a stability class D) in 70% of the time and 2F (wind speed is 2 m/s with a stability class F) in 30% of the time. A 2F condition is considered to be the most conservative wind condition according to NFPA 59A.

3 LNGC Collision with FSU

This study uses the standard ship collision methodology, summarized in LR ship collision risk analysis methodology report, Ref. /3/. The LR methodology has been continually updated with the new technology on vessels and has been validated with hundreds of ship collision studies.

An LNGC is used to carry and transfer LNG to the FSU at the new terminal. The generic information for a typical LNGC, which will be used for the project, and its operations are summarized in Table 3.1.

Table 3.1: LNGC Characteristics and Operation Procedures

LNGC	Parameters
Length (m)	294
Overall height	68.50
Breadth moulded (m)	46.00
Gross tonnage (international)	111,459
Maximum air draught (m)	59.5
Visits per year	7
Approach to Sea Island	• The LNGC will first enter the pilot boarding area to be escorted/piloted to the LNG terminal. • Two tugs will be used to escort the LNGC (twin engine, 3,000 horsepower). The approach speed of the LNGC is less than 1.5 knots.
Duration of offloading operation	• Approach, mooring, and hose connection (arrival): 6 hours • LNG transfer: 32 hours • Unmooring and departure: 2 hours

The LNGC collision risks are estimated based on the operation procedures as follows:

- Approach and connection
- Disconnection and unmooring

3.1 Collision Frequency

3.1.1 During Approach and Connection

A possible collision scenario is that the LNGC approaches Sea Island and deviates from the planned course because of a human error or equipment failure and collides with the nearby FSU. During approach and connection phases, both powered and drifting collisions can occur.

$$P(collision) = P(UM) \times P(Failure\ of\ \text{Recovery} \mid UM) \qquad \text{Eq. (1)}$$

where:

$P(collision)$ = Probability of collision

$P(UM)$ = Probability of uncontrolled movement (UM, either UPM or UDM) of a LNGC that has the potential to cause a collision

$P(Failure\ of\ \mathrm{Recovery}|UM)$ = Failure probability of recovery initiated from the LNGC and/or external means, given the uncontrolled movement of the LNGC.

3.1.1.1 Powered Collision Frequency

The uncontrolled powered movement (UPM) towards the FSU may be triggered by either human error or equipment failure. Human error is the main contributor to the possible powered collision during approach.

Human error is more likely to be caused by the captain or pilot who uses inappropriate approaching heading and too high approaching speed. Generally, the LNGC crews are trained, and operational procedures are established and practiced prior to the operation. Based on LR's experience, this type of human error has a failure rate of 1.00E-05 per ship hour, Ref. /3/.

P (UM)	~	P (human error)
	=	1.00E-05 per ship hour
	=	6.00E-05 per arrival (the duration for approach and connection is 6 hours)

The recovery of the LNGC from uncontrolled movement can generally occur in two ways: recovery initiated from the LNGC or from the tugboat.

Failure of recovery from the LNGC is difficult to assess based on current available operational information. In principle, it is widely accepted that an effective recovery when UPM occurs depends on the LNGC captain and crew in terms of their intervention of the UPM. A successful intervention is further determined by the reaction time of the LNGC captain or crew. The reaction time of the LNGC crew depends on its relative distance to the FSU and the corresponding approaching speed. The longer the reaction time is, the lower the failure probability is.

Based on the estimated approaching speed of the LNGC, the average LNGC recovery failure rate is assumed to be 0.35.

The probability of recovery failure from tugboat is conservatively assumed to be 0.5 in this case considering the limited time to react available and relatively large momentum of the LNGC.

Thus,

P (Failure of Recovery)	=	P (Failure of recovery from LNGC) x P (Failure of recovery from tugboat)
	=	0.35 x 0.5
	=	0.17

Applying the general collision frequency model in Equation 1:

P (Powered collision)	=	P (UM) x P (Failure of Recovery)
	=	6.00E-05 x 0.17
	=	1.04E-05 per arrival

Considering seven visits per year, the powered collision frequency during approach and connection phases is **7.28E-05 per year**.

3.1.1.2 Drifting Collision Frequency

A drifting collision (uncontrolled drifting movement – UDM) can occur due to partial or total blackout of the LNGC. During approach, an LNGC may become adrift if there is a blackout caused by the breakdown of the main engine. Once the LNGC becomes adrift, only a special weather condition would lead to a collision, i.e., the vector of combined weather forces pushes the LNGC toward the FSU. As the LNGC is coming from the pilot boarding area, located southwest of Sea Island, the special weather condition contributing to the drifting collision is wind coming from southwest (including SSE, SW, and WSW). Based on the metocean data (Ref. /1/), it is found that the probability P (special condition) is 9.41%.

The frequency of engine failure is estimated based on failure data of single-engine tankers, which is 1.10E-04 per ship hour (Ref. /4/).

Thus,

P (UDM)	=	P (Engine Failure) x P (Special condition)
	=	1.10E-04 x 9.41%
	=	1.04E-06 per ship hour
	=	2.07E-05 per arrival

The UDM may escalate to a drifting collision if the tugboat fails to control the drifting vessel. Since the reaction time for a tugboat is generally longer and the relative speed of the drifting LNGC is slower, it is assumed that in 10% of the cases, intervention of a tugboat for emergency towing of a drifting LNGC on the collision course will not be successful due to maneuvering errors of the tugboat or extreme weather conditions. Because the LNGC is coming from southwest (the pilot boarding area) to Sea Island, the special weather condition contributing to the drifting collision is wind coming from the southwest (including SSE, SW, and WSW). Based on the metocean data (Ref. /1/), it is found that the probability P (special condition) is 9.41%.

Applying the general collision frequency model in Equation 1:

P (Drifting collision)	=	P (UM) x P (Failure of Recovery)
	=	6.21E-05 x 0.1
	=	6.21E-06 per arrival

Considering seven visits per year, the drifting collision frequency during approach and connection phases is **4.35E-05 per year**.

3.1.2 During Disconnection and Unmooring

It is considered that only a drifting collision is possible to occur during the disconnection and unmooring phases of the operation.

During the disconnection and unmooring phases, the LNGC may become adrift if there is a total blackout caused by the breakdown of main engine. The UDM may escalate into a drifting collision if the LNGC drifts toward the FSU in a special weather condition while the tugboat fails to control the drifting vessel.

P (UDM)	=	P (Engine Failure) x P (Special Weather Condition)
	=	1.10E-04 x 9.41%
	=	1.04E-05 per ship hour
	=	6.21E-05 per disconnection (the duration of the disconnection and unmooring is 6 hours)

Applying the general collision frequency model in Equation 1:

P (Drifting collision) = P (UDM) x P (Failure of Recovery)

= 6.21E-05 x 0.10

= 3.11E-06 per disconnection

Considering seven visits per year, drifting collision frequency during disconnection and unmooring phases is **2.17E-05 per year**.

3.2 Collision Consequence

3.2.1 Powered Collision Consequence

The collision consequence is measured by the impact energy, which is calculated by equation (2). The collision energy depends on the velocity of the vessel at contact.

The initial kinetic energy of a ship collision is expressed by:

$$\mathrm{E} = \frac{1}{2} \times m \times (1+a) \times V^2 \qquad \text{Eq. (2)}$$

where

E	=	Collision energy (joules)
m	=	Mass of vessel (ton)
a	=	Added mass factor (a = 0.1 for head-on collision and 0.4 for glancing blow)
V	=	velocity of vessel (m/s^2)

Based on the tonnage (111,459 tons), the possible collision impact energy values conditioned on vessel speed is summarized in Figure 3.1.

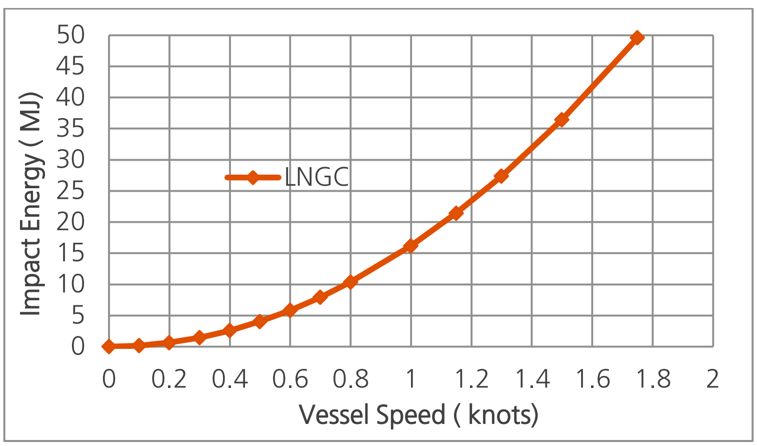


Figure 3.1: Collision impact energy vs. vessel speed for LNGC.

Due to the low speed limit of the LNGC approaching Sea Island, the impact energy of the LNGC collision is low. Given an approaching speed of 1.5 knots, the impact energy is calculated to be 36.4 MJ.

HSE has studied the structure strength of FPSO (single hull) against impacts from ship collision, Ref. /5, 6/. Due to the similarity in shape between LNGC and FPSO, the structure strength used in this study for the FPSO is considered a conservative representation of the LNGC. The following observations can be drawn:

- If the impact consequence is on port and starboard sides of ship and the impact energy is less than 28 MJ, it is usually believed that the collision only causes local damage, or may penetrate the outer hull of LNGC.
- If the impact energy is between 28 and 50 MJ, the collision can penetrate the outer hull and maybe the inner hull of LNGC tank. It has the potential to cause LNG release.
- If the impact energy is great than 50 MJ, the collision can penetrate the inner hull of the LNGC tank and a high possibility for a severe fire, leading to total loss of LNGC.
- An impact energy greater than 100 MJ is usually considered a potential cause for the total loss of the LNGC.

Another study identified critical speeds for collision of one LNGC in another LNGC of 6.6–7.4 knots leading to tank spillage, and for very large crude carriers (VLCCs) of 1.7–7.7 knots, for heavy and light colliding loadings, respectively, Ref. /7/. For LNGC used for the new LNG terminal, the maximum approaching speed of 1.5 knots is less than the speed that can result in the leak of an LNGC tank. Collisions for the LNGC with the FSU are likely to be T-bone collisions; hence, it is unlikely that collisions of the LNGC with the FSU will lead to LNG release from the LNGC. However, LNG release from the FSU is possible and will be dependent on speed of LNGC and impact location. Given the FSU is kept almost empty upon LNGC arrival, a powered collision of the LNGC with the FSU is considered unlikely to cause a LNG spill.

3.2.2 Drifting Collision Consequence

The consequence of a drifting collision is usually not critical, since the drifting speed is, in general, low. The speed of wind from the southwest sector is usually less than 10 knots at Acajutla port, based on the wind rose data. This kind of wind speed will not result in a high drifting speed of the vessel. Thus the drifting collision is considered to only cause minor or local damage of the FSU.

3.3 Summary of LNGC Collision Risk

The collision frequencies due to LNGC operations are summarized in Table 3.2. Collision impact frequencies per impact energy type is calculated and presented in Table 3.3.

Table 3.2: Summary of Collision Frequency for LNGC Collision with FSU

Vessel Type	Operating Conditions	Collision Type	Collision Frequency (per year)
LNGC	Approach and connection	Powered	7.28E-04
		Drifting	4.35E-05
	Disconnection and unmooring	Drifting	1.45E-05
Total			1.31E-04
Return year			7,644 years

Table 3.3: Collision Frequency Distribution per Energy Class for LNGC Collision with FSU

Energy Class	Impact Energy (MJ)	Frequency per Year
I	0–22	1.24E-04
II	22–28	3.64E-06
III	28–50	3.64E-06
Total		1.31E-04

The total collision frequency between LNGC and FSU is estimated to be 1.31E-04 per year (every 7,644 years). Most of these collisions will result in a minor structural damage of FSU with low impact energy of less than 28 MJ, considering all drifting collisions. The only case where the powered collision has a potential to penetrate the LNGC outer hull and to cause LNG release from the FSU is the LNGC approach at a higher speed than 1.3 knots. If it is assumed that in 5% of the cases, the LNGC is approaching the terminal at a speed higher than 1.3 knots, the occurrence of this scenario is estimated to be 3.64E-06/year. Given the FSU is kept almost empty on LNGC arrival, a collision between LNGC and FSU is considered unlikely to cause a spill from the FSU.

4 Oil Tanker to Cenérgica Mooring Area Collision with FSU

Oil tankers visit the Cenérgica mooring area to transfer oil to the offloading buoy. The general information about the oil tanker and its operation is summarized in Table 4.1.

Table 4.1: Oil Tanker and Its Operation Procedure

Oil Tankers	Parameters
Vessel type	Panamax
Length (m)	289.56
Beam (m)	32.31
Tonnage (DWT)	52,500
Draft (m)	12.04
Visits per year	31
Approach to the Cenérgica mooring area	• The oil tanker will first enter the pilot boarding area to be escorted/piloted to the Cenérgica mooring area. • Two tugs will be used to escort the tanker (twin engine, 3,000 horsepower). • Oil tanker will go north from pilot boarding area, maneuvers in a clockwise arc to achieve anchoring course of 135 and speed of 1–1.5 knots.
Duration of offloading operation	• Approach and mooring (arrival): 4 hours • Hose connection and cargo transfer: 34 hours • Unmooring and departure : 2 hours

The oil tanker collision risks are estimated based on the operation procedures as follows:

- Approach and mooring
- Unmooring and departure

4.1 Collision Frequency

The collision model used to calculate oil tanker collision with Sea Island is the same as the model used for LNGC collision with FSU.

4.1.1 During Approach and Connection

A possible collision scenario is that the oil tanker approaches the Cenérgica mooring area and deviates from the planned course by human error or equipment failure and collides with the nearby FSU. During approach and connection phases, both powered and drifting collisions can occur.

4.1.1.1 Powered Collision Frequency

The general collision frequency model is described in Equation 1. Human error is the main contributor to the possible powered collision during approach. The recovery of the oil tanker with uncontrolled movement can generally occur in two ways: recovery initiated from the oil tanker or from the tugboat.

The tanker recovery failure rate is estimated based on the reaction time of the oil tanker, which depends on its relative distance to the FSU and the corresponding approaching speed. Given the distance between oil tanker approach route to Cenérgica mooring area and Sea Island and the low approach speed (less than 1.5 knots), the probability of recovery failure from oil tanker is assumed to be 0.2. The probability of recovery failure from tugboat is assumed to be 0.1 in this case.

It is also assumed that only 50% of uncontrolled powered movement (UPM) is toward the FSU.

Thus,

P (Powered collision)	=	P (UM) x P (Failure of Recovery)
	=	1.00E-05/ship hour x 4 hours (approach time) x 50% (towards the FSU) x 0.20 (Failure of recovery from oil tanker) x 0.1(Failure of recovery from tugboat)
	=	4.00E-07 per arrival

Considering 31 visits per year, the powered collision frequency during approach and connection phases is **1.24E-05 per year**.

4.1.1.2 Drifting Collision Frequency

During approach, collision of oil tanker with the FSU will occur when a special weather condition will lead to the oil tanker becoming adrift at a special weather condition would lead to a collision with FSU. The oil tanker approaches the Cenérgica mooring area from the north from the pilot boarding area and maneuvers in a clockwise arc to achieve anchoring track. Since the Cenérgica mooring area is located to the northwest of Sea Island, it is conservatively assumed that the special weather condition contributing to the drifting collision with FSU is wind coming from west (including WSW, W, and WNW). Based on the metocean data (Ref. /1/), it is found that the probability P (special condition) is 6.39%.

P (Drifting collision)	=	P (UM) x P (Failure of Recovery)
	=	1.10E-04 (Engine Failure) x 6.39% (Special condition) x 4 hours (approaching time) x 0.1 (Failure of recovery from tugboat)
	=	2.81E-06 per arrival

Considering 31 visits per year, the drifting collision frequency during approach and connection phases is **8.72E-05 per year**.

4.1.2 During Unmooring and Departure

It is considered that only a drifting collision is possible to occur during the unmooring and departure phases of the operation. The general collision frequency model in Equation 1 is as follows:

P (Drifting collision)	=	P (UDM) x P (Failure of Recovery)
	=	1.10E-04 (Engine Failure) x 6.39% (Special condition) x 2 hours (approaching time) x 0.1 (Failure of recovery from tugboat)
	=	1.41E-06 per unmooring

Considering 31 visits per year, drifting collision frequency during disconnection and unmooring phases is **4.36E-05 per year**.

4.2 Collision Consequence

4.2.1 Powered Collision Consequence

The collision consequence is measured by the impact energy, which is calculated with equation (2). The collision energy depends on the velocity of the vessel at contact. Based on the tonnage (52,500 tons), the possible collision impact energy value per vessel speed is summarized in Figure 4.1.

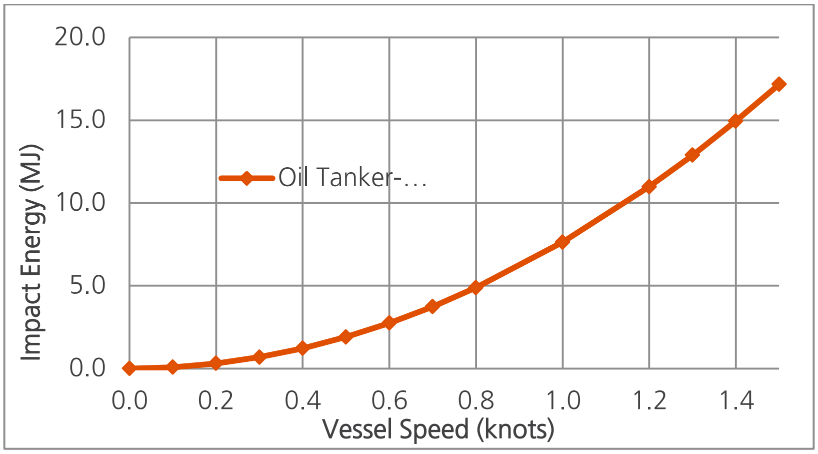


Figure 4.1: Collision impact energy vs. vessel speed.

Due to the low approach speed of the oil tanker, the impact energy of the oil tanker collision is low. Considering a maximum speed of 1.5 knots, the impact energy is calculated to be 17.2 MJ. Thus, the oil tanker collision with the FSU will only cause local or minor damage.

4.2.2 Drifting Collision Consequence

The consequence of drifting collision is usually not critical, since the drifting speed is in general low. The speed of wind from the northwest sector is usually less than 10 knots at Acajutla port, based on wind rose data. This order of magnitude of wind speed will not result in a high drifting speed of the vessel. Thus, the drifting collision is considered to only cause minor or local damage of FSU.

4.3 Summary of Oil Tanker Collision Risk

The collision frequencies due to oil tanker visits to the Cenérgica mooring area are summarized in Table 4.2: Collision impact energy vs. frequency is calculated and presented in Table 4.2.

The collision frequencies due to oil tanker operations are summarized in Table 4.3.

Table 4.2: Summary of Collision Frequency for Oil Tanker Collision with FSU

Vessel Type	Operating Conditions	Collision Type	Collision Frequency (per year)
Oil tanker	Approach and mooring	Powered	1.24E-05
		Drifting	8.72E-05
	Unmooring and departure	Drifting	4.36E-05
Total			1.43E-04
Return year			6986 years

The total collision frequency between oil tanker and FSU is estimated to be 1.43E-04 per year (every 6,986 years). However, all these collisions will have an impact energy of less than 22 MJ, which would result in minor structural damage of FSU, as shown in Table 4.3.

Table 4.3: Collision Frequency Distribution per Energy Class for Oil Tanker Collision with FSU

Energy Class	Impact Energy (MJ)	Frequency per Year
I	0–22	1.43E-04
II	22–28	0
III	28–50	0
Total		1.43E-04

5 Merchant Vessels to/from Acajutla Port Collision with FSU

5.1 Vessel Distribution

There were 742 vessel entries (341 unique vessels callings) to the Port of Acajutla registered from 16 August 2014 to 15 August 2015 (Ref. /8/). A summary of the vessel categorization is provided in Table 5.1 and the vessel distribution in the Port of Acajutla is provided in Table 5.2.

Table 5.1: Vessel Category Based on DWT

Vessel Category	DWT (ton)
A	0–1,499
B	1,500–4,999
C	5,000–14,999
D	15,000–39,999
E	>40,000

Table 5.2: Vessel Distribution to the Acajutla Port

Deadweight Tonnage (ton)	A	B	C	D	E	Number of Entries	Percentage
	0–1499	1,500–4,999	5,000–14,999	15,000–39,999	>40,000		
Bulk Carrier	0	0	8	57	77	142	19%
Tanker	0	4	4	40	198	246	33%
Container	0	0	28	225	0	253	34%
Carriers (Vehicles)	0	0	18	44	0	62	8%
General Cargo	0	1	5	8	21	35	5%
Other Vessels	2	1	0	0	1	4	1%
Total	2	6	63	374	297	742	100%
Percentage	0%	1%	8%	50%	40%	100%	

Ninety percent (90%) of the vessels to the port are in class D or class E with a DWT above 15,000 tons, as shown in Figure 5.1.

The types of merchant vessels to the port include bulk carriers, tankers (chemical/products/crude oil tanker), containers, vehicle carriers, general cargo, and other vessels (cruises and hospital ships). The distribution of each type of vessel is presented in Figure 5.2. Tankers (chemical/products/crude oil tanker) and container ships are dominating vessels sailing to the port with a contribution of 33% and 34% respectively. Bulk carrier is the third contributor (19%).

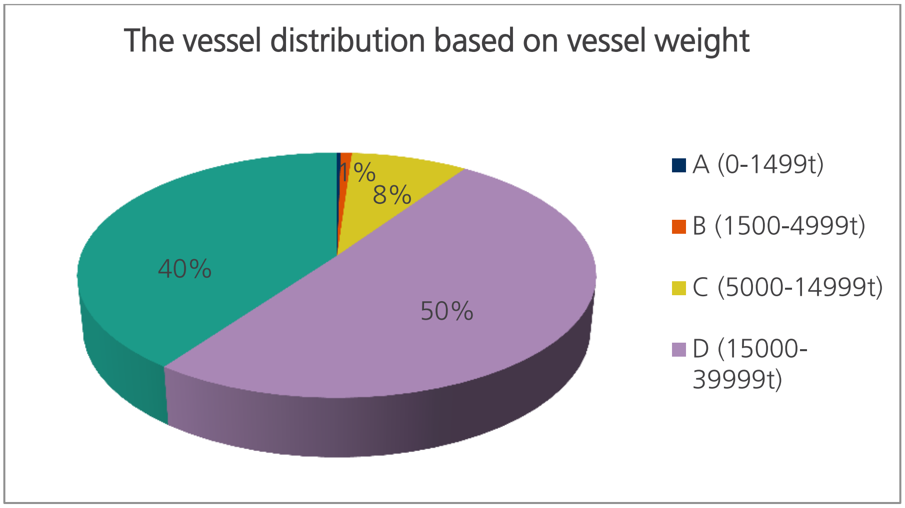


Figure 5.1: Distribution of vessels to Acajutla Port based on the vessel weight.

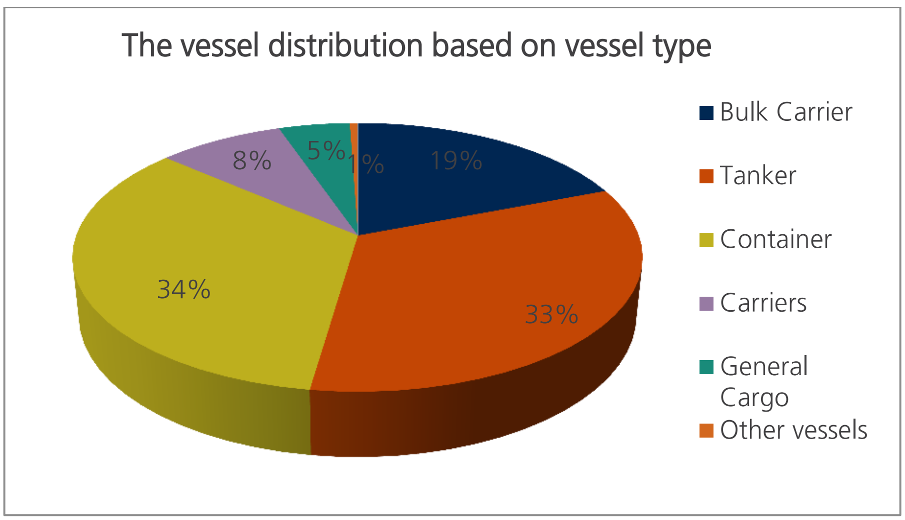


Figure 5.2: Distribution of vessels to Acajutla Port based on the vessel type.

5.2 Collision Frequency

5.2.1 Powered Collision

For the powered collision of passing vessels with a fixed target, the most commonly used collision model is a theoretical model based on the Risk Assessment of Buoyancy Loss (RABL) project (Ref. /9/) and illustrated in Figure 5.3.

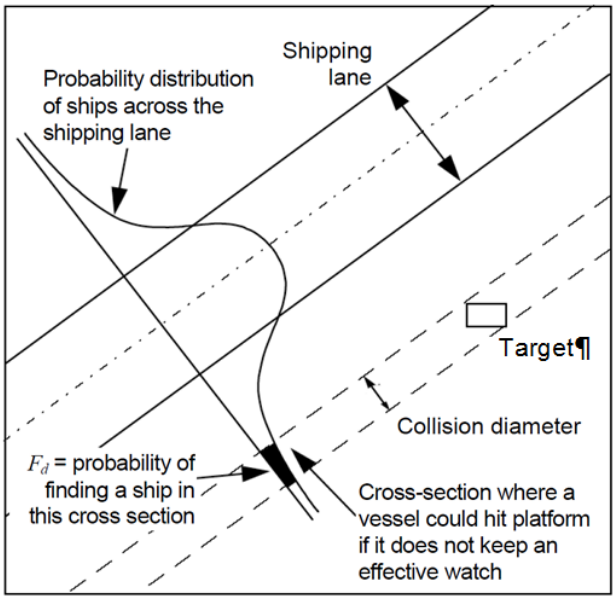


Figure 5.3: Powered collision model.

It is assumed that 95% of merchant vessels will maintain their sailing trajectory in the CEPA defined approach corridor, based on navigational aids, tugboat assistance, and procedures after Sea Island is installed.

The frequency for merchant vessel-powered collisions is as follows:

$$P = \sum N \times F_d \times P_1 \times P_2 \times P_3 \qquad \text{Eq. (2)}$$

Where

N	=	Number of vessels on the route
F_d	=	Fraction of vessels heading for installation: $\frac{(D+B)}{\sqrt{2\pi}\,SD} e^{-\frac{(X/SD)^2}{2}}$
D	=	Installation diameter
B	=	Vessel beam
SD	=	Standard deviation of route width
X	=	Distance from location to route center line
P_1	=	Planning factor. The probability that a vessel fails to plan its route adequately so as to avoid an installation
P_2	=	Watch-keeping failure. The probability that a vessel is not keeping an adequate watch and that this continues for a significant period (about 20 minutes)
P_3	=	Installation-initiated recovery. The probability that installation fails to take some action, e.g., by means of the standby vessel, to recover the watch-keeping failure and prevent a collision.

The values for P_1, P_2, and P_3 were provided in the RABL study. With the development of new technology on modern merchant vessels, such as Automatic Identification System (AIS) and

Automatic Radar Plotting Aid (ARPA), these P factors have been updated based on LR's experience and are shown in Table 5.3: The detailed information can be found in Ref. /3/.

Table 5.3: Merchant Vessel Collision Probability Factors

Vessel Types Merchant	P1	P2 x P3		P1 x P2 x P3	
		G.V.	B.V.	G.V.	B.V.
0–1,499 t	0.15	0.0026	0.013	0.00039	0.00195
1,500–4,999 t	0.15	0.0026	0.013	0.00039	0.00195
5,000–14,999 t	0.15	0.0026	0.013	0.00039	0.00195
15,000–39,999 t	0.1	0.00182	0.0132	0.000182	0.00132
> 40,000 t	0.05	0.00096	0.0108	0.000048	0.00054

G.V. - Good visibility B.V. - Bad visibility

The powered collision frequency is calculated to be 7.90E-04/year. In other words, a powered collision of merchant vessel with FSU could occur once every 1,265 years.

5.2.2 Drifting Collision Model

The model used to calculate drifting collision frequency of passing merchant vessel with FSU is illustrated in Figure 5.4. The frequency of drifting collisions is calculated by dividing the parts of the shipping lanes that come near the FSU into small boxes, considering only those within a distance for which external assistance or self-repair is unlikely. For each box, a vessel can break down and drift in the target (Sea Island).

Vessels outside of the 10 nm radius of the facility are not considered likely to cause a collision since it is assumed that there is sufficient time for the ships to be repaired before they drift into the facility.

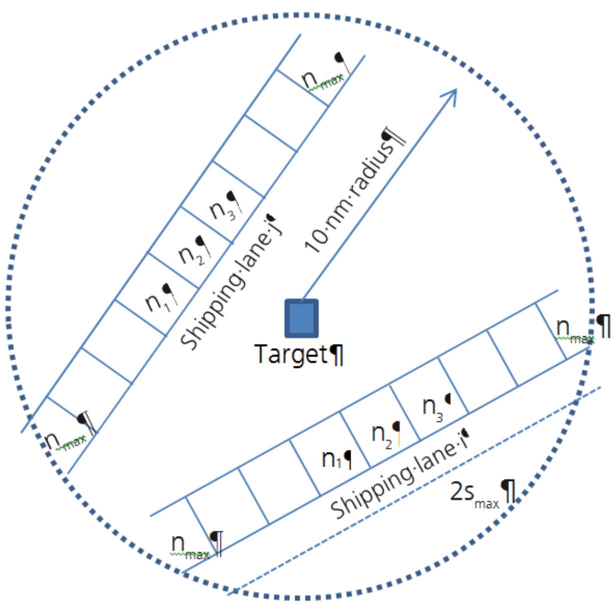


Figure 5.4: Drifting collision model.

The model for passing vessel drifting collisions is as follows:

$$P = \sum_i N_i \times (2 \times \frac{SMAX/_{NMAX}}{\pi V} \times \sum_{n=0}^{NMAX} \tan^{-1} \frac{1}{2} \frac{(D+L)}{\sqrt{X^2 + (SMAX/_{NMAX} \times n)^2}}) \times P_{PLP} \times P_3 \qquad \text{Eq. (3)}$$

where

N_i	=	Number of vessels per year of size "i" on the route
D	=	Installation diameter (m)
L	=	Vessel length (m)
X	=	Distance from location to route center line
V	=	Speed of vessel
$2 \times S_{MAX}$	=	Route length of interest
$2 \times N_{MAX}$	=	Number of steps
P_{PLP}	=	Prolonged loss of propulsion, 2.0E-5 per ship hour
P_3	=	Fraction to account for help from the standby vessel

Collision frequencies are presented for each side of the target (Sea Island), each vessel size, and each wind/drifting speed.

The collision risk for passing vessels is calculated by using LR's in-house tool "CollRisk," which was developed based on the frequency models from the 1987 RABL report, Ref. /9/. The CollRisk has been used in most of LR's collision risk studies for offshore fields. The model and tool have been validated and upgraded. Further details of the models in the CollRisk tool can be found in the user's manual, Ref. /10/.

5.3 Summary of Merchant Vessel Collision Risk

The collision frequencies due to merchant vessel operations are summarized in Table 5.4. Collision impact energy vs. frequency is calculated and presented in Table 5.5.

Table 5.4: Summary of Collision Frequency for Merchant Vessel Collision with FSU

Vessel Type	Collision Type	Collision Frequency (per year)
Merchant vessels	Powered	7.90E-04
	Drifting	4.40E-04
Total		1.23E-03
Return year		813 years

The total collision frequency between merchant vessel and Sea Island is estimated to be 1.23E-03 per year (every 813 years). Most of these collisions will result in minor structural damage of the FSU with low impact energy of less than 28 MJ. In extreme weather condition, such as 45.3 knots of wind speed, the drifting vessel could have a higher speed; this could result in a collision with a large impact energy of 50–100 MJ. Such a collision has the potential to cause a leak from the inner tank of the FSU. It is estimated that the frequency of such occurrence is 1.55E-07 per year. The frequency is considered negligible.

Table 5.5: Collision Frequencies Distribution per Energy Class for Merchant Vessel Collision with Sea Island

Energy Class	Impact Energy (MJ)	Frequency per Year
I	0–22	1.21E-03
II	22–28	1.85E-05
III	28–50	0
IV	50–100	1.55E-07
Total		1.23E-03

6 Loss of Containment of FSU/LNGC Tank

A few scenarios have been identified to potentially cause an LNG release from the FSU due to a high-impact energy. For example, the large merchant vessels traveling to the Acajutla port colliding with Sea Island under extreme weather conditions could result in an LNG leak from FSU (frequency of 1.55E-07/year). This risk is considered negligible.

The loss of containment of LNG due to collision and grounding has been studied (Ref. /7/). This study shows that a 'puncture' type of event would result in a credible hole size of between 250 and 750 mm and models LNG release from both 750 mm and 250 mm hole sizes. The largest tank capacity of 29,887 m^3 is used in the calculation to model LNG release from FSU tank, Ref. /11/.

PHAST (Process Hazards Analysis Software Tool) version 7.1 was used to perform the consequence of LNG spill (dispersion and fire) and to graphically display the results. The consequence assessment involves an estimate of the hazard distance (downwind distance) and of the effect zone (for all wind directions) if a hazardous scenario occurs.

6.1 Gas Dispersion

Flash fires occur when a dispersing vapor cloud is ignited. Vapor-air mixture will ignite and burn only over a well-specified range of compositions, Ref. /12/. The mixture will not burn when the composition is lower than the lower flammable limit (LFL) because the mixture is too lean for combustion. The mixture is also not combustible above the upper flammable limit (UFL) because the mixture is too rich. A mixture is flammable only when the composition is between the LFL and UFL. In a flash-fire scenario, the flame front moves through the cloud, consuming at least the proportions of the cloud within the flammability limits. The dispersion of the vapor is dependent on atmospheric conditions. It is used as basis for determination of flash-fire hazard distances. A flash fire is relatively short in duration and since the flame spreads at subsonic velocity, the overpressure damage to equipment and structures is usually negligible. Damage of equipment and structures is often caused by heat radiation from secondary fires. However, inhalation of the hot air within a flash fire can cause fatal damage to tissue and lungs.

The gas dispersion of LNG is modelled by PHAST for a 750 mm hole and a 250 mm hole at both 2F and 5D weather conditions. The hazard distance results of flash fires (gas dispersion) are presented in Table 6.1 and shown in Figure 6.1 and Figure 6.2.

Table 6.1: Hazard Distances to UFL, LFL, and 1/2 LFL

Scenario Name	Hole Size (mm)	Weather Condition	UFL Distances (m)	LFL Distances (m)	½ LFL Distances (m)
LNG release from a hole on FSU tank leak due to collision	750	5D	74.6	292	622
		2F	60.5	1517	3515
	250	5D	39.4	135	251
		2F	28.5	193.6	740

Figure 6.1: Effect zone of LNG gas dispersion from 750 mm hole at 5D weather condition.

Figure 6.3 shows that the LFL hazard zone covers part of the approach corridor defined by CEPA and almost touches the port clearance zone.

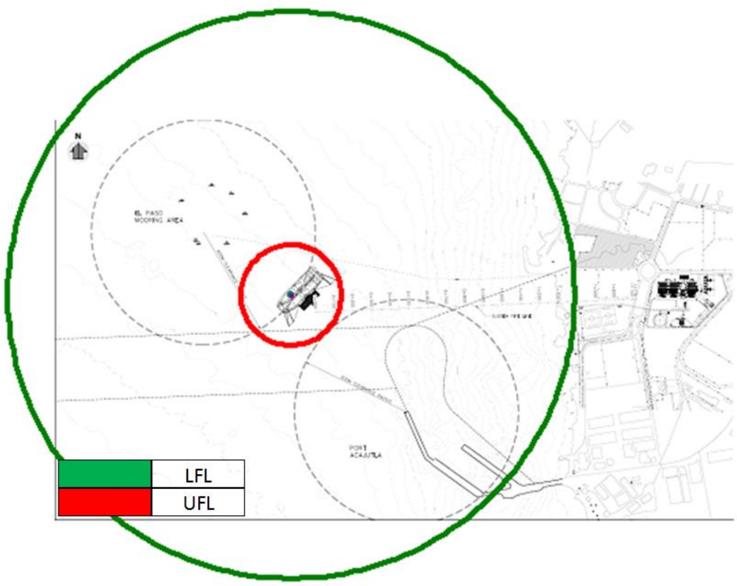


Figure 6.2: Effect zone of LNG gas dispersion from 750 mm hole at 2F weather condition (30% of the time).

As discussed in Section 2.2, the dominating weather condition is 5D (70% of time). The weather condition of 2F usually occurs at night.

Thus, it is recommended that the simultaneous operation of LNG transfer and merchant vessel entry to the Port of Acajutla is avoided, especially at night.

6.2 Pool Fire

A pool fire event is assumed to occur after all the hydrocarbon contents of one or all tanks have been released, leaving a liquid pool on the ground/sea, and are ignited. The pool fire consequences are examined by the maximum distances to certain heat radiation levels, as defined in NFPA 59A (Ref.

/13/) and OGP, (Ref. /14/), and as shown in Table 6.2. The results are shown in Table 6.3 for 5D and 2F weather conditions. Figure 6.3 shows the heat radiation contours for the pool fire, resulting in LNG release from a 750 mm hole at a 5D weather condition.

Table 6.2: Criteria for Property Damage Due to Radiant Heat from Fires

Heat Radiation (kW/m^2)	Effects
32	Loss of strength of structural steel exposed to the fire to an extent that is primary load-bearing capacity is reduced significantly over the duration of LNG fire being analyzed.
12.5	Significant chance of fatality for medium duration exposure. Thin steel with insulation on the side away from the fire may reach thermal stress level high enough to cause structural failure. Wood ignites after prolonged exposure.
5.0	At least 10 persons or one person inside the building would suffer 2nd degree skin burns on at least 10% of their bodies within 30 seconds of exposure to the fire.

Table 6.3: Hazard Distances to Heat Radiation of 32, 12.5, and 5 kW/m^2 for Pool Fire

Scenario Name	Hole Size (mm)	Weather Condition	Hazard Distance (m)		
			32 kW/m2	12.5 kW/m2	5 kW/m2
LNG release from hole on FSU tank leak due to collision	750	5D	114	191	278
		2F	87	165	263
	250	5D	43	76	109
		2F	34	66	104

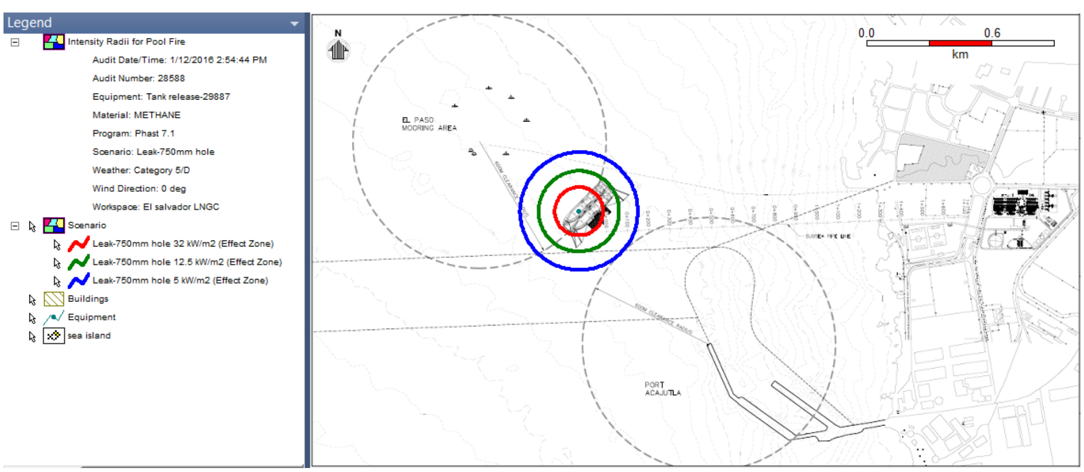


Figure 6.3: Effect zone of LNG pool fire from 750 mm hole at 5D weather condition (70% of the time).

7 Risk Summary

This study has assessed the ship collision risks to the FSU at the new LNG terminal, including the LNGC, oil tanker to Cenérgica mooring area, and merchant vessels to Acajutla port. The powered and drifting collision scenarios for each type of vessel have been analyzed. The collision frequencies and the consequence (impact energy) are calculated for each scenario. The collision frequencies are summarized in Table 7.1, Figure 7.1,and Table 7.2. The total collision frequency for the FSU is estimated to be 1.50 E-03 per year (every 665 years).

The merchant vessels are the major contributors to the total collision frequency (82%, 1.23 E-03/year). This is explained by the fact that there are more merchant vessels in the area than the other two types of vessels. Most of these collisions will only cause local or minor damage to the FSU and are not likely to cause an LNG release from the FSU. In extreme weather conditions (such as 45.3 knots of wind speed), the high speed of the drifting vessel could result in a collision with a large impact energy of 50–100 MJ. This collision has the potential to cause a leak from the FSU. The frequency of this scenario is estimated to be 1.55E-07/year, which is considered a negligible risk.

The oil tankers contribute to 9.5% of the total collision frequencies, with a collision frequency of 1.43E-04 occurrence per year. These collisions will only cause local or minor damage to the FSU and are not likely to cause LNG leak from the FSU due to the light weight and low speed of the oil tanker.

The LNGCs contribute to 8.7% to the total collision frequencies, with a collision frequency of 1.31E-04 per year. Most of these collisions will result in minor structural damage of the FSU with low impact energy of less than 28 MJ. When the approaching speed of the LNGC is higher than 1.3 knots, the powered collision has the potential to cause LNG release from the FSU. Given the FSU is almost empty upon LNGC arrival, the collision of the LNGC in the FSU is unlikely to cause a spill from the FSU.

Table 7.1: Total Collision Frequencies per Collision Model

Vessel Type	Collision Frequency (per year)		
	Powered	Drifting	Total
LNGC	7.28E-05	5.80E-05	1.31E-04
Oil tanker to Cenérgica mooring area	1.24E-05	1.31E-04	1.43E-04
Merchant vessels to Acajutla port	7.90E-04	4.40E-04	1.23E-03
Total	8.76E-04	6.28E-04	**1.50E-03**
Return year			665 year

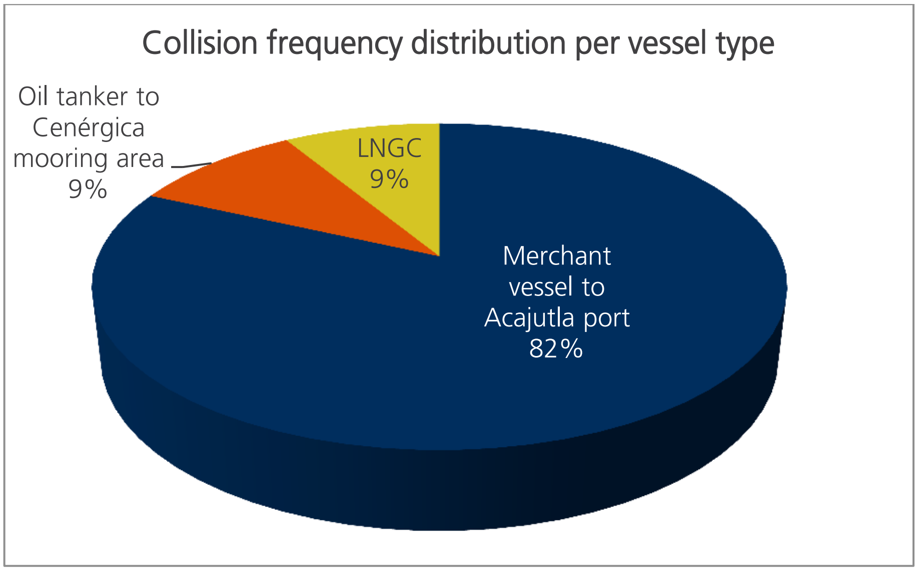


Figure 7.1: Collision frequency distribution per vessel type.

Table 7.2: Collision Frequencies Distribution per Energy Class and Vessel Type

Energy Class	Impact Energy (MJ)	Collision Frequency (per year)			
		LNGC	Oil Tanker	Merchant Vessel	Total
I	0–22	1.24E-04	1.43E-04	1.21E-03	1.48E-03
II	22–28	3.64E-06		1.85E-05	2.21E-05
III	28–50	3.64E-06		0.00E+00	3.64E-06
IV	50–100			1.55E-07	1.55E-07
V	100–200				
VI	>200				
Total		1.31E-04	1.43E-04	1.23E-03	1.50E-03

8 Reference

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Appendix 9C–

Quantitative Risk Analysis

Lloyd's Register Energy

Working together
for a safer world

EDP LNG Power to Shore Project, Acajutla, El Salvador

Quantitative Risk Analysis

Report for
Invenergy Clean Power

Reference: US4280.1

Release: 4

Report by: Danielle Chrun / Rhey Lee

Summary

EDP LNG Power to Shore Project, Acajutla, El Salvador		
Quantitative Risk Analysis		
Date of Issue	18 November 2016	
Administrative Review	Margaret Bush	
Report by	**Reviewed by**	**Approved by**
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Document History			
Release	**Date**	**Description**	**Contributors**
1	01 June 2016	Initial release	**Report by:** Danielle Chrun / Rhey Lee **Reviewed by:** Therese L. Baas **Approved by:** Kyle Wingate
2	30 June 2016	Second release—Comments from Invenergy, Exmar, M&N, and MARN are implemented.	**Report by:** Danielle Chrun / Rhey Lee **Reviewed by:** Therese L. Baas **Approved by:** Kyle Wingate
3	28 September 2016	Third release—Pipeline size changed from 20″ to 24″ and inclusion of future development	**Report by:** Danielle Chrun / Rhey Lee **Reviewed by:** Susan Guo **Approved by:** Kyle Wingate
4	18 November 2016	Fourth release—Comments from Invenergy, Exmar, and M&N are implemented.	**Report by:** Danielle Chrun / Rhey Lee **Reviewed by:** Therese L. Baas **Approved by:** Robert Hall

Table of Contents

Abbreviations

ALARP	as low as reasonably practicable
BOG	boil-off gas
CAMS	Central American Marine Services
CEPA	Comisión Ejecutiva Portuaria Autónoma
EDP	Energía del Pacífico
EIA	environmental impact assessment
ESD	emergency shutdown
FEED	front-end engineering design
FERC	Federal Energy Regulatory Commission
FRSU	floating regasification storage unit
FSU	floating storage unit
HAZID	hazard identification
IR	individual risk
LFL	low flammable limit
LR	Lloyd's Register
LNG	liquefied natural gas
LNGC	liquefied natural gas carrier
LSIR	location-specific individual risk
MARN	Ministerio de Medio Ambiente y Recursos Naturales (Ministry of Environment and Natural Resources)
MMSCFD	million standard cubic feet per day
NG	natural gas
NFPA	National Fire Protection Association
OGP	Oil and Gas Producers
P&ID	piping and instrumentation
QRA	quantitative risk analysis
RPT	rapid phase transition
STS	ship-to-ship
UFL	upper flammability limit

1 Executive Summary

Scope of Work

Lloyd's Register (LR) has been engaged by Invenergy Clean Power (Invenergy) to carry out a quantitative risk assessment (QRA) for the Energía del Pacífico (EDP) liquefied natural gas (LNG) import terminal in Acajutla, El Salvador, for the front-end engineering design (FEED) phase. The EDP LNG import terminal will receive LNG from an LNG carrier (LNGC). The LNGC will offload LNG to a floating storage unit (FSU). The LNG will be transferred to a floating storage regasification unit (FSRU) and re-gasified. A production rate of 140 million standard cubic feet per day (MMSCFD) of natural gas (NG) (base case) will be sent by pipeline to a power plant and power to end consumers in El Salvador. The scope of the QRA includes the LNG import terminal up to the onshore pipeline isolation valve (also called in this report onshore emergency shutdown [ESD] valve). Marine transportation risk is not included in the scope of work.

In addition, EDP plans to develop the LNG import terminal in the future to include an additional third train to meet a production rate of 280 MMSCFD of natural gas. The QRA for this future development is also analyzed.

Objectives

The current regulatory regime in El Salvador is focused on preventing the occurrence of accidents and/or malfunctions from new industrial developments and their respective activities. The main objective of the QRA performed in FEED is two-fold: 1) examine the potential risks to the environment and the public as a result of major and worst-case, credible events from the LNG import terminal and associated infrastructure; and 2) support the Environmental Impact Assessment (EIA) and subsequent application process to fulfill the requirements applicable to the project as part of the requirements from Ministerio de Medio Ambiente y Recursos Naturales (Ministry of Environment and Natural Resources).

Methodology

The risk posed by the project is evaluated in the FEED based on an identification of 13 major and worst-case, credible scenarios as identified in the HAZID sessions that were conducted prior to the QRA. For each scenario, the following is analyzed:

- Scenario description
- Frequency analysis
- Consequence assessment
- Risk assessment as a combination of frequency and consequence
- Risk evaluation against the risk criteria and recommendations to reduce risk

The risk acceptance criteria used in the QRA are shown in Table 1.1.

Table 1.1: QRA Risk Acceptance Criteria [1]

Risk Region	Description	Average Public Individual Risk (IR) Criteria (per annum)
Intolerable risk	Authority requirements, corporate requirements, international standards, and recommended practices together define an upper level of risk above which risk is considered to be unacceptable. Intolerable risk cannot be justified except in extraordinary circumstances.	≥ 1E-04
Tolerable risk, provided risk is ALARP	Recognized, industry-wide accepted approaches demonstrate that an appropriate level of scrutiny and mitigation has been applied to risks from identified hazards, and that the residual risk to the public and the environment is as low as reasonably practicable (ALARP).	1E-06 < IR < 1E-04
Broadly acceptable risk	These risks are generally regarded as insignificant and adequately controlled.	≤ 1E-06

The location-specific individual iso-risk (LSIR) curves are often used early in the project planning phases and are deemed conservative to estimate the risk to the public. The LSIR measures the risk to the nearby areas (industrial or public areas) and is used in this QRA to measure the risk from the project to the public and indirectly to the environment. The LSIR is calculated for two locations: LNG import terminal and onshore location.

Results

The individual risk (IR) results per process release location are provided in Table 1.2.

Table 1.2: IR Results

Process Release Location	IR per Year	Risk Region
LNG import terminal	8.89E-07	Broadly acceptable
Onshore	3.49E-05	ALARP

On the one hand, the results show that the risk at the LNG import terminal is within the broadly acceptable range according to the risk criteria (≤ 1E-06 per year). The major contributor to the risk is the FSU to FSRU loading arm release. Given the high flow rate and pressure, the event will lead to a large release of LNG, leading to gas dispersion, jet fire, and pool fire events. On the other hand, the risk at the onshore location falls in the ALARP risk region (between 1E-04 per year and 1E-06 per year). The major contributor is the release from the onshore inlet ESD valve due to the large inventory of natural gas pipeline from the riser platform and its high flow rate.

LSIR iso-risk contours for both locations are shown in Figure 1.1.

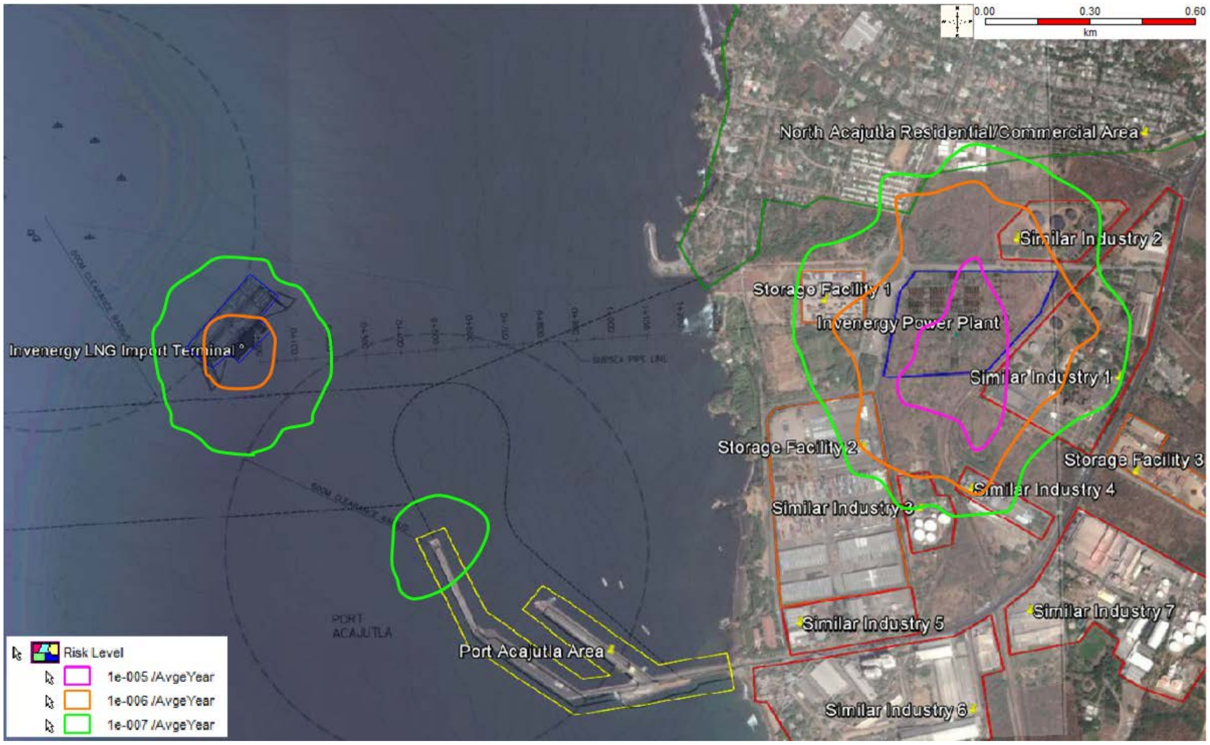

Figure 1.1: LSIR iso-risk contours for LNG import terminal and onshore location.

- **LNG Import Terminal**

The LSIR iso-risk contours for the LNG import terminal and respective contours fall into the broadly acceptable risk region. As a result, any public areas within the vicinity of the LNG import terminal are deemed acceptable based on the risk acceptance criteria.

The orange risk curve (1E-06 per year) is localized around the import terminal and does not reach the current shipping lane. The green risk curve (1E-07 per year) reaches the shipping lane but corresponds to a risk that is broadly acceptable (≤ 1E-06 per year) and, as such, no further mitigating measures are required if based on risk only to the public and the environment. Figure 1.1 also shows a green risk curve at the port of Acajutla due to possible ignition sources at the port that may ignite a gas cloud if exposed. Even though it is an unlikely event, the gas cloud may extend to the port. The LSIR iso-risk curve is, however, of a magnitude of 1E-07 per year, which is within the broadly accepted risk region.

- **Onshore Location**

All LSIR iso-risk contours fall within the ALARP risk region (1E-06 per year < IR < 1E-04 per year) or in the broadly acceptable risk region (IR ≤ 1E-06 per year). The pink risk curve (1E-05 per year) could reach adjacent industrial areas. As the risk is within the ALARP region, mitigating measures as suggested in this report should be further looked into. The other two curves (orange: 1E-06 per year, and green: 1E-07 per year) represent iso-risk contours that fall within the broadly acceptable risk region and no further measures are required.

Although the risk for the onshore location meets the risk criteria, it is within the ALARP region, and sensitivity analyses are conducted to look into possible mitigation measures for the risk within the ALARP region. The sensitivity analyses include three scenarios:

1) Reduction of onshore pipeline isolation/ESD valve closure time from 60 seconds to 30 seconds;
2) Reduction of pipeline inventory by adding another onshore pipeline isolation valve in the vicinity of the shoreline;
3) Reduction of both the onshore pipeline isolation/ESD valve closure time to 30 seconds and pipeline inventory with additional onshore pipeline isolation valve.

The results of the sensitivity cases analyses show that each of the three sensitivity cases lead to a risk reduction of 5%, 78%, and 86%, respectively.

Future Development Results

The future development individual risk (IR) of the 280 MMSCFD production rate results per process release location are provided in Table 1.3. The future LSIR iso-risk contours for both locations are shown in Figure 1.2.

Table 1.3: LSIR Results

Process Release Location	IR per Year	Risk Region
LNG import terminal	8.95E-07	Broadly acceptable
Onshore	3.89E-05	ALARP

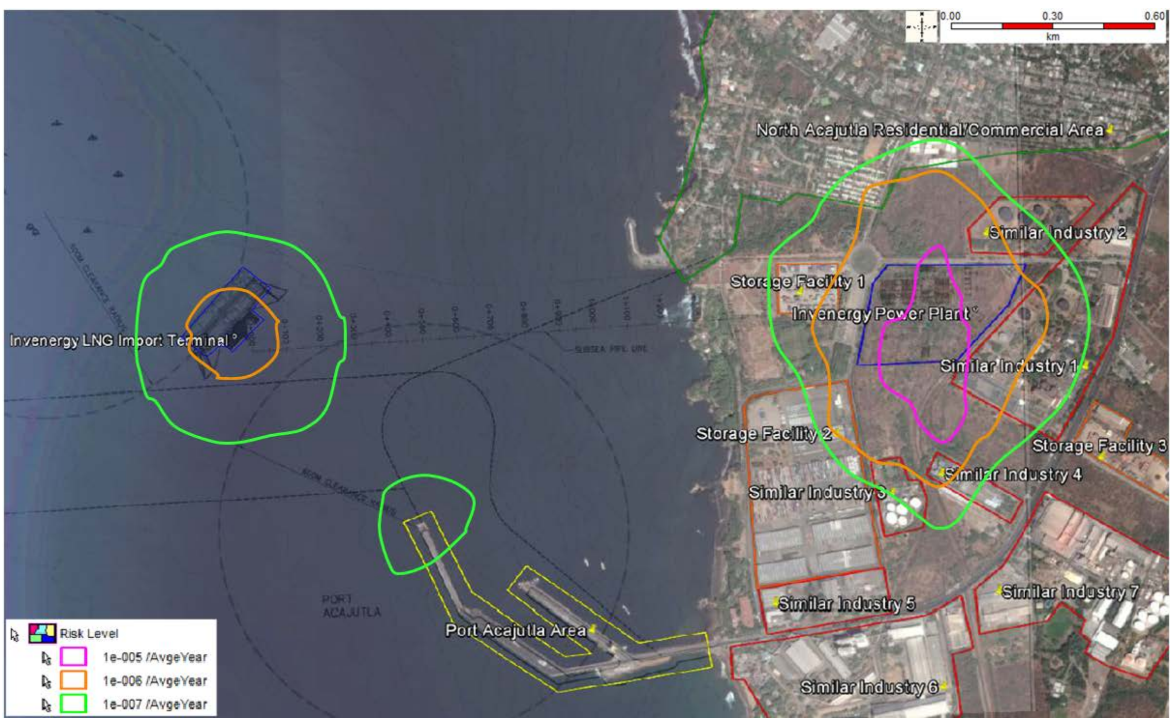

Figure 1.2: LSIR iso-risk contours for LNG import terminal and onshore location for future development case.

The results show that the risk at the LNG import terminal is within the broadly acceptable range according to the risk criteria (≤ 1E-06 per year). The risk at the onshore location falls in the ALARP risk region (between 1E-04 per year and 1E-06 per year). The major contributor is the release from the onshore inlet ESD valve due to the large inventory of natural gas pipeline from the riser platform and its high flow rate. These results are similar to the base case with production rate of 140 MMSCFD, but have an increase in the public individual risk by 11.3% for the onshore releases and 0.6% for the LNG import terminal releases. This increase in risk is expected with higher natural gas flowrate and additional third train.

Discussion and Recommendations

In summary, the QRA did not identify LSIR in the intolerable risk region according to the risk acceptance criteria. The public and environment are not exposed to any unacceptable risks from the EDP project.

Recommendations resulting from the QRA are the following:

- The LSIR iso-risk contours, however, can be used to determine more stringent exclusion zones. For example, the pink risk curve at the onshore location extends approximately 190 meters south of the power plant and can be used to define a zone where the public should be restricted from entering. The orange risk curve at the LNG import terminal extends approximately 90 meters from the edge of the terminal and can be used to define a marine exclusion zone where no unauthorized traffic should be allowed to enter. The LSIR is one input to define the extent of safety zones. However, other inputs not included in the LSIR, such as security risk, may require a larger marine exclusion zone.
- The QRA shows that the risk from the LNG import terminal exposing the shipping lane is broadly acceptable as the green and orange curves reaching the shipping lane fall within the broadly acceptable risk region. In general, the shipping lane is acceptable as is; however, the project may consider moving the shipping lane outside of the 1E-07 per year regions for other reasons not being reflected in the LSIR, such as security risk, required turning radius for ships, or traffic control. Another option is to advise ships to sail in and out of the port of Acajutla further south, below the currently marked shipping lane.
- It is recommended to investigate mitigation measures for the potential release of natural gas from the onshore inlet ESD valve, similar to what has been investigated in the sensitivity cases in the QRA.
- It is recommended to analyze the design of process equipment shelters and buildings within the LNG import terminal and power plant limit to minimize confined spaces to reduce explosion events. No explosion scenarios were analyzed at the FEED stage. Explosion events will be further analyzed in detailed engineering.
- Accidents at the LNG import terminal and power plant area can affect the closest neighboring industry. Active fire protection such as gas detectors will be installed around the facility, and an emergency response plan will provide a process for notifying people in the neighboring facilities and on the LNG import terminal during an emergency event from a release of LNG or NG. It is recommended to add gas detectors at the port of Acajutla, if not already installed, and to coordinate an alarm system and emergency response plan that includes the port in case of incident at the LNG import terminal.

2 Introduction

2.1 Background

LR has been engaged by Invenergy to carry out a QRA for the EDP LNG import terminal in Acajutla, El Salvador, for the FEED phase. The EDP LNG import terminal will receive LNG from an LNGC. The LNGC will offload LNG to an FSU. The LNG will be transferred to an FSRU and re-gasified. The NG will be sent by pipeline to an onshore power plant, creating power to end consumers in El Salvador. The project was announced in November 2013 and is expected to begin in the first quarter of 2020.

The current regulatory regime in El Salvador is focused on preventing the occurrence of hazards and accidents by supporting the application of good international practices for new industrial developments and their respective activities.

2.2 Objective

The main objective of the FEED QRA is to examine the potential risks to the environment and the public as a result of major and worst-case, credible events from the LNG import terminal and associated infrastructure.

The QRA is also to act as supporting information for the Environmental Impact Assessment and subsequent application process to fulfill the requirements applicable to the project as part of the MARN [2] requirements.

2.3 Scope

The scope of the QRA includes the LNG import terminal and associated project infrastructure up until the onshore power plant with natural gas production rate of 140 MMSCFD (base case). In addition, the future development of the LNG import terminal to meet a production rate of 280 MMSCFD of natural gas is analyzed. Marine transportation risk is not included in the scope of work.

2.4 Conditions and Limitations

It should be recognized that this is an early FEED QRA addressing the global safety issues and that it focuses on the major and worst-case, credible scenarios to identify the maximum effect of the hazards in terms of hazard distances that may affect population and/or the environment.

The QRA performed in the FEED phase is based on preliminary information provided by the engineering partners, and conservative assumptions are taken to compensate for the lack of engineering details reached at this stage. The QRA is aiming at providing feasibility data and mitigation measures at an early stage. Engineering parameters are to be further updated at a later stage, along the development of the project.

2.5 Assumptions

QRA assumptions are provided in Appendix A and have been validated by EDP and partners.

3 System Description – Base Case

The EDP LNG import terminal will be located in the area of the port of Acajutla, El Salvador (see Figure 3.1). It will supply NG to an adjacent 380 MW power plant and to other energy consumers in El Salvador.

Figure 3.1: Site location.

The following operations will be performed (see Figure 3.2):

- An LNGC will offload LNG to an FSU approximately 16 times per year.
- The FSU will transfer LNG to a floating storage regasification unit (FSRU) where LNG will be processed into high-pressure (HP) NG.
- The NG will be transferred from the FSRU to the onshore plant via riser and pipeline at 10 barg.

Figure 3.2: LNG import terminal facility.

The LNG import terminal facility is shown in Figure 3.3 with LNGC (ship-to-ship [STS] transfer), FSU, floating FSRU barge, and subsea pipeline to shore. The main characteristics are provided in Table 3.1. The process flow diagram is shown in Figure 3.4.

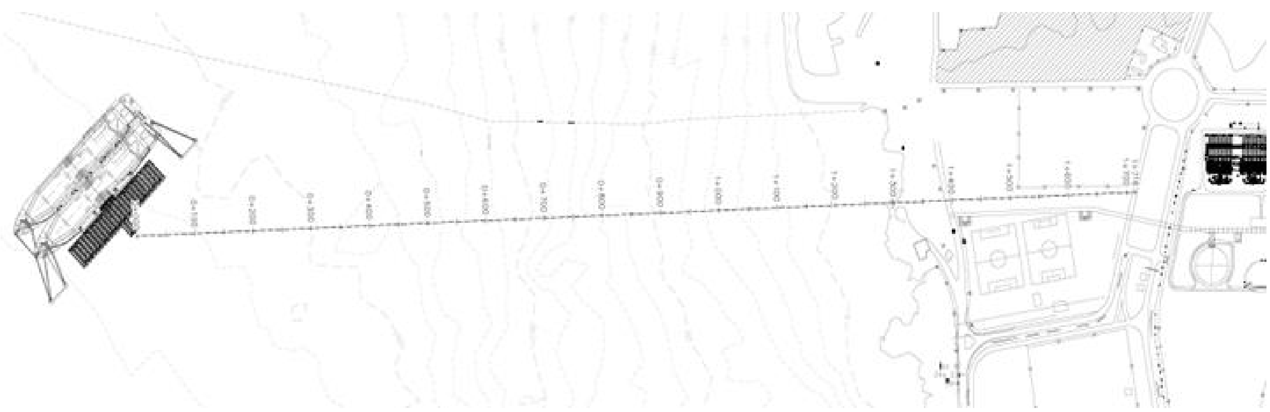

Figure 3.3: LNG import terminal.

Table 3.1: Assets/Infrastructure Characteristics

Assets/Infrastructure	Characteristics
LNGC	165,000 m^3
FSU	125,000–140,000 m^3 (140,000 m^3 is conservatively used in the QRA)
FSRU	Yearly production: 140 MMSCFD LNG buffer storage capacity: 50,000 m^3
Riser and pipeline	24 inches, subsea pipeline Onshore pipeline to shore 10 barg

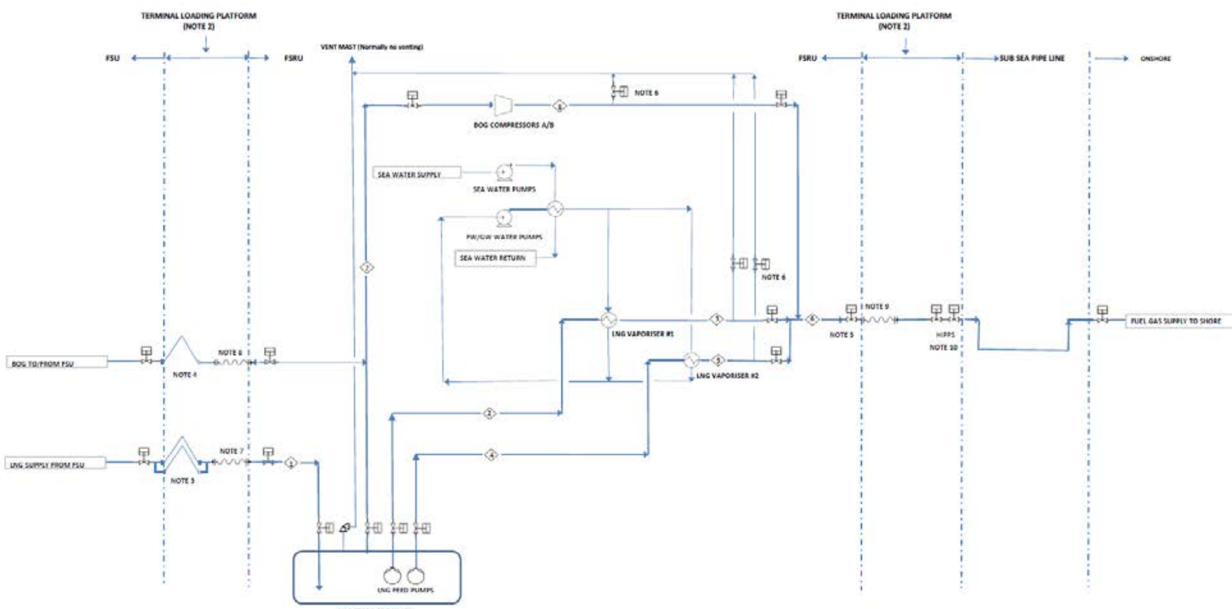

Figure 3.4: LNG Import Terminal Process Flow Diagram.

3.1 LNGC

The LNG transfer between LNGC and FSU will be performed via STS transfer and will rely on six hoses for LNG and two hoses for vapor. The total transfer rate will be approximately 6,000 m^3/hr. A total of 16 LNGC offloading operations have been conservatively estimated per year and approved by EDP and partners.

3.2 FSU

The FSU will most likely be a converted Moss-type LNG tanker and will have four or five storage tanks. To be conservative, four storage tanks have been used in the QRA with a larger inventory for each tank. Conventional mooring will be used for the FSU. The FSU will stay moored at the LNG import terminal unless environmental conditions exceed safe mooring loads. The LNG transfer between FSU and FSRU will be performed using loading arms with hoses. The total transfer rate will be 3,000 m^3/hr. A total of 104 FSU offloading operations have been conservatively estimated per year and approved by EDP and partners.

3.3 FSRU

The FSRU barge will have LNG buffer storage and perform the regasification of LNG into NG. The FSRU will be floating and safely moored within a cofferdam structure. The structure will protect the FSRU at all times and can withstand all identified environmental loads (inherently safe design). The structure will be closed except for submerged culverts on the aft tailgate to allow sufficient water replenishment for regassification (see Figure 3.5); hence, no potential for explosions is considered. The structure will also limit any potential cryogenic spills on water, since they will most likely be contained within the structure. There will be two hose connections from the FSRU to the riser platform. The FSRU process comprises two LNG vaporizers and two boil-off-gas (BOG) compressors. The NG send-out rate to the onshore power plant is estimated to be 140 MMSCFD.

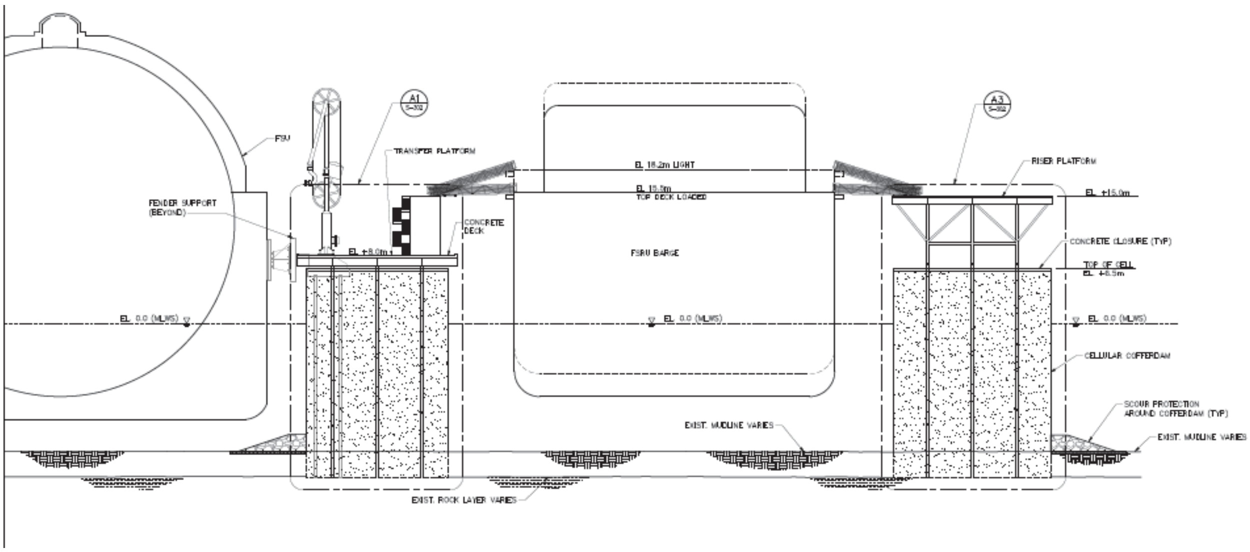

Figure 3.5: Section view of the LNG import terminal.

3.4 Riser Platform and Subsea Pipeline

NG will be continuously sent out from the riser platform to the onshore power plant via a riser and a 24″ pipeline. The pipeline will run subsea from the LNG import terminal to onshore, as shown in Figure 3.6. A length of 1,817 meters is used for the pipeline and includes

- 17 meters of vertical pipeline leaving the riser platform;
- 1,300 meters from the riser platform to onshore;
- 160 meters of pipeline onshore, buried; and
- 340 meters of pipeline onshore, above ground.

The pipeline onshore will then be buried until the onshore inlet valve at the power plant. Given the pipe is buried, its leak frequency is negligible and the onshore buried pipeline is not considered in the consequence modeling for leaks and ruptures.

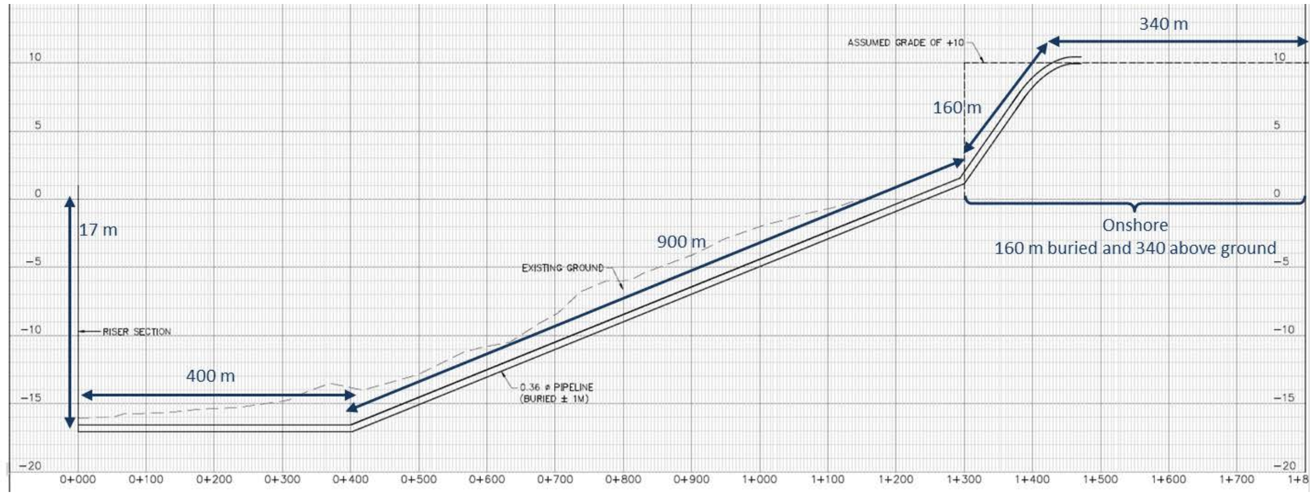

Figure 3.6: Pipeline profile.

The onshore inlet valve is located at the power plant. The assumed location for the onshore inlet valve is shown in Figure 3.7.

Figure 3.7: Location of onshore inlet valve.

4 Methodology

The QRA performed in FEED follows good industry practice for risk analysis and the QRA methodology is illustrated in Figure 4.1.

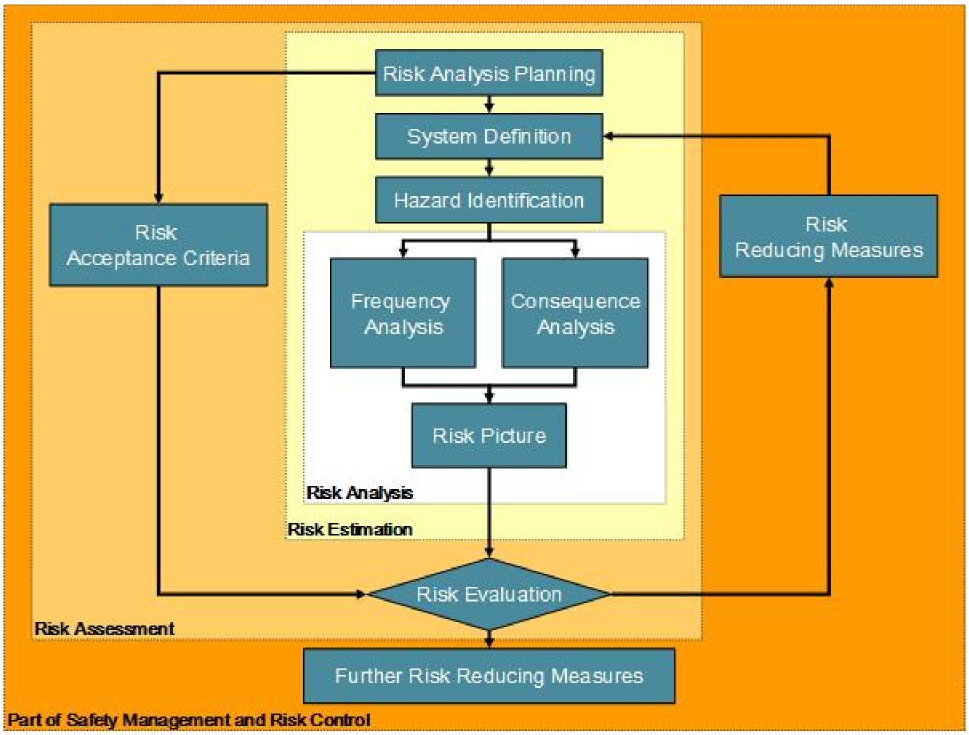

Figure 4.1: Risk analysis methodology.

This QRA was performed based on preliminary information provided by the engineering partners, and conservative assumptions were taken to compensate the lack of engineering details reached at this stage. Assumptions for the QRA are provided in Appendix A. The FEED QRA is based on the major and worst-case, credible scenarios as identified in the HAZID sessions [13], [14].

For each scenario the following is described:

- Scenario description,
- Frequency analysis,
- Consequence assessment,
- Risk assessment to the public/other industry area if applicable,
- Risk evaluation and risk recommendations to reduce risk if applicable.

The QRA performed in FEED is based on the following recognized regulations and standards as guidelines:

- NFPA 59A, Standard for the Production, Storage, and Handling of LNG by the National Fire Protection Association [3]
- The US Energy Regulatory Commission (FERC), US risk based proposed guideline [1]

- EN 1473: Installation and Equipment for Liquefied Natural Gas – Design of Onshore Installations [4]
- UK HSE, UK risk based regulatory framework for HSE in Oil and Gas industry [5]
- NORSOK Z-013, Norway risk based regulatory framework for HSE in Oil and Gas industry [6]
- OGP, Risk Assessment Data, Report No. 434 [7]

4.1 Risk Acceptance Criteria

The risk acceptance criteria for individual risk (IR) used in the QRA is shown in Table 4.1 and graphically represented in Figure 4.2. The risk is split into three categories:

- **Intolerable risk:** Authority requirements, corporate requirements, international standards, and recommended practices together define an upper level of risk above which the risk is considered to be unacceptable. Intolerable risk cannot be justified except in extraordinary circumstances.
- **Tolerable risk:** Recognized, industry-wide accepted approaches demonstrate that an appropriate level of scrutiny and mitigation has been applied to risks from identified hazards, and that the residual risk to the public and the environment is as low as reasonably practicable (ALARP).
- **Broadly acceptable risk:** These risks are generally regarded as insignificant and adequately controlled.

Table 4.1: Risk Acceptance Criteria

Description	Average Public IR Criteria (per annum)
Intolerable risk	≥ 1E-04
Tolerable risk, provided risk is ALARP	1E-06 < IR < 1E-04
Broadly acceptable risk	≤ 1E-06

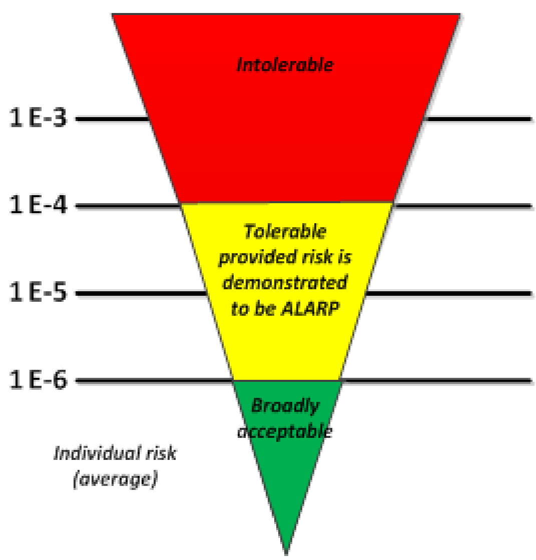

Figure 4.2: Risk regions.

The LSIR curves are often used early in the project planning phases and are deemed conservative to estimate the risk to the public. The LSIR measures the risk to the nearby areas (industrial or public areas). In this QRA, the LSIR is a conservative approach and measures the risk from the project to the public and indirectly to the environment.

For LSIR, a continuous exposure of the receptor is assumed, which means that an individual at a specific location is always present (24 hours per day, 7 days per week, and 52 weeks per year). This value does not include an 'actual' presence factor to account for the 'actual' amount of time a person would be reasonably expected to be in a given area and as such is considered conservative.

The LSIR is presented with iso-risk contour plots on an actual map of the location. The iso-risk contour is independent of the time a person is actually exposed and thus is a conservative measure to help guide the project risk levels and the facility safety zone in the planning phase. The facility safety zone should be within the tolerable iso-risk contour (IR ≤ 1E-4 per year). The LSIR iso-risk contours for the FEED QRA are provided in Section 8.

4.2 System Definition

The system to be analyzed should be defined, including geographical, operational, and logical limits as well as the relevant time periods. Topography and surface type relevant to the local conditions in Acajutla area are provided in Assumption Sheet 3 in Appendix A. In addition, weather data from the Metocean report prepared by Moffatt & Nichol [8] were used as input to the QRA to best model the local conditions in El Salvador (Assumption Sheet 2 in Appendix A). The scope for the QRA includes the LNG import terminal and associated project infrastructure up until the inlet valve at the power plant and is based on the project documentation available at the time of the analysis.

4.3 Hazard Identification

The major hazards, which are associated with the activities, were identified and analyzed in the HAZID workshop in October 2015 at Invenergy's offices in Chicago [8] and in a separate marine HAZID session in January 2016 in El Salvador [9]. Key stakeholders were present.

4.4 Frequency Analysis

The frequency analysis was performed to select and define the scenarios that represent the risk posed by the LNG import terminal and associated infrastructure. Event tree methodology was used to establish the end event frequencies for each scenario. The frequency analysis is described in Section 6.

LR's experience from similar projects and generic data were used and aligned with available project-specific data such as transfer time for LNGC and FSRU offloading, major equipment, and size of piping to determine leak frequencies. Probabilities for immediate and delayed ignition were calculated and entered into the event trees for each scenario to determine the end event frequencies.

The estimation of the risk to the public and environment assessed in the QRA was based on the major and worst-case, credible scenarios and two leak sizes (rupture cases and release from a hole with effective diameter of 10% of the nominal piping diameter). Hole sizes of 750 mm and 250 mm were modeled for the ship collision scenarios between LNGC and FSU based on the floating storage study by Pitblado [9]. Traffic data registered for the port of Acajutla from 16 August 2014 to 15 August 2015 [10] was used to determine the ship collision frequency.

Leak frequencies are based on available data, generic data, and LR's best practice. The recognized software tool Phast Risk/Safeti version 6.7 was used to determine the frequency of each end event for each scenario with use of event trees. Figure 4.3 shows an event tree example. Note that for this project, due to the open, flat surface as well as anticipated low FSRU congestion levels where gas cannot accumulate, explosion scenarios were deemed not relevant in the FEED design.

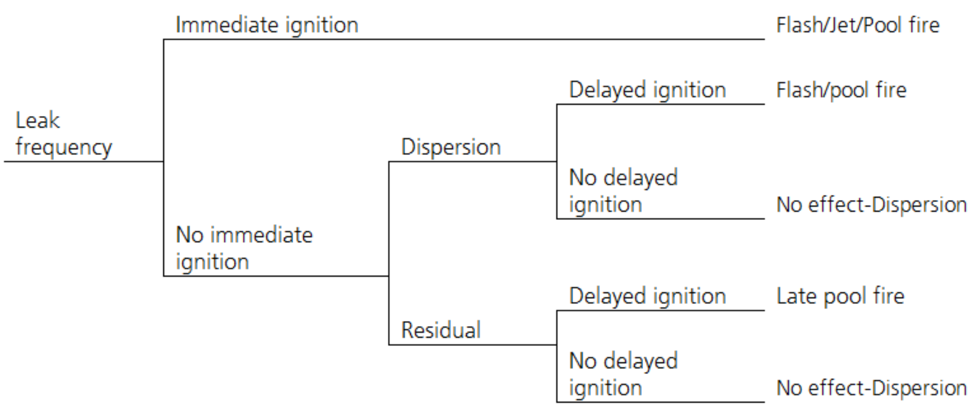

Figure 4.3: Example event tree.

4.5 Consequence Analysis

For each identified scenario a consequence assessment was performed either qualitatively or quantitatively. The consequences were assessed quantitatively for all hazardous scenarios involving release of LNG or natural gas.

The recognized software tool Phast Risk/Safeti version 6.7 was used to perform the quantitative consequence calculations for unignited releases, jet fires, pool fires, flash fires, and vapor cloud explosions. The results of the consequence analysis are provided in Section 7. The following sections describe the acceptance criteria used to assess the consequences.

4.5.1 Gas Dispersion

The lower flammable limit (LFL) and the upper flammable limit (UFL) are respectively the minimum and maximum volume fraction at which a gas/air mixture is flammable. In a flash-fire scenario, the flame front moves through the cloud consuming at least the proportions of the cloud within the flammability limits. The dispersion of the vapor is dependent on atmospheric conditions. It is used as a basis for determining flash-fire hazard distances. A flash fire is relatively short in duration and the flame spreads at subsonic velocity; thus, the overpressure damage to equipment and structures is usually negligible. Damage of equipment and structures is often caused by heat radiation of secondary fires. However, inhalation of the hot air within a flash fire can cause fatal damage to tissue and lungs. For a flash-fire scenario, Phast Risk/Safeti simulates a flash fire for the area between LFL and UFL. The contours represent the maximum distance that can be affected by a flash fire. A ½ LFL is shown as a buffer and uncertainty zone for the flammable zone.

4.5.2 Thermal Radiation

The distances to safe levels of radiant heat flux values were used in the risk calculations for fatalities. Thermal radiation from fires could damage the property, exposed personnel, and the public. NFPA 59A [3] and OGP [7] are used as guidance for the thermal radiation criteria, which are listed in Table 4.2. The effect zones of the thermal radiation of 32, 12.5, and 5 kW/m^2 were modeled in the study. The ignition model and criteria for vulnerability followed the guideline provided by the "Purple Book" [11] and LR's best practice [12].

Table 4.2: Heat Radiation Levels to the Public per NFPA 59A [3] and OGP [7]

Permissible Design Level K (kW/m^2)	Exposure
5	The nearest point located outside the owner's property line that, at the time of plant siting, is used for outdoor assembly by groups of 50 or more persons, for a fire over an impounding area.
12.5	Significant chance of fatality for extended exposure. High chance of injury. Extended exposure may cause the temperature of wood to rise to a point where it may be readily ignited by a naked flame. Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure.
32	Loss of strength of structural steel exposed to the fire to an extent that is primary load-bearing capacity is reduced significantly over the duration of LNG fire being analyzed.

4.5.3 Explosion/Overpressure

Overpressure/explosion criteria use the blast damage criteria shown in NFPA 59A, Table 15.8.4.3 [3] (see Table 4.3). The hazard distances and effect zone to the lower overpressure limit of 5000 N/m^2 (0.05 bar), 15,000 N/m^2 (0.15 bar), and 25,000 N/m^2 (0.25 bar) are modeled in the study. The ignition model and criteria for vulnerability follow the guideline provided by the "Purple Book" [11] and Lloyd's Register's best practice [12]. Due to the open, flat surface as well as anticipated low FSRU congestion levels where gas cannot accumulate, explosion scenarios were deemed not relevant in the FEED design. In detailed engineering, explosion events will be analyzed further in the fire and explosion analysis. Confined spaces will be limited but may not be completely eliminated.

Table 4.3: Overpressure Level per NFPA 59A, Table 15.8.4.3 [3]

NFPA 59A Blast Damage Criteria	Reflected Damage Overpressure (N/m^2)	
	Lower Limit	Upper Limit
Window glass damage	250	4,000
Damage to doors, cladding, and persons	5,000	10,000
Severe structural damage to building	15,000	20,000
Severe injury to people	25,000	50,000*

* Complete demolition of building

4.6 Risk Picture

The risk is the combination of the results from the frequency analysis and the consequence analysis for all evaluated scenarios (Risk = Frequency x Consequence). The risk picture uses consequences that are vulnerable to people as provided in the Purple Book [11] and areas between LFL and UFL where flash fire could occur. The risk is measured by LSIR and presented by iso-risk contours on the project site map. The risk picture is provided in Section 8. The ignition model and criteria for vulnerability follow the guideline provided by the "Purple Book" [11] and Lloyd's Register's best practice [12].

4.7 Risk Evaluation

The resulting risk picture was evaluated against the risk acceptance criteria defined in Section 4.1.

4.8 Risk-Reducing Measures

Risk-reducing measures are presented as recommendations for mitigation where there is a risk of undesired impact to the public and/or environment. If there are no significant impacts, mitigating measures may still be suggested to improve the design and document ALARP. Risk-reducing measures are provided in Section 11.

5 Hazards Identification

The major hazards, which are associated with the activities, were identified and analyzed in the HAZID workshop in October 2015 at Invenergy's offices in Chicago [13] and in a separate marine HAZID session in January 2016 in El Salvador [14]. Key stakeholders from Invenergy, Exmar, Moffatt & Nichol, Dillon Consulting, EDP, Shell, Central American Marine Services (CAMS), Comisión Ejecutiva Portuaria Autónoma (CEPA), Ministerio de Medio Ambiente y Recursos Naturales (MARN) and LR were present.

The hazards that were identified as medium or high risks in the HAZID or marine HAZID were further investigated. They are listed in Table 5.1.

Table 5.1: HAZID Summary

Reference	Hazards	Comments
HAZID items 1.2, 1.3 [13]	Natural hazards such as long-period swells, tsunamis	This is discussed in Section 10.2.
HAZID items 2.2, 2.3 [13] Marine HAZID items 1.1, 1.2, 1.3, 1.4, 2.1, 3.1, 3.2, 3.3 [14]	Ship collisions	This is discussed in Section 10.1.
HAZID items 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.3, 7.1, 7.2, 7.3 [13] Marine HAZID items 3.4, 3.5, 5.1, 8.1, 8.2 [14]	Release of LNG/NG, which can lead to fire if ignited or explosion	Major and worst-case, credible scenarios are further analyzed in the QRA, as detailed in Table 5.2.
HAZID item 9.1 [13]	Marine structures and mooring: impaired evacuation route from FSU/FSRU due to layout configuration	Design of the installation will ensure the risk is as low as reasonably practicable and contingency planning will address evacuation and rescue in emergency situation.
Marine HAZID item 7.1 [14]	Security issues in Acajutla	This is discussed in Section 10.3.
Marine HAZID item 8.3 [14]	Other emergency situations originating at port of Acajutla, Cenérgica mooring area, Albapetroleos terminal, or Rasa terminal	Situations will be handled by the port or terminal when appropriate, per relevant contingency planning. Simultaneous operations have been discussed in the marine HAZID [14].

In the QRA, the major and worst-case, credible events that could have an impact on the environment or affect the public have been considered. The flammable materials present in the processing, storage, and offloading operation include NG, boil-off gas (BOG), and LNG. The selection of the major and worst-case, credible scenario for each flammable materials release is based on the process conditions (pressure, temperature, inventory, flow rate, etc.). In addition, a release from a large inventory and/or high-pressure segment usually results in a worse consequence, which has also been accounted for in the scenarios selected.

The following major flammable releases (loss of containment) scenarios have been identified and analyzed in the QRA. The scenarios are summarized in Table 5.2.

Table 5.2: QRA Scenarios

Location	Scenario	Description	Scenario ID
LNG storage and import	LNG release	The scenarios of LNG release at the LNG storage and import are when releases occur at the inlet segments (hose/storage arm) or at the LNG storage tanks because the inlet segments have large inventories and high pressure and the LNG storage tanks have high inventories and volumes of LNG. The representative scenarios of LNG release at LNG storage and import include: - LNG release from LNGC to FSU offloading hoses (6x)	1
		- LNG release from LNGC storage (250 mm and 750 mm)	3
		- LNG release from FSU to FSRU platform loading arms (1x with spare)	4
		- LNG release from FSU storage (250 mm and 750 mm)	6
	Vapor release	The scenarios of vapor release from LNG storage and import due to large inventories and high pressure are the following: - Vapor release from LNGC to FSU offloading hoses (2x)	2
		- Vapor release from FSU to FSRU platform loading arms with hoses (1x)	5
FSRU process	LNG release	The scenarios of LNG release in FSRU process are the ruptures of pipelines in the process due to potential high pressures and large inventories. The scenarios of LNG release at FSRU process include: - LNG feed to vaporizers (2x)	7
	NG release	The scenarios of NG release in FSRU process are the ruptures of pipelines in the process due to high pressures. The scenarios of NG release at FSRU process include: - BOG line to compressors	8
		- Compressors and BOG line from compressors (2x)	9
		- LNG vaporizers and line from the LNG vaporizers (2x)	10
		- Total NG pipeline between process equipment shelter and gas send-out manifold	11
Terminal riser platform	NG release	The scenarios of NG release at the terminal riser platform occur due to large inventories and high pressure. They include the release of NG from a pipeline rupture (including two hose connections from FSRU), pig launcher/receiver, or ESD valve.	12
Onshore	NG release	The scenario of NG release onshore is at the ESD valve at the power plant. Total volume includes pipe lengths from the terminal riser platform ESD valve.	13

If a very large LNG spill or leak followed by a vaporization event were to occur in or near water, then water in contact with the spilled LNG can accelerate the vaporization process and increase the concentration of vapor in the immediate area. This is known as one of the risks of LNG called rapid phase transition (RPT). This is also called cold explosion or physical explosion. During such an event, there is no combustion (flameless) but rather, a high amount of energy is transferred in the form of heat from the water to the LNG at a large temperature difference. Although the consequences of RPT will not cause ignition, it could be severe. It will be highly localized within the spill area and could potentially damage equipment or the installation. This event was discussed in both HAZID sessions [13] [14] and based on the layout and design is not deemed to pose a hazard to the public or environment. As a result, RPT is not further assessed in the QRA.

6 Frequency Analysis

6.1 Leak Frequency

The likely frequencies of occurrence for the process scenarios were estimated based on pipe lengths provided by Exmar, Moffatt & Nichol, and Invenergy [15] and generic failure frequencies provided in the FERC failure frequency database [16]. These generic failure frequencies are deemed appropriate for the QRA.

For the LNG release from the LNGC tank (scenario 3) and for the LNG release from FSU tank (scenario 6), two cases were considered: 250 mm hole size and 750 mm hole size. Loss of containment from these scenarios is assumed to release the total volume of the tank.

For the other scenarios (1, 2, 4, 5, and 7 to 13), two scenarios of failures were considered: catastrophic rupture and a hole (leak) of a diameter of 10% of the nominal diameter of the piping or process equipment. It is also assumed that a leak scenario is detected and shut down within 60 seconds of the ESD response time for 97% of the occurrences and within 10 minutes for 3% of occurrences due to ESD failure [17]. ESD failures are defined as scenarios where the ESD system fails to close the ESD valve within the required response time (60 seconds) and fails to keep a tight shut-off/seal from the loss of containment. The upset is detected by a flow or a pressure transmitter signal that is sent to the ESD system or directly to the valve to shut in. Details on frequency assumptions are listed in Assumption Sheet 4 in Appendix A.

A 20% increase of frequency per scenario was added to account for smaller equipment, pipelines, and instrumentation. This is seen as a conservative approach. The selected scenarios (rupture/leak, with ESD response/with ESD failure) and their frequencies are presented in Table 6.1. For scenarios 3 and 6, the leak frequency for 750 mm hole size is shown in column "Rupture, without ESD" and the leak frequency for 250 mm hole size is shown in column "Leak, without ESD ."

Table 6.1: QRA Scenarios Leak Frequency per Annum

ID	Scenario	Rupture, with ESD (per year)	Rupture, without ESD (per year)	Leak, with ESD (per year)	Leak, without ESD (per year)	Total (per year)	Return Period (years)
1	LNG release from LNGC to FSU offloading hoses (6x)	1.50E-05	1.52E-07	3.60E-04	3.64E-06	3.79E-04	2,639
2	Vapor release from LNGC to FSU offloading hoses (2x)	5.01E-06	5.06E-08	1.20E-04	1.21E-06	1.26E-04	7,919
3	LNG release from LNGC storage (250 mm and 750 mm)*	N/A	2.97E-09	N/A	8.92E-09	1.19E-08	84,101,382
4	LNG release from FSU to FSRU platform loading arms with hoses (1x with spare)	1.01E-05	1.02E-07	2.37E-04	2.40E-06	2.50E-04	4,005

ID	Scenario	Rupture, with ESD (per year)	Rupture, without ESD (per year)	Leak, with ESD (per year)	Leak, without ESD (per year)	Total (per year)	Return Period (years)
5	Vapor release from FSU to FSRU platform loading arms (1x)	1.01E-05	1.02E-07	2.37E-04	2.40E-06	2.50E-04	4,005
6	LNG release from FSU storage (250 mm and 750 mm)*	N/A	3.88E-08	N/A	1.16E-07	1.55E-07	6,451,613
7	LNG feed to vaporizers (2x)	5.59E-05	1.73E-06	6.61E-04	2.04E-05	7.39E-04	1,353
8	BOG line to compressors	2.21E-05	6.84E-07	3.19E-04	9.86E-06	3.52E-04	2,844
9	Compressors and BOG line from compressors (2x)	4.54E-05	1.40E-06	5.75E-04	1.78E-05	6.40E-04	1,563
10	LNG vaporizers and line from the LNG vaporizers (2x)	2.62E-05	8.10E-07	5.52E-04	1.71E-05	5.96E-04	1,678
11	Total NG pipeline between process equipment shelter and gas send-out manifold	1.16E-05	3.60E-07	3.07E-04	9.50E-06	3.29E-04	3,041
12	Pipelines (including two hose connections from FSRU), pig launcher/ receiver, and ESD valve	1.22E-05	3.78E-07	3.13E-04	9.68E-06	3.35E-04	2,982
13	Aboveground release from the ESD valve onshore at power plant	1.84E-05	5.69E-07	3.75E-04	1.16E-05	4.05E-04	2,467
Total (per year)		2.32E-04	6.38E-06	4.06E-03	1.06E-04	4.40E-03	227
Total (percentage of total frequency)		5.3%	<0.1%	92.2%	2.4%	-	-

* The leak frequency for 750 mm hole size is shown in column "Rupture, without ESD" and the leak frequency for 250 mm hole size is shown in column "Leak, without ESD."

The total leak frequency is 4.40E-03 per year (once in 227 years). The major contributors to the total leak frequency are leak scenarios with a shutdown within the 60-second ESD response (92.2%). The ESD system is a crucial safety measure to protect a process by stopping flow upon detection of a dangerous event such as a leak. The high contribution of the scenario where an ESD successfully shuts down the process is explained by the following:

- Leaks have a higher probability of occurrence than ruptures. Hence, leak scenarios have a higher contribution to the total frequency than rupture scenarios.
- The probability of an ESD valve successfully shutting down the process is significantly higher than the probability of an ESD failure. As a result, the frequency of having a leak and no ESD failure is greater than the frequency of having a leak and an ESD failure.

The contribution of each scenario to the leak frequency for a leak with ESD is shown in Figure 6.1. The major contributing scenarios are scenario 7 – LNG feed to vaporizers (17%), scenario 9 – Compressors and BOG line from compressors (15%), and scenario 10 – NG vaporizers and line from the LNG vaporizers (14%). These scenarios are the major contributors because of the number and types of leak sources.

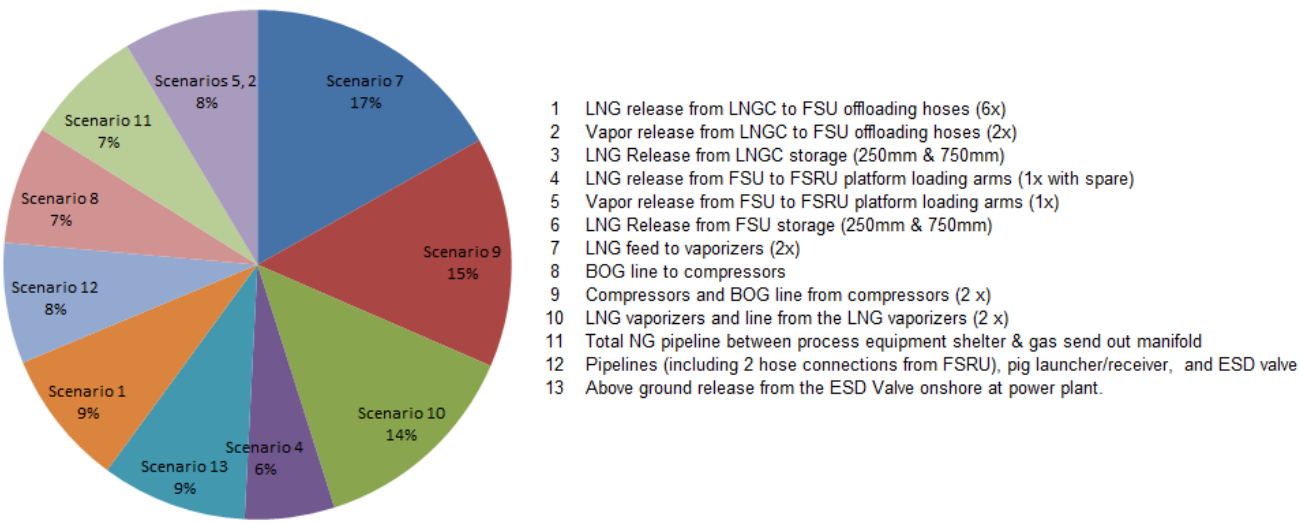

Figure 6.1: Scenario contribution to total leak frequency for a leak with ESD.

6.2 Ignition Probabilities

The consequence of a given leak is dependent on ignition probabilities of either immediate or delayed events. An internal event tree was analyzed in Phast Risk/Safeti to determine the frequency of each end event for each scenario.

The three ignition scenarios were characterized by three different ignition probabilities:

- Probability of immediate ignition
- Probability of delayed ignition inside the LNG import terminal and power plant
- Probability of delayed ignition outside the LNG import terminal and power plant

6.2.1 Immediate Ignition Probability

Immediate ignition is related to the cause of a leak and the release rate. The probability for immediate ignition is based on LR's data dossier [18]. Table 6.2 shows the probability of immediate ignition based on release rate.

Table 6.2: Immediate Ignition Probability

Release Rate (kg/s)	Immediate Ignition Probability
0.05–1	0.001
1–10	0.001
10–30	0.003
> 30	0.03

6.2.2 Delayed Ignition Probability inside the LNG Import Terminal and Power Plant

Delayed ignition is the result of a buildup of a flammable vapor cloud which is ignited by a source remote from the release point. The delayed ignition probability was calculated based on the model of UKOOA look-up correlations and release rate provided in the Oil and Gas Producers (OGP) Risk Assessment Data Directory [19]. Based on the review of OGP Risk Assessment Data Directory and LR's experience, scenario 24 is found to be the most adequate to represent the EDP LNG import terminal with respect to process conditions and was chosen to calculate delayed ignition probability. The overall ignition probability based on release rate used in the QRA is presented in Table 6.3. This probability will be subtracted by the immediate ignition probability to determine the delayed ignition probability.

Table 6.3: OGP Ignition Probability Correlation

Release Rate (kg/s)	Ignition Probability
0.1	0.0010
0.2	0.0011
0.5	0.0012
1	0.0013
2	0.0030
5	0.0092
10	0.0213
20	0.0493
50	0.1500
100	0.1500
200	0.1500
500	0.1500
1,000	0.1500

6.2.3 Delayed Ignition Probability outside the LNG Import Terminal and Power Plant

A gas cloud originating from the LNG import terminal and power plant that was not ignited within the installation boundary or is dissipated into the air could propagate and be ignited outside the installation boundary. Phast Risk/Safeti calculates each release and dispersion scenario in discrete time steps, and if a combustible gas cloud covers an ignition source in a time step, the probability of ignition is calculated according to the formula:

$$P_{i,t} = f_i(1-e^{-\omega_i t})$$

$P_{i,t}$	Probability of ignition by source *i* in the duration of time step *t*
f_i	Operating probability of source *i* (e.g., if the ignition source is only present part of the time)
ω_i	Effectiveness factor for ignition source *i*
t	Duration of time step

Assuming LNG and natural gas operating probabilities and effectiveness factor (probability of ignition in 60s) for ignition sources in the Acajutla surrounding area, the calculated delayed ignition probability outside the installation boundary over a 600-meter squared area is 0.20. Detailed calculations and results of immediate and delayed ignition probabilities are provided in Appendix B.

7 Consequence Analysis

The consequence analysis was performed with Phast Risk/Safeti version 6.7. Phast Risk/Safeti is commonly used for modeling gas cloud dispersion and heat radiation from fires for the onshore industry. The geometry and topography for the LNG import terminal location was considered by selecting a surface roughness parameter for both sea (0.2 mm open water) and land (10 cm low crops; occasional large obstacles) in the calculations. LNG and BOG were modeled using methane. The initial temperature of a release was set to –163ºC for liquid (LNG) streams and −140ºC for vapor streams (BOG). Natural gas was modeled as shown in Table 7.1 [20].

Table 7.1: Natural Gas Composition

Natural Gas Composition	mol%
methane	85.00%
ethane	15.00%
propane	5.00%
butane	2.50%
pentane	0.25%
nitrogen	1.00%

The scenario process conditions shown in Table 7.2 are in accordance with Invenergy, Exmar, and Moffatt & Nichol's input for the QRA [15].

Table 7.2: Scenario Process Conditions

ID	Scenario	Location	Modeled as	Pressure (bara)	Temp (°C)	Flow Rate (m^3/s)	Density (kg/m^3)	ESD Time (sec)	Pipe Size (in.)	Pipe Lgth. (m)	Release Height (m)
1	LNG release from LNGC to FSU offloading hoses (6x)	LNG Import and Storage	LNG (lq.)	3.0	–163	0.28	460	60	8	20	17.85
2	Vapor release from LNGC to FSU offloading hoses (2x)	LNG Import and Storage	NG (vp.)	1.1	–140	3.93	1	60	8	20	17.85
3	LNG release from LNGC storage (250 and 750 mm)	LNG Import and Storage	LNG (lq.)	1.1	–163	N/A	460	N/A	N/A	N/A	0

ID	Scenario	Location	Modeled as	Pressure (bara)	Temp (°C)	Flow Rate (m^3/s)	Density (kg/m^3)	ESD Time (sec)	Pipe Size (in.)	Pipe Lgth. (m)	Release Height (m)
4	LNG release from FSU to FSRU platform loading arms with hoses (1x with spare)	LNG Import and Storage	LNG (lq.)	3.0	–163	0.83	460	60	16	24	17.85
5	Vapor release from FSU to FSRU platform loading arms (1x)	LNG Import and Storage	NG (vp.)	1.1	–140	3.93	1	60	16	24	17.85
6	LNG release from FSU storage (250 and 750 mm)	LNG Import and Storage	LNG (lq.)	1.1	–163	N/A	460	N/A	N/A	N/A	0
7	LNG feed to vaporizers (2x)	FSRU Process	LNG (lq.)	13.0	–163	0.04	460	60	6	75	17.85
8	BOG line to compressors	FSRU Process	NG (vp.)	1.1	–140	3.93	1	60	10	50	17.85
9	Compressors and BOG line from compressors (2x)	FSRU Process	NG (vp.)	11.0	5	3.93	8	60	8	100	17.85
10	LNG vaporizers and line from the LNG vaporizers (2x)	FSRU Process	NG (vp.)	12.0	5	22.93	9	60	14	50	17.85
11	Total NG pipeline between process equipment shelter and gas send-out manifold	FSRU Process	NG (vp.)	11.0	5	45.86	8	60	24	50	17.85

ID	Scenario	Location	Modeled as	Pressure (bara)	Temp (°C)	Flow Rate (m^3/s)	Density (kg/m^3)	ESD Time (sec)	Pipe Size (in.)	Pipe Lgth. (m)	Release Height (m)
12	Pipelines (including two hose connections from FSRU), pig launcher/ receiver, and ESD valve	Terminal Riser Platform	NG (vp.)	11.0	5	45.86	8	60	24	75	6.5
13	Above-ground release from the ESD valve onshore at power plant	Onshore	NG (vp.)	11.0	5	45.86	8	60	24	1,817*	0

*Indicates the estimated total length of pipeline from the LNG import terminal riser isolation valve to the onshore inlet ESD valve at the power plant. Location of this scenario is considered to be in the middle of the power plant.

The ignition model and criteria for vulnerability follow the guideline provided by the "Purple Book" [11] and LR's best practice [12]. The consequence analysis includes releases of LNG and natural gas, followed by gas dispersion and possibility of ignition, which can lead to pool fires, jet fires, flash fires, and/or explosions. Due to the open, flat surface as well as anticipated low FSRU congestion levels where gas cannot accumulate, explosion scenarios are deemed not relevant in the FEED design. For more details on modeling assumptions such as process conditions, Phast Risk/Safeti inputs, and atmospheric conditions, see Appendix A.

7.1 Gas Dispersion Results

Based on the information above, Table 7.3 shows the maximum ULF, LFL, and ½ LFL hazard distances for gas dispersion of each scenario at different weather conditions. In the presence of a delayed ignition, the area between UFL and LFL concentrations could result in a flash fire.

Table 7.3: Gas Dispersion Results

ID	Scenario	Dispersion																
		Flammability Levels	Rupture ESD Horizontal Distance (m)				Rupture 10 min Horizontal Distance (m) or 750 mm Release Tank				Leak ESD Horizontal Distance (m)				Leak 10 min Horizontal Distance (m) or 250 mm Release Tank			
			1.5 / F	3 / D	5 / D	9 / D	1.5 /F	3 / D	5 / D	9 / D	1.5 / F	3 / D	5 / D	9 / D	1.5 /F	3 / D	5 / D	9 / D
1	LNG release from LNGC to FSU offloading hoses (6x)	UFL	108.5	102.5	81.0	52.4	108.6	102.5	81.1	52.4	20.7	20.2	20.2	21.4	20.7	20.2	20.2	21.4
		LFL	338.1	434.8	488.6	434.9	337.7	408.4	488.7	435.2	37.3	36.6	39.2	44.3	37.2	36.6	39.2	44.3
		1/2 LFL	481.5	769.3	821.4	630.4	627.5	882.4	849.5	630.7	118.3	52.4	55.7	64.7	118.1	52.4	55.6	64.7
2	Vapor release from LNGC to FSU offloading hoses (2x)	UFL	12.1	12.4	12.6	13.1	12.1	12.4	12.6	13.1	1.3	1.3	1.4	1.5	1.3	1.3	1.4	1.5
		LFL	48.6	48.5	48.2	47.9	48.6	48.5	48.2	48.0	5.7	6.0	6.3	6.6	5.7	6.0	6.3	6.7
		1/2 LFL	93.3	88.3	86.0	82.3	93.3	88.4	86.0	82.3	11.2	12.1	12.4	12.8	11.2	12.1	12.4	12.8
3	LNG release from LNGC storage (750 mm and 250 mm)*	UFL					81.7	142.8	96.4	104.8					27.8	46.6	52.9	56.5
		LFL					1456.5	621.9	360.7	365.5					721.4	157.6	170.1	174.0
		1/2 LFL					3896.0	1191.4	754.3	666.2					1589.5	328.0	307.0	279.0
4	LNG release from FSU to FSRU platform loading arms with hoses (1x with spare)	UFL	190.6	196.1	202.7	212.0	187.2	198.1	203.3	212.2	38.8	35.9	35.2	35.8	38.9	35.9	35.2	35.8
		LFL	621.7	732.2	892.4	777.9	616.5	748.1	896.2	777.8	196.0	191.4	124.0	67.8	174.1	191.4	124.0	67.8
		1/2 LFL	1193.8	1622.0	1667.0	1041.2	1184.5	1667.0	1670.7	1041.0	294.0	453.6	405.4	169.4	327.1	446.3	405.5	169.4
5	Vapor release from FSU to FSRU platform loading arms (1x)	UFL	12.2	12.4	12.7	13.2	12.2	12.4	12.7	13.2	2.7	2.8	2.9	3.0	2.7	2.8	2.9	3.1
		LFL	48.8	48.7	48.4	48.1	48.8	48.7	48.4	48.1	11.3	12.0	12.3	12.8	11.3	12.0	12.3	12.8
		1/2 LFL	93.8	88.8	86.3	82.7	93.8	88.8	86.3	82.6	21.7	23.4	23.6	23.6	21.7	23.4	23.6	23.6
6	LNG release from FSU storage (750 mm and 250 mm)*	UFL					81.7	142.8	96.4	104.8					27.8	46.6	52.9	56.5
		LFL					1456.5	621.9	360.7	365.5					721.4	157.6	170.1	174.0
		1/2 LFL					3896.0	1191.4	754.3	666.2					1589.5	328.0	307.0	279.0
7	LNG feed to vaporizers (2x)	UFL	37.2	36.6	36.1	36.3	37.2	36.6	36.1	36.3	26.3	26.3	26.2	26.6	26.3	26.3	26.2	26.6
		LFL	112.0	77.9	72.6	76.0	112.0	77.8	72.6	76.0	59.8	55.8	56.4	58.5	59.8	55.8	56.4	58.5
		1/2 LFL	247.5	236.5	145.5	107.4	233.2	236.2	145.6	107.4	138.5	83.8	79.4	85.7	138.5	83.8	79.4	85.7
8	BOG line to compressors	UFL	12.2	12.4	12.7	13.2	12.1	12.4	12.7	13.2	1.9	2.0	2.0	2.2	1.9	2.0	2.0	2.2
		LFL	48.8	48.7	48.4	48.1	48.8	48.6	48.4	48.1	8.1	8.6	8.9	9.4	8.1	8.6	8.9	9.4
		1/2 LFL	93.8	88.8	86.3	82.7	93.7	88.7	86.3	82.6	15.8	17.1	17.4	17.6	15.8	17.1	17.4	17.6
9	NG line from compressors and compressors	UFL	12.4	12.4	12.4	12.5	12.4	12.4	12.4	12.5	3.0	3.0	3.1	3.1	3.0	3.0	3.1	3.1
		LFL	56.9	56.3	56.1	55.8	56.9	56.3	56.1	55.8	14.0	14.1	14.2	14.5	14.0	14.1	14.2	14.5
		1/2 LFL	113.8	109.3	107.1	103.8	113.8	109.3	107.1	103.8	28.2	28.4	28.5	28.6	28.2	28.4	28.5	28.6
10	NG leaving the LNG vaporizers (2x) and vaporizers	UFL	30.8	30.7	30.8	30.9	30.8	30.7	30.8	30.9	4.1	4.1	4.1	4.2	4.1	4.1	4.1	4.2
		LFL	140.8	137.0	135.0	131.6	140.8	137.0	135.0	131.6	18.7	18.9	19.0	19.3	18.7	18.9	19.0	19.3
		1/2 LFL	297.2	279.9	265.6	238.5	297.2	279.9	265.6	238.5	37.8	37.6	37.6	37.5	37.8	37.6	37.6	37.5
11	Total NG pipeline between process equipment shelter and gas send-out manifold	UFL	41.4	41.1	41.2	41.3	41.4	41.1	41.2	41.3	5.9	5.9	6.0	6.1	5.9	5.9	6.0	6.1
		LFL	191.4	183.2	179.6	173.1	191.4	183.2	179.6	173.1	27.4	27.4	27.5	27.7	27.4	27.4	27.5	27.7
		1/2 LFL	418.1	404.8	395.6	366.6	418.1	404.8	395.6	366.5	55.1	54.2	53.8	53.2	55.1	54.2	53.8	53.2
12	Pipelines (including two hose connections from FSRU), pig launcher/receiver, and ESD valve	UFL	41.2	40.9	40.8	40.5	41.2	40.9	40.8	40.5	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
		LFL	216.1	217.2	220.0	223.2	216.1	217.2	220.0	223.2	28.4	28.3	28.0	27.6	28.4	28.3	28.0	27.6
		1/2 LFL	491.2	503.7	525.0	560.0	491.2	503.7	525.0	560.0	57.0	54.7	52.9	50.5	57.0	54.7	52.9	50.5
13	Aboveground release from the ESD valve onshore at power plant	UFL	90.8	75.5	76.7	79.1	90.8	75.5	76.7	79.1	41.5	31.9	32.4	33.3	41.5	31.9	32.4	33.3
		LFL	475.9	413.6	446.0	513.4	476.0	413.6	446.1	513.6	239.3	180.0	195.2	228.8	239.2	180.1	195.1	228.7
		1/2 LFL	960.6	914.9	1046.0	1101.6	959.2	914.9	1044.6	1101.2	494.5	420.5	478.0	495.5	494.5	420.9	477.9	495.4

* For the LNG release from the LNGC tank (scenario 3) and from FSU tank (scenario 6), two cases were considered: 250 mm hole size and 750 mm hole size. Loss of containment from these scenarios will release the total volume of the tank.

The 750 mm releases from either the LNGC or FSU LNG storage tanks (scenarios 3 and 6) result in the largest dispersion hazard distances due to the LNG inventory dispersing into air (UFL – 81.7 m, LFL – 1,456.5 m, ½ LFL – 3,896 m for 1.5/F weather condition). However, a hole of 750 mm in the LNGC tank resulting in an LNG release is at a very low leak frequency as shown in Section 6.1.

For the same weather condition, the loss of containment of natural gas from the onshore ESD valve (scenario 13) and the LNG release from FSU loading arms (scenario 4) also result in large dispersion hazard distances. The leak frequency for the onshore ESD valve and FSU loading arms is 4.05E-04 per year (once in 2,467 years) and 2.50E-04 per year (once in 4,005 years) respectively, and the risk picture for these events is further assessed in Section 8.

As an example, Figure 7.1 shows the contour of gas dispersion maximum hazard distances from any direction of the release point by a rupture to the FSU LNG transfer arm (scenario 4). This illustrates that the ½ LFL (blue curve) gas cloud could reach the port of Acajutla area, the LFL (green risk curve) gas cloud is about 590 meters away from the LNG import terminal, and the UFL (yellow curve) is within 120 meters from the LNG import terminal. The results of this scenario are due to the process conditions and LNG volume spilled. It should be noted that this is based on the major and worst-case, credible scenario. Even though the hazardous distance reaches the port, the frequency of the scenario is at 1.01E-05 per year (once in 99,394 years). Given that the 1/2 LFL contour reaches the port, it is recommended to install gas detectors at the port, if not already installed, and to coordinate an alarm system and emergency response plan that includes the port in case of incident at the LNG import terminal.

Figure 7.1: Gas dispersion from an FSU LNG transfer arm rupture.

7.2 Jet Fire Results

Based on the process information, Table 7.4 shows the maximum hazard distances for the jet fire radiation values (5 kW/m^2, 12.5 kW/m^2, and 32 kW/m^2) of each scenario. When the jet fire does not reach a certain radiation level, it is referenced as "Not Reached" in the table.

Table 7.4: Jet Fire Results

ID	Scenario	Jet Fire																
		Radiation Levels	Rupture ESD Horizontal Distance (m)				Rupture 10 min Horizontal Distance (m) or 750 mm Release Tank				Leak ESD Horizontal Distance (m)				Leak 10 min Horizontal Distance (m) or 250 mm Release Tank			
			1.5 / F	3 / D	5 / D	9 / D	1.5 / F	3 / D	5 / D	9 / D	1.5 / F	3 / D	5 / D	9 / D	1.5 / F	3 / D	5 / D	9 / D
1	LNG release from LNGC to FSU offloading hoses (6x)	5 kW/m2	268.1	243.4	225.7	213.8	268.1	243.5	225.8	213.9	66.9	60.1	55.6	52.9	66.8	60.1	55.6	52.8
		12.5 kW/m2	225.5	200.8	183.8	172.7	225.6	200.9	183.8	172.8	48.6	40.8	35.9	33.0	48.5	40.8	35.9	33.0
		32 kW/m2	193.1	169.1	153.0	142.7	193.2	169.1	153.0	142.7	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
2	Vapor release from LNGC to FSU offloading hoses (2x)	5 kW/m2	36.4	38.8	42.1	44.1	36.4	38.8	42.1	44.1	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
		12.5 kW/m2	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
		32 kW/m2	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
3	LNG release from LNGC storage (750 mm and 250 mm)*	5 kW/m2					156.3	152.3	148.3	152.8					89.7	91.4	91.2	95.5
		12.5 kW/m2					133.1	128.7	124.4	127.6					76.5	77.5	76.8	80.2
		32 kW/m2					112.8	111.0	107.3	110.1					63.7	66.8	66.5	69.4
4	LNG release from FSU to FSRU platform loading arms with hoses (1x with spare)	5 kW/m2	439.26	399.91	371.58	352.74	439.27	399.92	371.59	352.75	148.45	134.11	124.12	117.42	148.48	134.14	124.14	117.45
		12.5 kW/m2	370.13	222.74	303.62	286.07	370.13	222.75	303.62	286.08	122.54	107.94	98.54	92.46	122.57	107.96	98.56	92.48
		32 kW/m2	318.00	222.74	254.72	238.78	318.01	222.75	254.72	238.78	103.64	86.34	76.31	71.79	103.66	86.37	76.33	71.81
5	Vapor release from FSU to FSRU platform loading arms (1x)	5 kW/m2	36.7	39.1	42.5	44.4	36.7	39.1	42.5	44.4	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
		12.5 kW/m2	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
		32 kW/m2	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
6	LNG release from FSU storage (750 mm and 250 mm)*	5 kW/m2					156.3	152.3	148.3	152.8					89.7	91.4	91.2	95.5
		12.5 kW/m2					133.1	128.7	124.4	127.6					76.5	77.5	76.8	80.2
		32 kW/m2					112.8	111.0	107.3	110.1					63.7	66.8	66.5	69.4
7	LNG feed to vaporizers (2x)	5 kW/m2	124.4	113.4	106.1	101.2	124.3	113.4	106.0	101.2	85.4	77.5	72.2	68.8	85.4	77.5	72.2	68.8
		12.5 kW/m2	101.5	90.2	82.8	78.0	101.4	90.2	82.8	78.0	67.7	59.6	54.4	51.1	67.7	59.6	54.4	51.1
		32 kW/m2	82.6	69.1	63.3	58.8	82.6	69.1	63.3	58.8	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached

ID	Scenario	Radiation Levels	Jet Fire															
			Rupture ESD Horizontal Distance (m)				Rupture 10 min Horizontal Distance (m) or 750 mm Release Tank				Leak ESD Horizontal Distance (m)				Leak 10 min Horizontal Distance (m) or 250 mm Release Tank			
			1.5 / F	3 / D	5 / D	9 / D	1.5 / F	3 / D	5 / D	9 / D	1.5 / F	3 / D	5 / D	9 / D	1.5 / F	3 / D	5 / D	9 / D
8	BOG line to compressors	5 kW/m2	36.7	39.1	42.5	44.4	36.6	39.0	42.4	4.4	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
		12.5 kW/m2	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
		32 kW/m2	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
9	NG line from compressors and compressors	5 kW/m2	98.6	99.9	101.4	103.6	98.6	99.9	101.4	103.6	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
		12.5 kW/m2	70.3	71.9	75.1	81.4	70.3	71.9	75.1	81.4	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
		32 kW/m2	Not Reached	Not Reached	Not Reached	54.7	Not Reached	Not Reached	Not Reached	54.7	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
10	NG leaving the LNG vaporizers (2x) and vaporizers	5 kW/m2	228.0	230.0	230.8	227.2	228.0	230.0	230.8	227.2	Not Reached	Not Reached	20.0	Not Reached	Not Reached	Not Reached	20.0	Not Reached
		12.5 kW/m2	167.4	172.5	177.8	184.2	167.4	172.5	177.8	184.2	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
		32 kW/m2	128.1	132.2	136.6	146.8	128.1	132.2	136.6	146.8	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
11	Total NG pipeline between process equipment shelter and gas send-out manifold	5 kW/m2	299.5	302.5	303.4	297.7	299.5	302.5	303.4	297.7	43.4	44.3	45.4	47.2	43.4	44.3	45.4	47.2
		12.5 kW/m2	220.8	226.6	233.0	240.1	220.8	226.6	233.0	240.1	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
		32 kW/m2	170.8	175.6	179.8	194.4	170.8	175.6	179.8	194.4	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
12	Pipelines (including two hose connections from FSRU), pig launcher/receiver, and ESD valve	5 kW/m2	302.3	304.4	304.1	295.9	302.3	304.4	304.1	295.9	53.6	54.2	54.8	55.9	53.6	54.2	54.8	55.9
		12.5 kW/m2	225.9	231.4	236.4	240.9	225.9	231.4	236.4	240.9	41.0	42.1	43.7	46.5	41.0	42.1	43.7	46.5
		32 kW/m2	177.3	180.3	182.7	201.4	177.3	180.3	182.7	201.4	29.2	30.6	32.6	36.7	29.2	30.6	32.6	36.7
13	Aboveground release from the ESD valve onshore at power plant	5 kW/m2	327.2	329.2	328.2	318.3	327.2	329.2	328.2	318.3	149.0	149.4	149.2	147.0	149.0	149.4	149.2	147.0
		12.5 kW/m2	245.9	251.4	256.0	259.4	245.9	251.4	256.0	259.4	116.1	118.4	120.9	124.5	116.1	118.4	120.9	124.5
		32 kW/m2	193.7	196.0	201.1	218.6	193.7	196.0	201.1	218.6	90.7	92.9	99.3	108.6	90.7	92.9	99.3	108.6

* For the LNG release from the LNGC tank (scenario 3) and from FSU tank (scenario 6), two cases were considered: 250 mm hole size and 750 mm hole size. Loss of containment from these scenarios will release the total volume of the tank.

For example, for the 1.5/F weather condition, the LNG discharge from the FSU transfer arm (scenario 4) results in the largest jet fire radiation hazard distances (e.g., rupture case: 5 kW/m^2 – 439.26 m, 12.5 kW/m^2 – 370.13 m, and 32 kW/m^2 – 318 m). This is followed by a loss of containment of natural gas from the onshore pipeline isolation valve (scenario 13) (e.g., rupture case: 5 kW/m^2 – 327.2 m, 12.5 kW/m^2 – 245.94 m, and 32 kW/m^2 – 193.7 m). These two scenarios are expected to have large hazard distances due to their process conditions and pipeline inventory. The leak frequencies of the FSU transfer arm scenario and of the onshore isolation valve scenario are 2.50E-04 per year (once in 4,006 years) and 4.05E-04 per year (once in 2,467 years), respectively.

As an illustrative example, Figure 7.2 shows the contour of jet fire maximum hazard distances from any direction from the release location by a rupture to the FSU LNG transfer arm. The jet fire radiation curves from this scenario do not reach any defined public areas. If the shipping lane (not defined) reaches the area within the 439 meters distance of the LNG import terminal, the release could potentially affect people traveling through this area.

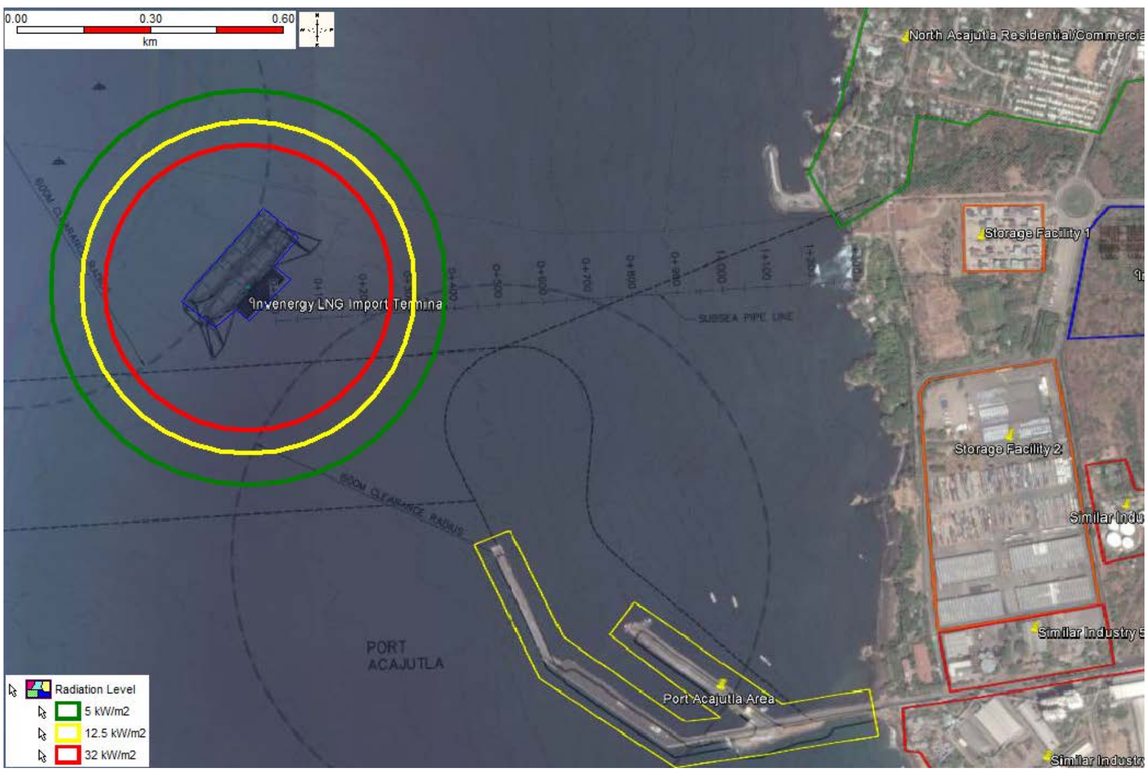

Figure 7.2: Jet fire hazard distances from a FSU LNG transfer arm rupture.

7.3 Pool Fire Results

In the event of a leak, the amount of LNG spilled from the pipeline or equipment will rapidly vaporize due to the large change in temperature (from –163°C to 27°C). When there is a significant amount of LNG released, a portion of the LNG located inside the volume released will stay liquid. This situation creates a potential for a pool. The scenarios for which a pool fire is possible are the scenarios that can create a large release of LNG based on the flow rate and volume of inventory within its containment. Only three scenarios have been identified as potential scenarios for pool fires. These scenarios and the maximum hazard distances for the pool fire radiation values (5 kW/m^2, 12.5 kW/m^2, and 32 kW/m^2) are shown in Table 7.5.

Table 7.5: Pool Fire Results

ID	Scenario	Pool Fire																
		Radiation Levels	Rupture ESD Horizontal Distance (m)				Rupture 10 min Horizontal Distance (m) or 750 mm Release Tank				Leak ESD Horizontal Distance (m)				Leak 10 min Horizontal Distance (m) or 250 mm Release Tank			
			1.5 / F	3 / D	5 / D	9 / D	1.5 /F	3 / D	5 / D	9 / D	1.5 / F	3 / D	5 / D	9 / D	1.5 /F	3 / D	5 / D	9 / D
3	LNG release from LNGC storage (750 mm and 250 mm)*	**5 kW/m2**					315.0	323.7	330.4	332.2					132.3	136.2	138.1	137.4
		12.5 kW/m2					209.4	224.3	231.9	240.6					88.7	95.0	97.9	101.4
		32 kW/m2					125.7	144.8	159.8	173.6					53.1	62.3	68.9	74.3
4	LNG release from FSU to FSRU platform loading arms with hoses (2x)	**5 kW/m2**	197.75	170.53	80.61	Not Reached	197.76	170.37	80.77	Not Reached								
		12.5 kW/m2	147.74	133.84	73.04	Not Reached	147.76	133.72	73.16	Not Reached								
		32 kW/m2	107.25	104.72	65.73	Not Reached	107.28	104.63	65.91	Not Reached								
6	LNG release from FSU storage (750 mm and 250 mm)*	**5 kW/m2**					315.0	323.7	330.4	332.2					132.3	136.2	138.1	137.4
		12.5 kW/m2					209.4	224.3	231.9	240.6					88.7	95.0	97.9	101.4
		32 kW/m2					125.7	144.8	159.8	173.6					53.1	62.3	68.9	74.3

* For the LNG release from the LNGC tank (scenario 3) and from FSU tank (scenario 6), two cases were considered: 250 mm hole size and 750 mm hole size. Loss of containment from these scenarios will release the total volume of the tank.

The 750 mm releases from either the LNGC or FSU LNG storage tanks (scenarios 3 and 6) result in the largest pool fire radiation hazard distances. These scenarios are expected to have large hazard distances due to the volume of LNG released but are unlikely to occur at 2.97E-09 per year (once in 336,700,337 years) for the LNGC and 3.88E-08 per year (once in 25,800,000 years) for the FSU.

As a graphical example, Figure 7.3 shows the contour of pool fire maximum hazard distances from any direction by a 750 mm release from the LNGC tanker. Similar to the jet fire radiation curves, pool fires do not reach any defined public areas. If the shipping lane (not defined) reaches the area within the 224 meters distance of the LNG import terminal, the release could potentially affect people traveling through this area at radiation levels of 5 kW/m^2 and 12.5 kW/m^2. Radiation levels of 32 kW/m^2 would only affect personnel within the perimeter of the LNG import terminal. The leak frequency of this scenario is 2.97E-09 per year (once in 336,700,337 years), and this scenario is very unlikely to occur.

Figure 7.3: Pool fire hazard distances from a release of LNGC or FSU LNG storage tanks.

Appendix C presents detailed Phast Risk/Safeti consequence results for all the selected scenarios.

8 QRA Risk Picture

In this QRA, the main areas of concern are the risk exposure to a third party and indirectly the risk to the environment. A third party corresponds to people off-site not directly involved in the activities within the site (general public and neighboring industries). LSIR iso-risk curves are presented to show the risk picture to the public (see Section 4.1).

8.1 Overall – LSIR Iso-Risk Contours

The IR for the LNG import terminal and the IR for the onshore location are provided in Table 8.1. The IR for both the LNG import terminal and onshore locations meet the risk criteria as defined in Section 4.1. The risk to the public and environment from the LNG import terminal is broadly acceptable (≤ 1E-06 per year), and the risk to the public and environment from the onshore location is within the ALARP region (between 1E-06 per year and 1E-04 per year).

Table 8.1: IR per Process Release Location

Process Release Location	IR per year	Risk Region
LNG import terminal	8.89E-07	Broadly acceptable
Onshore	3.49E-05	ALARP

The overall LSIR contours are provided in Figure 8.1, which shows that the onshore location has a public risk of up to 1E-05 per year (pink risk curve). However, the iso-risk contour of 1E-05 per year and 1E-06 per year meets the risk criteria as defined in Section 4.1 and falls in the ALARP region. The LSIR iso-risk curve of 1E-07 per year (green risk curve) represents risks that are broadly acceptable per the risk criteria (Section 4.1).

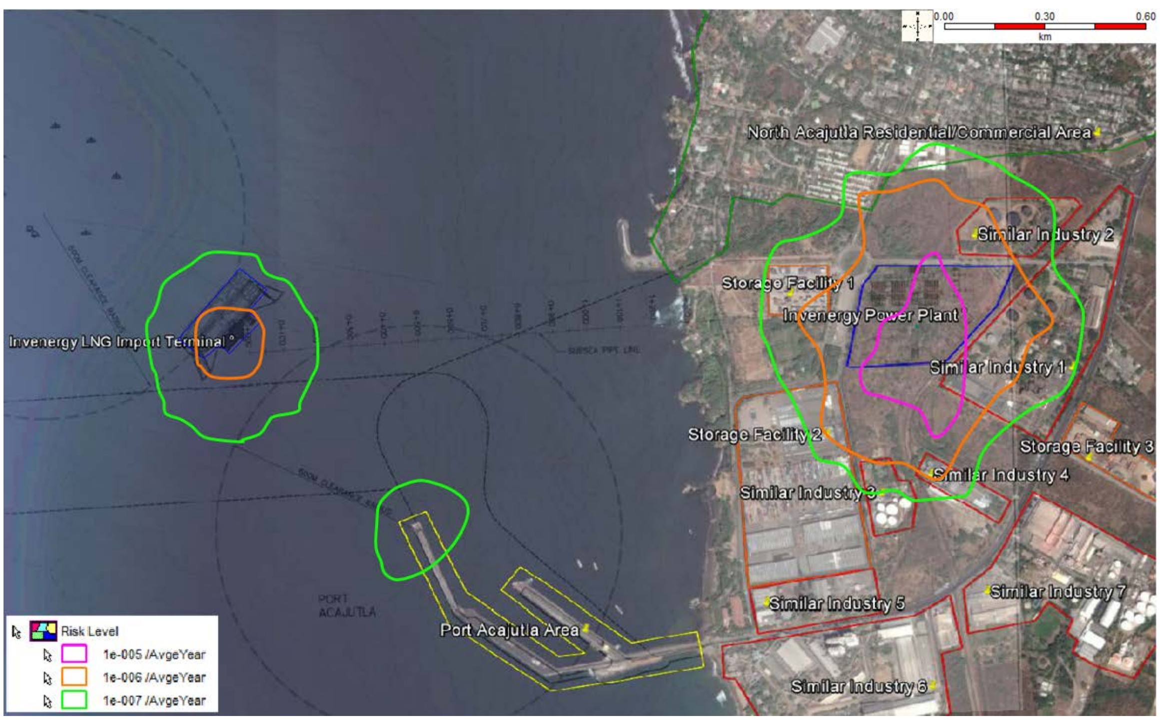

Figure 8.1: Overall LSIR iso-risk contours.

Figure 8.1 shows that the LNG import terminal has a public risk up to 1E-06 per year (orange risk curve). This risk curve does not reach the shipping lane. All risk curves at the LNG import terminal (orange – 1E-06 per year, green – 1E-07 per year) fall in the region where the risk is broadly acceptable per the risk criteria. The port of Acajutla is exposed to the risk from the LNG import terminal; however, the risk is up to 1E-07 per year (green risk curve) and is a broadly acceptable risk. The following sections describe these areas separately to further evaluate the analysis.

8.2 LNG Import Terminal – LSIR Iso-Risk Contours

The LNG import terminal LSIR iso-risk contours involve only the scenarios in this area that are from the LNGC, FSU, FSRU, and riser platform. The IR is calculated to be 8.89E-07 per year and falls in the broadly acceptable region (≤ 1E-06 per year) per the risk criteria defined in Section 4.1.

Figure 8.2 shows the LSIR iso-risk contours for the LNG import terminal, and all contours fall in the broadly acceptable risk region. The orange risk curve (1E-06 per year) is localized around the import terminal and does not reach the current shipping lane. The green risk curve (1E-07 per year) extends approximately 180 meters in the shipping lane but corresponds to a risk that is broadly acceptable (≤ 1E-06 per year). The figure also shows a green risk curve at the port of Acajutla due to possible ignition sources at the port that may ignite a gas cloud if exposed. Even though it is an unlikely event, the gas cloud may extend to the port. The LSIR iso-risk curve, however, is of a magnitude of 1E-07 per year, which is within the broadly accepted risk region.

As a result, any public areas within the vicinity of the LNG import terminal are deemed acceptable based on the risk acceptance criteria in Section 4.1.

Figure 8.2: LNG import terminal LSIR iso-risk contours.

Further, the IR per release location is provided in Table 8.2. The scenarios related to the FSU location contribute to 99.81% of the total risk. Among these scenarios, scenario 4 involving the FSU loading arm release represents 99.82% of the total risk at the FSU, with an individual risk of 8.88E-07 per year. The high contribution of this scenario is due to its consequence, which could lead to loss of containment in the vicinity. The probability of occurrence is, however, low. This scenario results in a very negligible risk.

Table 8.2: LSIR per Release Location at the LNG Import Terminal

Release Location	Scenarios	LSIR per year	% of Total Risk
LNGC	1 to 3	1.73E-09	0.19%
FSU	4 to 6	8.88E-07	99.81%
FSRU	7 to 11	<< 0	<< 0.00%
Riser Platform	12	<< 0	<< 0.00%
Total LNG Import Terminal	-	8.89E-07	-

8.3 Onshore – LSIR Iso-Risk Contours

The onshore LSIR iso-risk contours only involve the scenario related to the natural gas release from the inlet ESD valve at the power plant (scenario 13). The overall individual risk from the onshore power plant is 3.49E-05 per year. The risk for the onshore location meets the risk criteria as defined in Section 4.1 and falls in the ALARP risk region.

Figure 8.3 below shows the LSIR contour for the onshore ESD valve. All LSIR iso-risk contours fall in the ALARP risk region or in the broadly acceptable risk region. The area inside the orange risk curve (1E-06 per year) reaches adjacent industrial areas. Since this risk is within the ALARP region, mitigating measures as suggested in this report should be further looked into. The area outside the orange risk curve (1E-06 per year) represents iso-risk contours that fall within the broadly acceptable risk region, and no further measures are required.

The leak from the onshore inlet ESD valve contributes to the individual risk at 2.80E-05 per year and the rupture contributes to 6.50E-06 per year. This is due to the large inventory of natural gas pipeline from the riser platform ESD valve to the inlet ESD valve at the power plant and its high flow rate.

Figure 8.3: Onshore LSIR iso-risk contours.

Although the risk for the onshore location meets the risk criteria, it is within the ALARP region, and sensitivity analyses are conducted to look into possible mitigation measures for the risk within the ALARP region. The results are provided in Section 8.4.

8.4 Sensitivity Analysis

The onshore inlet ESD valve scenario falls in the ALARP region, and this scenario has the highest LSIR per year. Sensitivity analyses have been performed to understand the possibilities to reduce the risk level as an additional ALARP measure. The following sensitivity analyses were performed:

- Reduction of onshore pipeline isolation/ESD valve closure time from 60 seconds to 30 seconds;
- Reduction of pipeline inventory by adding another onshore pipeline isolation valve in the vicinity of the shoreline;
- Reduction of both the onshore pipeline isolation/ESD valve closure time to 30 seconds and pipeline inventory with additional onshore pipeline isolation valve.

These scenarios are expected to reduce the amount of natural gas released. Table 8.3 shows the volume reduction for these scenarios.

Table 8.3: Onshore Pipeline Volume Assessment

Options	Rupture ESD Volume (m^3)	Rupture 10 min Volume (m^3)	Leak ESD Volume (m^3)	Leak 10 min Volume (m^3)
Base case	3,282	32,816	572	5,721

Options	Rupture ESD Volume (m^3)	Rupture 10 min Volume (m^3)	Leak ESD Volume (m^3)	Leak 10 min Volume (m^3)
30-second onshore pipeline isolation/ESD valve	1,906	19,059	551	5,512
Reduced pipe volume with additional isolation valve	2,851	28,506	141	1,412
30-second onshore pipeline isolation/ESD valve and reduced pipe volume with additional isolation valve	1,475	14,749	120	1,202

The base case scenario considers the release of 60 seconds ESD valve closure time and the full volume of the pipeline from the LNG import terminal riser ESD valve to the inlet ESD valve at the power plant. On the one hand, the 30-second ESD valve closure time significantly reduces the volume for the rupture cases but does not have a significant impact on the volume for the leak cases. On the other hand, the addition of an onshore isolation valve significantly reduces the volume for the leak case but has little impact on the volume for the rupture case. This is explained by the facts that 1) in a rupture case, the release rate (flow rate) is large and the amount of fluid released during the ESD closing time in a rupture case is dominated by the total release volume; and 2) in a leak case, the release rate is small and the total released volume during a leak is dominated by the pipeline volume. This shows that the rupture cases are dependent on the flow rate of natural gas, and the leak cases are dependent on pipe length. The combination of both mitigating options allows significant reductions of both rupture and leak cases.

Table 8.4 compares individual risk levels from the mitigated options for the onshore ESD valve release scenario. All three options display reductions in risk level. The reduction of the pipeline volume alone reduces the risk level by 78%. All sensitivity cases fall in the ALARP region with an IR between 1E-04 per year and 1E-06 per year, as defined in Section 4.1. Figure 8.4, Figure 8.5, and Figure 8.6 illustrate LSIR contours for all three sensitivity cases.

Table 8.4: Onshore Risk Comparison

Options	Individual Risk per Year	Risk Reduction
Base case	3.49E-05	-
30-second onshore pipeline isolation valve	3.31E-05	5%
Reduced pipe volume with additional isolation valve	7.76E-06	78%
30-second onshore pipeline isolation/ESD valve and reduced pipe volume with additional isolation valve	4.98E-06	86%

Figure 8.4: Onshore LSIR iso-risk contours – 30-second onshore pipeline isolation/ESD valve closure time option.

Figure 8.5: Onshore LSIR iso-risk contours – Reduced pipe volume with additional isolation valve in vicinity of shoreline option.

Figure 8.6: Onshore LSIR contour with both 30-second onshore pipeline isolation/ESD valve and reduced pipe volume with additional isolation valve options.

9 Future Development Analysis

9.1 Description

In addition to the base case, EDP is planning to modify the installation in the future for the LNG import terminal to meet a rate of 280 MMSCFD of natural gas throughput to the power plant. In doubling the throughput from 140 MMSCFD, the number of LNGC visits will increase from 16 to 32 visits annually and a third train will be added on the FSRU. Figure 9.1 shows the future process flow diagram [21]. It shows the third train in parallel with the other two trains, and the process conditions have changed to accommodate the 280 MMSCFD natural gas rate.

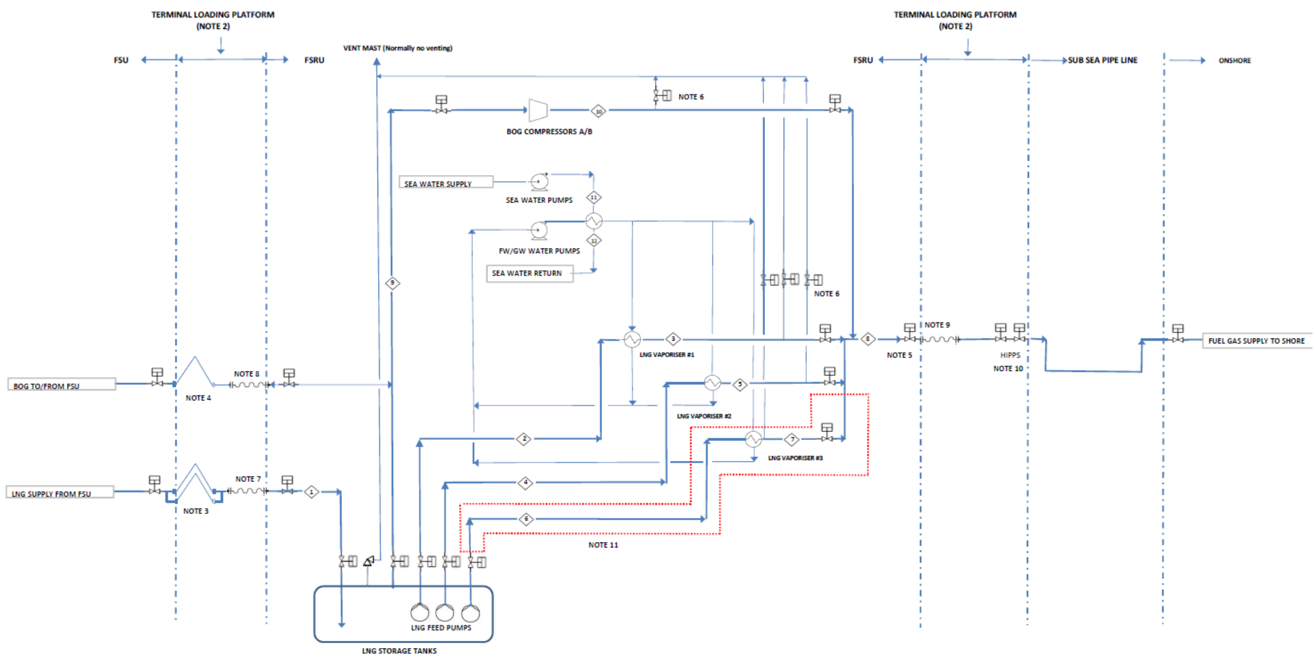

Figure 9.1: Future Process Flow Diagram.

9.2 Individual Risk and LSIR Contour

The future development IR values for the LNG import terminal, the onshore location, and total are provided in Table 9.1. The risk of 8.95E-07 per year to the public from the LNG import terminal is broadly acceptable (≤ 1E-06 per year), and the risk of 3.89E-05 per year to the public from the onshore location is within the ALARP region (between 1E-06 per year and 1E-04 per year).

Table 9.1: Future IR per Process Release Location

Process Release Location	IR per Year	Risk Criteria
LNG import terminal	8.95E-07	Broadly acceptable
Onshore	3.89E-05	ALARP

The overall LSIR contour for the future development is shown in Figure 9.2. The onshore location has a public risk in the range of 1E-05 per year (pink risk curve). The iso-risk contour of 1E-05 per year meets the risk criteria as defined in Section 4.1 and falls in the ALARP region. The LSIR iso-risk curve of 1E-07 per year (green risk curve) represents risks that are broadly acceptable per the risk criteria (Section 4.1).

Figure 9.2 shows that the LNG import terminal has a public risk within the range of 1E-06 per year (orange risk curve). This risk curve does not reach the shipping lane. All risk curves at the LNG import terminal (orange – 1E-06 per year, green – 1E-07 per year) fall in the region where the risk is broadly acceptable per the risk criteria. The port of Acajutla is exposed to the risk from the LNG import terminal; however, the risk is within the range of 1E-07 per year (green risk curve) and is a broadly acceptable risk.

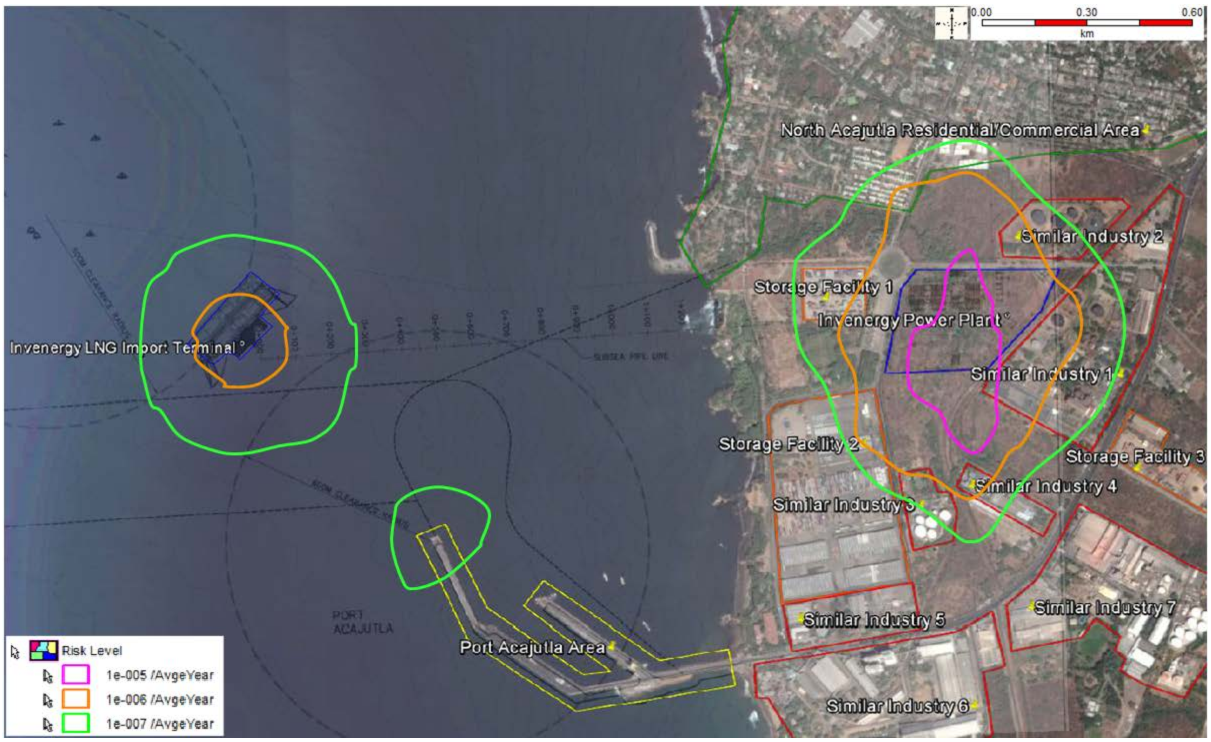

Figure 9.2: Future overall LSIR iso-risk contours.

In comparison to the base case, the future modifications with 280 MMSCFD natural gas rate increase the public individual risk by 11.3% for the onshore releases and 0.6% for the LNG import terminal releases. The major increase is due to the increase in flow rate in the onshore gas pipeline. Similar to the sensitivity analysis done for the base case in Section 8.4, reduction in ESD time and/or an additional ESD valve onshore is expected to reduce the risks to the public.

9.3 Onshore LSIR Contour

Figure 9.3 below illustrates the onshore section separately. The onshore IR risk is 3.89E-05 per year and has increased into the adjacent public areas compared to the base case. The affected areas are mostly similar industry to the power plant. The orange 1E-06 per year curve, which is tolerable criteria, slightly reaches the public residential population to the north of the power plant. This is caused by the large inventory of natural gas pipeline from the riser platform ESD valve to the inlet ESD valve at the power plant and its high flow rate. Similar to the base case, the inventory of natural gas released could be minimized by reducing the ESD time or by adding another isolation valve.

Figure 9.3: Future onshore LSIR iso-risk contours.

9.4 LNG Import Terminal LSIR Contours

The LNG import terminal LSIR iso-risk contours involve only the scenarios in this area that are from the LNGC, FSU, FSRU, and riser platform. The IR is calculated to be 8.95E-07 per year and falls in the broadly acceptable region (≤ 1E-06 per year) per the risk criteria defined in Section 4.1. Figure 9.4 below illustrates the LNG import terminal area separately. The LNG import terminal LSIR contour changed very slightly.

Figure 9.4: Future LNG import terminal LSIR iso-risk contours.

The IR per release location is provided in Table 9.2. The scenarios related to the FSU location contribute to 99.20% of the total risk. Among these scenarios, scenario 4 involving the FSU loading arm release represents 99.82% of the total risk at the FSU, with an individual risk of 8.88E-07 per year. The high contribution of this scenario is due to its consequence, which could lead to loss of containment in the vicinity. The probability of occurrence is, however, low and results in a negligible risk.

Table 9.2: Future IR per Release Location at the LNG Import Terminal

Release Location	Scenarios	IR per Year	% of Total Risk
LNGC	1 to 3	3.45E-09	0.39%
FSU	4 to 6	8.88E-07	99.20%
FSRU	7 to 11	<< 0	<< 0.00%
Riser Platform	12	3.73E-09	0.42%
Total LNG Import Terminal	-	8.95E-07	-

10 Other Risks

The following other risks for the project are discussed qualitatively at this stage in the QRA performed in FEED and are not included in the risk contour, except for ship collisions, which have been quantified:

- Ship collisions
- Tsunamis
- Security

10.1 Ship Collision Risk

A ship collision risk analysis has been completed [14]. Based on the HAZID [13], the following ship collision scenarios involving the LNG import terminal were identified for further analysis in the ship collision risk analysis:

- The potential collision of the LNGC with the LNG import terminal,
- The potential collision of an oil tanker en route to the Cenérgica mooring area with the LNG import terminal, and
- The potential collision of merchant vessels to/from the port of Acajutla with the LNG import terminal.

Collision of the LNGC in the LNG import terminal will result in minor structural damage of the FSU with low impact energy. When the approaching speed of the LNGC is higher than 1.3 knots, causing impact energy greater than 28 mJ, the powered collision has the potential to cause LNG release from the FSU. However, the collision of the LNGC in the FSU is unlikely to cause a spill from the FSU due to the low approaching speed of the LNGC. In addition, the most severe collision of the LNGC with the FSU is a head-on collision, which is not likely to cause loss of containment from the LNGC tank due to location of tank in the hull.

Collisions of oil tankers in the LNG import terminal will only cause local or minor damage to the FSU and are not likely to cause an LNG leak from the FSU due to the light weight, low speed, and low impact energy of the oil tanker.

Since collisions of the LNGC or oil tankers in the LNG import terminal are not likely to cause an LNG leak given the low impact energies, only the collision of merchant vessels with the LNG import terminal is considered a risk for collisions. There were 742 vessel entries (341 unique vessels callings) to the port of Acajutla registered from 16 August 2014 to 15 August 2015 [22]. The vessel distribution to the port of Acajutla and the vessel distribution based on vessel type are provided in Table 10.1 and Figure 10.1, respectively. Assuming mitigated measures like mandatory pilotage and tugboats accompanying larger vessels, most of these collisions will cause only local or minor damage to the FSU due to the low impact energy and are not likely to cause an LNG release from the FSU. In extreme weather conditions, the high speed of the drifting vessel could result in a collision with large impact energy. This collision has the potential to cause a leak from the FSU and LNGC. Based on the QRA, the ship collision risk is found to be 2.61E-09 per year and falls in the broadly acceptable region.

Table 10.1: Vessel Distribution to the Port of Acajutla

	Deadweight Tonnage (ton)					Number of Entries	Percentage
	0–1,499	1,500–4,999	5,000–14,999	15,000–39,999	>40,000		
Bulk Carrier	0	0	8	57	77	142	19%
Tanker	0	4	4	40	198	246	33%
Container	0	0	28	225	0	253	34%
Carriers (Vehicles)	0	0	18	44	0	62	8%
General Cargo	0	1	5	8	21	35	5%
Other Vessels	2	1	0	0	1	4	1%
Total	2	6	63	374	297	742	100%
Percentage	0%	1%	8%	50%	40%	100%	

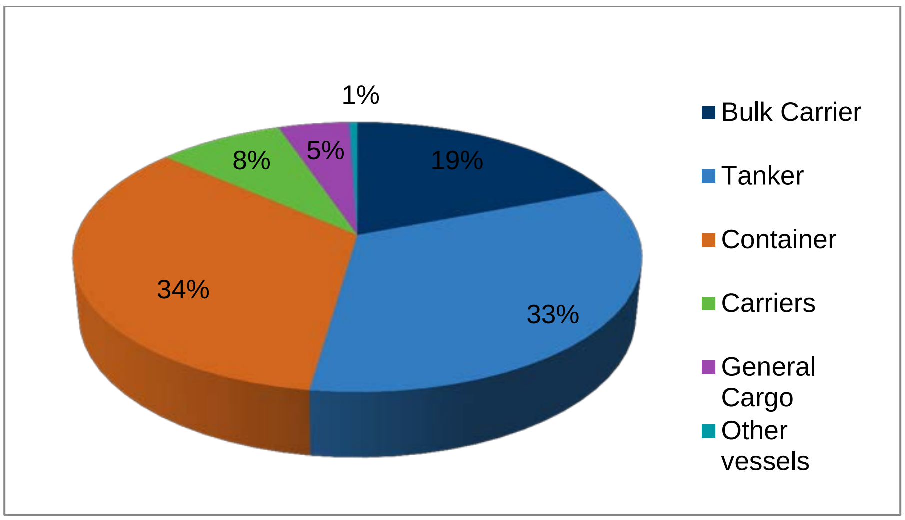

Figure 10.1: Vessel distribution based on vessel type.

10.2 Tsunamis Risk

El Salvador is located on the west coast of Central America, which has a reasonably well-documented history of subduction zone earthquakes that have produced tsunamis near the terminal site. Large eddies created by earthquakes can lead to major consequences in the vicinity of the site. Therefore, tsunami risk is a realistic potential hazard, as identified in the HAZID [13]. A tsunami study was performed by Moffatt & Nichol and results of the simulations are provided in the report [23]. This study is currently being updated.

Although tsunamis are rare events, they have been identified as potential hazards, given the magnitude of the consequences (damage to asset, environment, and people). A mooring system and fender system will be adequately designed based on the findings of the Moffatt & Nichol study to ensure that the installation can withstand a tsunami for which the conditions do not exceed the tsunami conditions chosen in the design criteria.

In the event of a distant earthquake, advance notice will be provided to evacuate personnel from the LNG import terminal and to ensure the LNGC, if present, is leaving the LNG import terminal to reach a safe area. The FSU can stay moored based on the adequately designed mooring and fender systems and no major damage is expected that would lead to a loss of containment.

In the event of long-period swells, which can be predicted in advance, the LNGC will leave the terminal and the personnel will be evacuated. The FSU may leave, depending on the situation.

10.3 Security Risk

Violence and crime are critically high in El Salvador. Local security threats have been identified as high risk for the project in the marine HAZID [14]. To deal with potential security threats, the port of Acajutla is currently committed to safe and efficient movement of goods and passengers through the port. The addition of the LNG import terminal in the area and its high profile as an international investment project may increase the security risk. The following recommendations should be considered for the project:

- Restricted access to the LNG import terminal
- Video surveillance of the LNG import terminal installation and surrounding marine area
- Lighting of the installation at night
- Marine exclusion/safety zone around the LNG import terminal
- Patrol/Security vessels enforcing the marine exclusion/safety zone
- Incident reporting program to track suspicious activity
- International Ship and Port Security (ISPS) plan for the LNG import terminal taking into account local security concerns.

11 Recommendations and Discussions

11.1 Safety Zones

The QRA did not identify IR in the intolerable risk region as defined in Section 4.1. Hence, based on the risk acceptance criteria, the public and the environment are not exposed to an unacceptable risk. Regions for ALARP and for broadly accepted risks have been identified, and conclusions on recommended safety zones follow.

Onshore Power Plant

The LSIR curves for the onshore power plant are in the tolerable region, given the risk is ALARP and is defined by the 1E-05 per year risk curve (pink risk curve in Figure 8.3) and 1E-06 per year risk curve (orange risk curve in Figure 8.3). This region covers the entire onshore power plant and the closest neighboring industries by the power plant. The orange iso-risk contour goes approximately 340 meters into the neighboring industry from the edge of the power plant.

The 1E-05 per year risk curve for the onshore power plant extends beyond the power plant boundaries up to approximately 190 meters south of the plant and can be used as an exclusion zone where the public should not be allowed to enter.

LNG Import Terminal

The calculated IR for the LNG import terminal falls in the acceptable region as defined in Section 4.1. No LSIR was found to be in the intolerable risk region or the ALARP region. The orange iso-risk curve (1E-06 per year) extends approximately 90 meters from the edge of the LNG import terminal. This region can be used to define the marine exclusion zone where no unauthorized traffic or public should be allowed to enter.

The LSIR contour is one input to define the extent of safety zones. However, other inputs not included in the LSIR contour, such as security risk, may require a larger marine exclusion zone.

11.2 Shipping Lane

The shipping lane as it is currently defined (for example in Figure 8.2) is acceptable in terms of LSIR. The risk from the LNG import terminal exposing the shipping lane is in the broadly acceptable region (1E-07 per year).

In general, the shipping lane is acceptable as is; however, the project may choose 1E-07 per year as the criteria for the shipping lane and may consider moving the shipping lane outside of the 1E-07 per year regions (green risk curve in Figure 8.2.

The LSIR contour is one input to define the acceptability of the shipping lane. However, there are other inputs not included in the LSIR contour, such as security risk, required turning radius for ships, or traffic control that may require the shipping lane to be moved. Another option is to advise ships to sail in and out of the port of Acajutla further south, below the currently marked shipping lane.

11.3 General Discussion and Recommendations

Based on the analysis, the following general recommendations are suggested:

- For the onshore power plant, it is recommended to investigate mitigation measures for the potential release of natural gas from the onshore pipeline isolation/ESD valve. As shown in Section 8.4, reducing the ESD time to 30 seconds, adding an onshore isolation valve to reduce the pipeline inventory, and/or both options combined are expected to reduce the risk to the public areas around the power plant.

- It is recommended, if possible, to analyze the design of process equipment shelters and buildings within the LNG import terminal and power plant limit to minimize confined spaces to reduce explosion events. No explosion scenarios were identified for the design at the FEED stage. Explosion events will be further analyzed in detailed engineering.

- Accidents at the LNG import terminal and power plant area can affect the closest neighboring industry. It is recommended to add gas detectors at the port of Acajutla, if not already installed, and to coordinate an alarm system and emergency response plan that includes the port in case of incident at the LNG import terminal to notify people in the neighboring facilities and the LNG import terminal of a release of LNG or NG.

- The LSIR is one input to define the extent of the marine exclusion zone. However, other risks like ship collision and security risks are other complementary inputs which can possibly require a larger marine exclusion zone. These are not included in LSIR and should be taken in for consideration.

- The project was presented to all stakeholders during workshops under the assumption that the FSRU capacity would be 50,000 m^3; however, it later became apparent that an FSRU storage of up to 100,000 m^3 could be necessary to comply with project delivery requirements. Given the little contribution of the FSRU scenarios to the overall risk, the increase in storage capacity is not expected to significantly affect the outcome of the QRA results presented in this report.

12 References

[1] FERC Risk-Informed Decision Making Guidelines, Chapter 3 – Risk Assessment, Federal Energy Regulatory Commission, Version 4.1, March 2016.

[2] Ley del Medio Ambiente, Decreto No. 233, Diario Official No. 79, Tomo No. 339, 28 May 2015.

[3] NFPA 59A, Standard for the Production, Storage, and Handling of LNG, 2016 Edition.

[4] British Standards BS EN 1473, Installation and equipment for liquefied natural gas — Design of onshore installations, 2007.

[5] Offshore Division Fire, Explosion and Risk Assessment Topic Guidance, HSE, June 2003.

[6] NORSOK Standard Z-013 – Risk and Emergency Preparedness Analysis, Revision 2, 2001.

[7] Risk Assessment Data Report, OGP, report no. 434, March 2010.

[8] Moffatt & Nichol, Metocean and numerical modelling for LNG import terminal Acajutla, El Salvador, Rev. A, 11/02/2015.

[9] Consequences of LNG Marine Incidents, R. M. Pitblado, Center for Chemical Process Safety (CCPS) Conference, July 2004.

[10] http://www.sadfiweb.gob.sv:8090/ConsultasEnLinea/HistoricoBuques/index.php

[11] "Reference Manual Bevi Risk Assessments version 3.2 – Module C", 01.07.2009.

[12] Lloyd's Register "Best Practice – Scenario selection for onshore QRA," 13 May 2011.

[13] Lloyd's Register, "Invenergy Power to Shore Project, LaPaz, El Salvador – HAZID Report," Report no. US4122.1, Rev. Final B, 03 March 2016.

[14] Lloyd's Register, "Invenergy Power to Shore Project, LaPaz, El Salvador – Marine HAZID Report," Report no. US4122.2, Rev. Final, 03 March 2016.

[15] Lloyd's Register, Exmar, Invenergy, and Moffatt & Nichol, "Questions_El Salvador QRA" Spreadsheet, Rev 3., 30 March 2016.

[16] US DOT PHMSA and FERC, "LNG Facility Nominal Failure Rate Table," 11 February 2015.

[17] SINTEF, "Reliability Prediction Data for Safety instrumented Systems," PDS Data Handbook, 2010 Edition.

[18] Lloyd's Register Data Dossier, Appendix F: Ignition probability calculation, 2011.

[19] Oil and Gas Producers (OGP) risk assessment Data directory- Ignition Probability, Report No. 434-6.1, March 2010.

[20] QRA comments from H. Larios, 14 April 2016.

[21] Exmar, Acajutla LNG Terminal Project Process Flow Diagram: Updated for 280MMSCFD Sendout, Rev B, 08/11/2016.

[22] http://www.sadfiweb.gob.sv:8090/ConsultasEnLinea/HistoricoBuques/index.php

[23] Moffatt & Nichol, "EDP LNG Import Terminal, Acajutla, El Salvador – Tsunami Simulation Report – FEED Phase," Revision No. A, 18 May 2016.

Appendix A

QRA Assumptions

Table of Contents

1 Introduction

The proposed LNG import terminal and LNG regasification barge near the Acajutla Port, El Salvador, will provide natural gas to an onshore power plant. A quantitative risk analysis (QRA) is performed to estimate the project risk towards the public and the environment. This appendix documents the relevant assumptions for the QRA.

2 Assumption Sheets

All assumptions sheets are listed in the following table.

Assumption Sheet No.	Subject	Rev.	Date	Comments
1	Scope of Work	1	April 21, 2016	Comments from Exmar, Invenergy and M&N implemented
2	Atmospheric Conditions	1	April 21, 2016	
3	Topography and Ground Surface Type	1	April 21, 2016	
4	Frequency Analysis	2	May 13, 2016	
5	Consequence Analysis	2	August 16, 2016	
6	Risk Criteria	1	April 21, 2016	

Assumption Sheet 1

Sheet No.:	**1**	**Assumption Rev.:**	**1**
Subject:	**QRA**	**Date:**	**April 21, 2016**
Topic:	**Scope of Work**		

Assumption Description

The QRA will include LNGC offloading to FSU, FSU offloading to FSRU, FSRU regasification process, gas send out from the riser platform to subsea pipeline, pipeline and the above ground isolation valve at the entrance into the power plant. Selected scenarios based on the HAZID [1] and process flow diagrams are listed in Table 2.1.

Table 2.1 – Selected scenarios

ID	Scenario	Location
1	LNG release from LNGC to FSU offloading hoses (6x)	LNG Import and Storage
2	Vapor release from LNGC to FSU offloading hoses (2x)	LNG Import and Storage
3	LNG Release from LNGC storage (250mm & 750mm)	LNG Import and Storage
4	LNG release from FSU to FSRU platform loading arms (1x with 1 spare)	LNG Import and Storage
5	Vapor release from FSU to FSRU platform loading arms (1x)	LNG Import and Storage
6	LNG Release from FSU storage (250mm & 750mm)	LNG Import and Storage
7	LNG feed to vaporizers (2x)	FSRU Process
8	BOG line to compressors	FSRU Process
9	Compressors and BOG line from compressors (2 x)	FSRU Process
10	LNG vaporizers and line from the LNG vaporizers (2 x)	FSRU Process
11	Total NG pipeline between process equipment shelter & gas send out manifold	FSRU Process
12	Pipelines (including 2 hose connections from FSRU), pig launcher/receiver, and ESD valve	Terminal Riser Platform
13	Above ground release from the ESD Valve onshore at power plant.	Onshore

References

1. Lloyd's Register, Marine HAZID Report: Invenergy Power to Shore Project, Acajutla, El Salvador," Rev final, 03 March 2016.

Client comments/ approval:

Assumption Sheet 2			
Sheet No.:	**2**	**Assumption Rev.:**	**1**
Subject:	**QRA**	**Date:**	**April 21, 2016**
Topic:	**Atmospheric Conditions**		

Assumption Description

Weather information used in this study is obtained from the Metocean report prepared by Moffatt & Nichol [1].

Temperature

The ambient temperature is assumed to be 27°C, which is the annual average temperature for Acajutla port [2].

Humidity

The average ambient relative humidity is assumed to be 80% [2].

Wind speed and wind direction

The wind rose is shown in Figure 2.1. The dominating wind direction is the wind from north and northeast sector to the South and southwest sector, followed by winds from the south to north.

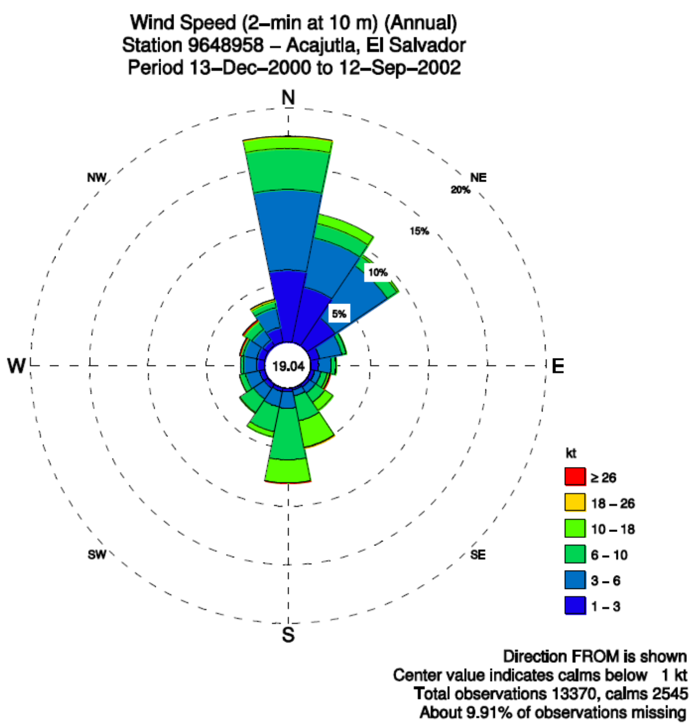

Figure 2.1 - Wind Rose Data at Acajutla

Stability class

Pasquil stability class is a measure of turbulence in the atmosphere and defined in Table 2.2

[2]. It is dependent on the wind speed, time of the day, and other conditions, as shown in Table 2.3.

Table 2.2 Pasquil Stability Classes

Pasquill Class	Stability
A	Extremely unstable
B	Moderately unstable
C	Slightly unstable
D	Neutral
E	Slightly stable
F	Moderately stable

Table 2.3 Stability Class from Wind speed and Solar Radiation

Wind speed (m/s)	Daytime insolation			Night-time conditions	
	Strong	Moderate	Slight	Thin overcast or > 4/8 low cloud	<=4/8 cloudiness
0-2	A	A-B	B	E	F
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D

For this study, it is assumed that the stability class at the LNG import terminal is 5D (wind speed is 5 m/s with a stability class D) in 70% of the time and 2F (wind speed is 2 m/s with a stability class F) in 30% of the time. 2F condition is considered to be the most conservative wind condition according to NFPA 59A (Ref. /3/).

Solar radiation will be 0.5 kW/m^2. The surface of water and soil temperatures will be assumed to be the same as the average ambient temperature of 27°C.

References

1. Moffatt & Nichol, Metocean and numerical modelling for LNG import terminal Acajutla, El Salvador, Rev. A, 11/02/2015.
2. https://weather-and-climate.com/average-monthly-Humidity-perc,Acajutla,El-Salvador.
3. NFPA 59A, Standard for the Production, Storage, and Handling of LNG, 2016 Edition.

Client comments/ approval:

Assumption Sheet 3

Sheet No.:	**3**	**Assumption Rev.:**	**1**
Subject:	**QRA**	**Date:**	**April 21, 2016**
Topic:	**Topography and Surface Type**		

Assumption Description

- The LNG terminal is located on the Pacific coast of El Salvador and the topography is flat in the Acajutla area. For consequence modeling, the Table 2.4 below shows the surface roughness for sea and on land.

Table 2.4 – Surface roughness (the lengths marked with * are used in the analysis)

Type of Surface	Roughness Length (m)
Open water, at least 5 km	0.0002*
Mud flats, snow; no vegetation, no obstacles	0.005
Open flat terrain; grass, few isolated objects	0.03
Low crops; occasional large obstacles, x/h > 20	0.10*
High crops; scattered large obstacles, 15 < x/h < 20	0.25
Parkland, bushes; numerous obstacles, x/h < 15	0.5
Regular large obstacle coverage (suburb, forest)	1
City center with high- and low-rise buildings	3

- The LNG terminal is in the Pacific Ocean about 1,250 meters west of the shoreline [1]. The onshore isolation valve is located about 1,000 meters from shoreline at the inlet of the power plant surrounded by other storage facilities and similar industry businesses.
- Storage tanks and transfer arm/hose releases when transferring LNG at the import terminal is assumed to be discharge to the sea surface (water).
- Other process releases on-board the FSU/FSRU is assumed to be collected and to leak to a cryogenic spill collection system on the FSU/FSRU surface.
- Process releases on the FSRU are also protected by the FSRU hull and a cofferdam structure in steel which will protect and prevent leakages from leaving outside the FSRU area to the sea except for northeast side of the cofferdam where it is open.
- Any leak from the onshore isolation valve is assumed to leak onto a soil ground surface.

References

1. Moffatt & Nichol, Invenergy LNG Import Terminal, 901700C-403-EXHB - PLAN - OPTION 3, Ref. No. C-403, 12/15/2015.
2.

Client comments/ approval:

Assumption Sheet 4

Sheet No.:	**4**	**Assumption Rev.:**	**2**
Subject:	**QRA**	**Date:**	**May 13, 2016**
Topic:	**Frequency Analysis**		

Assumption Description

- The ESD response time is assumed to be 1 minute (60 seconds). The ESD will also stop the transfer pumps [2].
- It is assumed that a leak scenario is detected and shut down during the ESD response time for 97% of the occurrences and during 10 minutes for 3% of the occurrences [1].
- A leak from a hole is defined as a leak with an effective diameter of 10% of the nominal diameter. For scenarios 3 and 6, loss of containment from the LNGC and FSU storage tank(s) will not have ESD and will spill LNG to sea until all inventory are released or when the physics of outflow reaches equilibrium. Transfer times for the LNGC, FSU, and FSRU are presented in Table 2.5. The transfer times are based on [2].
- The FSU is assumed to transfer LNG to the FSRU in a batched process about 104 times per year (two batched transfers per week) [4]. The transfer time per transfer is estimated to 17 hrs from FSU to FSRU. During the time the FSU is not transferring LNG to the FSRU, the transfer lines are assumed empty.

Table 2.5 – LNGC, FSU, and FSRU Annual LNG Transfer time

Description	LNGC to FSU	FSU to FSRU	FSRU to Process
Ship Size (m^3)	165,000	140,000	50,000
Liquid Density (kg/m^3)	460	460	460
Transfer Rate (m^3/hour)	6000	3000	300
Transfer Time (hours/ship)	28	17	continuous
Transfers (ships/year)	16	104	n/a
Transfer Time (hours/year)	440	1734	8766
Transfer Time (Proportion)	0.05	0.20	1.00

References

1. SINTEF, "Reliability Prediction Data for Safety instrumented Systems", PDS Data Handbook, 2010 Edition.
2. LR, Exmar, Invenergy, and Moffatt & Nichol, “Questions_El Salvador QRA” Spreadsheet, Rev 3., March 30, 2016.
3. US DOT PHMSA and FERC, “LNG Facility Nominal Failure Rate Table,” February 11, 2015.
4. LR, Exmar, phone discussion, April 19, 2016.

Client comments/ approval:

Assumption Sheet 5

Sheet No.:	**5**	**Assumption Rev.:**	**2**
Subject:	**QRA**	**Date:**	**August 16, 2016**
Topic:	**Consequence Analysis**		

Assumption Description

A consequence analysis will be performed with Phast Risk/Safeti version 6.7 with the scenarios listed in Table 2.6. Table 2.6 shows each scenario's process conditions [1, 2, 7]. Process conditions are determined by the hydrocarbon inventory volume between two isolation valves.

Table 2.6 – Scenario Process Conditions [1,2,7]

ID	Scenario	Fluid/Gas Type	Pressure (bara)	Temperature (C)	Volume (m^3)	Flow rate (m^3/s)	Density (kg/m^3)	Mass Flowrate (kg/s)	Pipe Size (inch)	Pipe length (m)	ESD Time (s)
1	LNG release from LNGC to FSU offloading hoses (6x)	LNG (lq.)	3.0	-163	17	0.28	460	128	8	20	60
2	Vapor release from LNGC to FSU offloading hoses (2x)	LNG (vp.)	1.1	-100	236	3.93	1	4	8	20	60
3	LNG Release from LNGC storage (250mm & 750mm)	LNG (lq.)	1.1	-163	50,000	n/a	460	n/a	n/a	n/a	n/a
4	LNG release from FSU to FSRU platform loading arms (1x with 1 spare)	LNG (lq.)	3.0	-163	53	0.83	460	192	16	24	60
5	Vapor release from FSU to FSRU platform loading arms (1x)	LNG (vp.)	1.1	-100	239	3.93	1	4	16	24	60
6	LNG Release from FSU storage (250mm & 750mm)	LNG (lq.)	1.1	-163	32,000	n/a	460	n/a	n/a	n/a	n/a
7	LNG feed to vaporizers (2x)	LNG (lq.)	13.0	-163	4	0.04	460	19	6	75	60
8	BOG line to compressors	LNG (vp.)	1.1	-140	238	3.93	1	4	10	50	60

9	Compressors and BOG line from compressors (2 x)	NG (vp.)	11.0	5	246	3.93	8	31	8	100	60
10	LNG vaporizers and line from the LNG vaporizers (2 x)	NG (vp.)	12.0	5	1,385	22.93	9	206	14	50	60
11	Total NG pipeline between process equipment shelter & gas send out manifold	NG (vp.)	11.0	5	2,766	45.86	8	367	24	50	60
12	Pipelines (including 2 hose connections from FSRU), pig launcher/receiver, and ESD valve	NG (vp.)	11.0	5	2,773	45.86	8	367	24	50	60
13	Above ground release from the ESD Valve onshore at power plant.	NG (vp.)	11.0	5	3,282	45.86	8	367	24	1817	60

- The LNG and LNG Boil Off Gas (BOG) are modeled using methane. The initial temperature of a release is set to -163 ºC for LNG streams and -140 ºC for LNG BOG streams. Process conditions are given Table 2.6 above.
- The gas fraction will be modeled based on the following [5]:
  - Methane: 85.00mol% minimum
  - Ethane: 15.00 mol% maximum
  - Propane: 5.00 mol% maximum
  - Butanes: 2.50 mol% maximum
  - Pentanes and heavier: 0.25 mol% maximum
  - Nitrogen: 1.0 mol% maximum

The ESD response times are assumed to be 1 minute (60 seconds) [2]. The release rates and durations are modeled as follows:

1. Rupture: The total volume released from pipe diameter in a specified time (ESD or 10 min.) with flow rate and pressure as specified in process conditions table.
2. Hole: A leak from a 10 % of nominal diameter hole during specified time (ESD or 10 min.) with flow rate and pressure as specified in process conditions table.

- Releases from piping are assumed to be 1 meter above main deck of FSRU, except the offloading arm/hose(s) which are assumed to be at 5 meters above deck.
- Process releases onboard the FSU/FSRU is assumed to be collected and leak to a cryogenic spill

collection system on the FSU/FSRU surface.

- Any large process releases on the FSRU is also protected by a cofferdam structure which will protect and prevent leakages from leaving outside the FSRU area to the sea except for northeast side of the cofferdam where it is open [5].

Consequences will calculate distances for various types of hazards such as gas dispersion, radiation, and overpressure. Gas dispersion has been modelled in order to investigate the distances that the lower flammability limits (LFL) (volume concentration value 5 percent), upper flammability limit (UFL), and ½ LFL can reach from the release point [1].

The distances to safe levels of radiant heat flux values will be used in the risk calculations for fatalities. The thermal radiation from fires could damage the property, expose personnel and the public. NFPA 59A [3] and OGP [6] are used as guidance for the thermal radiation criteria which are listed in the following table. Refer to QRA Methodology for more details. The effect zones of the thermal radiation of 32, 12.5, and 5 kW/m^2 are modeled in the study. The heat radiation of 12.5kW/m2 will be used as the fatality limit in this study, i.e. a heat radiation greater than 12.5kw/m^2 is fatal for persons present inside an exposed area.

Table 2.7 - Heat radiation levels to the public per NFPA 59A and OGP [3, 6]

Permissible Design level (kW/m2)	Exposure
5	• At least 10 persons would suffer second-degree skin burns on at least 10% of their bodies within 30 seconds of exposure to the fire. Maximum Modified Dosage Unit is 500 ((kW/m2)4/3t). • At least one person inside the building would suffer second-degree skin burns on at least 10% of the body within 30 seconds of exposure to the fire. Maximum Modified Dosage Unit is 300 ((kW/m2)4/3t) • Impairment of escape routes and survival craft embarkation areas • The nearest point located outside the owner's property line that, at the time of plant siting, is used for outdoor assembly by groups of 50 or more persons, for a fire over an impounding area.
12.5	• Significant chance of fatality for extended exposure. High chance of injury. • Extended exposure may cause the temperature of wood to rise to a point where it may be readily ignited by a naked flame. Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure
32	• Loss of strength of structural steel exposed to the fire to an extent that is primary load-bearing capacity is reduced significantly over the duration of LNG fire being analyzed • Immediate fatality (100% lethality)

Explosion/overpressure

Overpressure/explosion criteria use the blast damage criteria shown in NFPA 59A Table 15.8.4.3. The hazard distances and effect zone to the lower overpressure limit of 5000 N/m^2 (0.05 bar), 15,000 N/m^2 (0.15 bar), 25,000 N/m^2 (0.25 bar) are modeled in the study.

Table 2.8 - Overpressure level per NFPA 59A (Table 15.8.4.3).

NFPA 59A Blast Damage Criteria	Reflected Damage Overpressure (N/m^2)	
	Lower Limit	Upper Limit
Window glass damage	250	4,000
Damage to doors, cladding, and persons	5,000	10,000
Severe structural damage to building	15,000	20,000
Severe injury to people	25,000	50,000*

*complete demolition of building

The overpressure of 15, 000 N/m^2 (0.15bar) will be used as the fatality limit for explosion.

References

1. Exmar, Acajutla LNG Terminal Project Process Flow Diagram, Rev A, 03/15/2016.
2. LR, Exmar, Invenergy, and Moffatt & Nichol, “Questions_El Savador QRA” Spreadsheet, Rev 3., March 30, 2016.
3. NFPA 59A, Standard for the Production, Storage, and Handling of LNG, 2016 Edition.
4. Exmar and LR, “P15-022_Comment_Sheet_02_Rev0” April 11, 2016.
5. Invenergy comments, April 14, 2016.
6. OGP, Vulnerability of Humans, report No. 434-14, March 2010.
7. Exmar, Acajutla LNG Terminal Project Process Flow Diagram, Rev B, 08/11/2016.

Client comments/ approval:

Assumption Sheet 6

Sheet No.:	**6**	**Assumption Rev.:**	**1**
Subject:	**QRA**	**Date:**	**April 21, 2016**
Topic:	**Risk Criteria**		

Assumption Description

The individual risk criterion will be calculated to measure the risk towards the public as a conservative measure early in the project planning phases. The risk criteria for the QRA performed in FEED phase is presented in the Table 2.9. Refer to QRA Methodology for more details.

Table 2.9 – Public IR Criteria

Description	Average Public IR Criteria [per annum]
Intolerable risk	≥ 1E-4
Tolerable risk, provided risk is ALARP	1E-4 > IR > 1E-6
Broadly acceptable risk	≤ 1E-6

References

Client comments/ approval:

Appendix 9D–
Contingency Planning

Lloyd's Register

Working together
for a safer world

EDP LNG Power to Shore Project, Acajutla, El Salvador

Contingency Planning

Report for
Invenergy Clean Power

Reference: US4280.1/R2

Release: 2

Report by: Danielle Chrun

Summary

EDP LNG Power to Shore Project, Acajutla, El Salvador		
Contingency Planning		
Date of Issue	18 November 2016	
Administrative Review	Margaret Bush	
Report by	**Reviewed by**	**Approved by**
Danielle Chrun	Therese L. Baas	Robert Hall
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Document History			
Release	**Date**	**Description**	**Contributors**
1	01 September 2016	Initial Release	**Report by:** Danielle Chrun **Reviewed by:** Rhey Lee/Varsha Pedhireddy **Approved by:** Kyle Wingate
2	18 November 2016	Final Release—Comments from Invenergy are implemented.	**Report by:** Danielle Chrun **Reviewed by:** Therese L. Baas **Approved by:** Robert Hall

Table of Contents

Abbreviations

AMP	Autoridad Marítima Portuaria (Maritime Port Authority)
CAMS	Central American Marine Services
CEPA	Comisión Ejecutiva Portuaria Autónoma (Port Authority Executive Commission)
EDP	Energía del Pacífico
EIA	environmental impact assessment
ESD	emergency shutdown
FEED	front end engineering design
FERC	Federal Energy Regulatory Commission
FSRU	floating storage and regasification unit
FSU	floating storage unit
HAZID	hazard identification
LNG	liquefied natural gas
LNGC	liquefied natural gas carrier
LR	Lloyd's Register
M&N	Moffatt & Nichol
MARN	Ministerio de Medio Ambiente y Recursos Naturales (Ministry of Environment and Natural Resources)
MINEC	Ministerio de Economía (Ministry of Economy)
PFSA	Port Facility Security Assessment
PTWC	Pacific Tsunami Warning Center
RPT	rapid phase transition
SNET	Servicio Nacional de Estudios Territoriales (National System of Territorial Studies)
STPP	Secretaría Técnica y de Planificación de la Presidencia (Secretary of Technical and Planning)
VTS	Vessel Traffic Service

Definitions

Abnormal event: Event deviating from the normal and usual operating conditions as defined by the project.

Accident: Unplanned event that resulted in death, injury, or ill health of people, or damage to property or the environment.

Contingency plan: Plan that defines the actions to undertake in the event of an abnormal event or accident.

Emergency situation: Situation that poses an immediate risk to health, life, property, or environment.

Escalation: Increase in the consequence of a hazard.

Hazard: Situation that poses threat to people, property, or environment.

Mitigation: Action of reducing the consequence of a hazard.

Project: Energía del Pacífico's (EDP's) initiative to develop an LNG import terminal in the port of Acajutla, El Salvador.

1 Executive Summary

Lloyd's Register (LR) has been engaged by Invenergy to carry out a high-level review of the contingency plan for the EDP liquefied natural gas (LNG) import terminal in Acajutla, El Salvador. This review was developed early in the front-end engineering (FEED) phase of the project with limited information. The purpose of the review is to ensure a preliminary course of action designed for EDP and different stakeholders be prepared and to ensure EDP and stakeholders are prepared to respond to abnormal events when they occur. This plan provides a high-level review of contingencies for the project, early in the project. A detailed contingency plan will be developed later in the project, in detailed engineering, by EDP and other stakeholders. It is best practice to begin contingency planning early in the project's life and update it as the work progresses through the project's life cycle.

A contingency planning workshop was conducted in San Salvador, El Salvador, on 15 June 2016. The intent of the workshop was to discuss contingencies for the project. Discussions included the current contingency in place in the port of Acajutla and contingencies that will be in place at the LNG import terminal. The participants included the following: key regulatory bodies, stakeholders, and project participants from the Maritime Port Authority (Authoridad Marítima Portuaria – AMP), Government, Port of Acajutla Executive Commission (Commission Ejecutiva Portuaria Autonoma – CEPA), Invenergy, Moffatt & Nichol (M&N), Exmar, EDP, and Lloyd's Register. Main conclusions from the workshop are listed below:

- A detailed contingency plan for the LNG import terminal will be developed in detailed engineering. It will include the major hazards as discussed in the workshop, such as an LNG leak, fire, and explosion.
- Major hazards, as identified in the hazard identification (HAZID) workshop sessions [1] [2], were discussed to analyze the risks to people, environment, and assets.
- The project will evaluate the need for the LNG carrier (LNGC) and floating storage unit (FSU) to leave the LNG import terminal in the event of a tsunami or swells. The project will consider a self-powered FSU or dedicated tugs to move the FSU in the event where the FSU needs to be moved to a safe location.
- In the event of an emergency at the port, an early warning is provided by a loud audible alarm and the port authority will inform the civil protection group. The civil protection group will assess the situation and decide whether to evacuate or muster in place. Municipalities will be notified in case of evacuation and will coordinate the evacuation of people to safety. The project's contingency plan will be submitted to the civil protection group through the fire department for approval in order to ensure timely notification.
- The port of Acajutla is equipped with firefighting capabilities, including firefighters, a firefighting tug, and ambulance. However, the port will prioritize assistance to its own facilities and to commercial vessels; therefore, the project's contingency plan will complement the port's response and rescue.
- A port contingency plan that addresses remedial actions at the port in the occurrence of an abnormal event, has been developed by the port. At the time of the contingency planning workshop, the plan was being reviewed by firefighters and AMP.
- A spill response plan for the LNG import terminal will be developed in detailed engineering to cover contingency in the event of a release of other hydrocarbons such as diesel.
- The port facility security assessment (PFSA) will include security related risks at the port and address contingency in the occurrence of a security threat.

2 Introduction

2.1 Background

LR has been engaged by Invenergy to carry out a high-level review of the contingency plan for the LNG import terminal in Acajutla, El Salvador, in the FEED phase.

The EDP LNG import terminal is designed to receive LNG from an LNGC and supply natural gas to a power plant and power to end consumers in El Salvador. The following operations will be performed:

- An LNGC will offload LNG to an FSU.
- The FSU will transfer LNG to a floating storage regasification unit (FSRU) where LNG will be processed into high-pressure natural gas.
- The natural gas will be transferred from the FSRU to the onshore plant via riser and pipeline.

The project was announced in November 2013 and is expected to start the first quarter of 2020.

2.2 Objective

This objective of this report is to review contingencies for the project based on the information available at the FEED phase of the project. The intent of the review is to ensure contingencies and possible emergency scenarios are addressed at an early stage of the project. This report will be included of the Environmental Impact Assessment (EIA) application.

The contingency plan for the project will be developed in detailed engineering, by EDP and other stakeholders.

2.3 Scope of Work

The scope includes the LNG import terminal and does not address contingencies at the plant onshore. A workshop methodology was employed to review contingencies at the LNG import terminal and those currently in place at the port.

The contingency planning workshop was conducted in San Salvador, El Salvador, on 15 June 2016. The participants included key regulatory bodies, stakeholders, project participants from the Maritime Port Authority, Government, Port of Acajutla, Invenergy, M&N, Exmar, Energía del Pacífico, and Lloyd’s Register.

3 Contingency Planning

3.1 Objective

EDP, at a later stage of the project development, will develop a contingency plan that addresses the contingencies for the hazards related to the LNG import terminal installation.

The primary purpose of contingency planning for a project is to be prepared to respond to abnormal events when they occur. Contingency planning is usually based on several inputs such as risk analyses, and allows for emergency preparedness, as depicted in Figure 3.1. In the early design phase of a project, contingency planning is based on risk analysis to identify abnormal events and plan on contingency in the occurrence of such events. In the operational phase of the project, contingency planning should also include other sources of information such as accident reports and inspections to keep the plan updated at all times. It is best practice to begin contingency planning early in a project's life and continue to evolve as the work progresses through the project's life cycle. Figure 3.1 also shows that contingency planning is input to emergency preparedness. The effectiveness of the plan depends on the personnel regularly exercising their respective roles and responsibilities through training and exercises. Contingency planning will also allow the proponent to harmonize with existing emergency operation procedures, and to ensure an integrated and coordinated response with other key authorities such as the port authorities (AMP, CEPA) and the Ministerio de Medio Ambiente y Recursos Naturales (Ministry of Environment and Natural Resources – MARN).

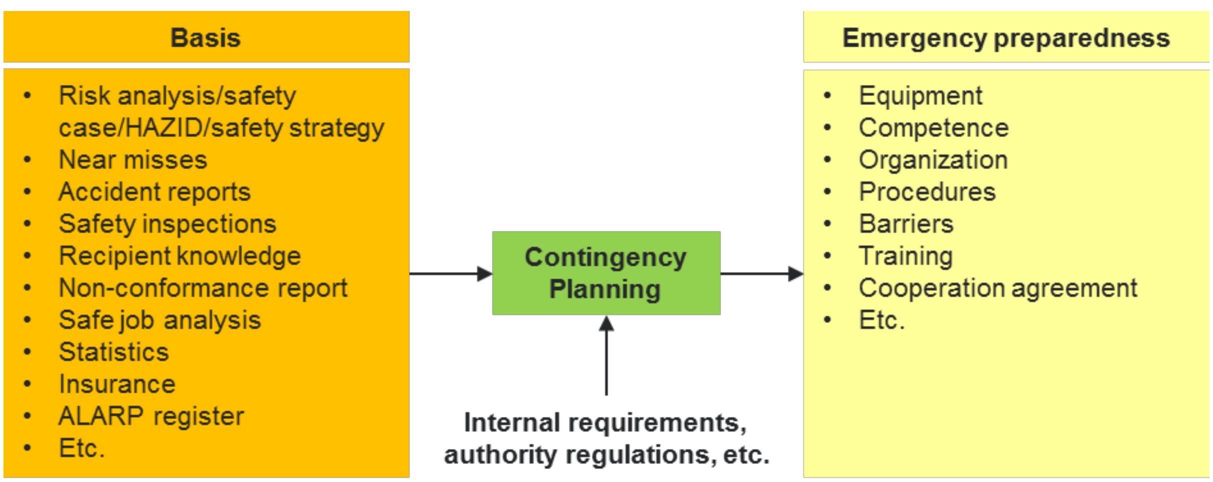


Figure 3.1: Contingency planning basis.

3.2 Contingency Planning Workshop

3.2.1 Methodology

A contingency planning workshop was carried out in the FEED phase of the project by a team of competent personnel. The purpose of the workshop was to review the contingency/emergency response in the occurrence of an abnormal event. The hazards assessed in the workshop are taken from the HAZID [1] and marine HAZID [2] and are listed in Table 3.1. Consequences to personnel, simultaneous operations at the port, environment, and third party, including the proper emergency response, were discussed and captured in a worksheet. The complete worksheet can be found in Appendix A.

Table 3.1: Critical Hazards

#	Defined Hazard and Accident Scenario
1	**Major Events**
1.1	Hydrocarbon leakage (LNG)/Gas dispersion
1.2	Fire (if LNG is ignited)
1.3	Rapid phase transition (RPT)
1.4	Toxic or flammable chemical leakage
1.5	Explosion
2	**Natural Hazards**
2.1	Short period sea movement
2.2	Long period swells
2.3	Tsunami, near field
2.4	Tsunami, far field
2.5	Seismic activity, earthquake
2.6	Electrical storm
2.7	High wind
3	**Dropped Objects**
3.1	Dropped objects during crane lifting or while transferring cargo from supply vessel to FSRU
3.2	Dropped objects during crane lifting on FSU
3.3	Dropped object on subsea pipeline to shore
4	**Riser and Subsea Pipeline**
4.1	Gas leakage to environment, subsea source (subsea pipeline or riser underwater)
4.2	Gas leakage to environment, topside source (connection to FSRU, riser part above sea)
5	**Security**
5.1	Security threats
6	**Other**
6.1	Leak of hydrocarbons of fire from another ship (e.g., sailing or berthed in port of Acajutla, berthed in Cenérgica terminal, berthed in Rasa terminal, or berthed in Alba terminal)

3.2.2 Participants List

A contingency planning workshop was conducted at the Hilton Princess Hotel in San Salvador, El Salvador, on 15 June 2016. Key participants at the workshop included personnel from regulatory bodies, stakeholders, and project participants from the Maritime Port Authority, Government, CEPA, Invenergy, M&N, Exmar, Energía del

Pacífico, and LR. The expertise of the team, both with respect to technical engineering and maritime operational experience, was considered appropriate and adequate for the workshop.

Representatives from LR facilitated and scribed the review. A list of workshop participants is presented in Table 3.2.

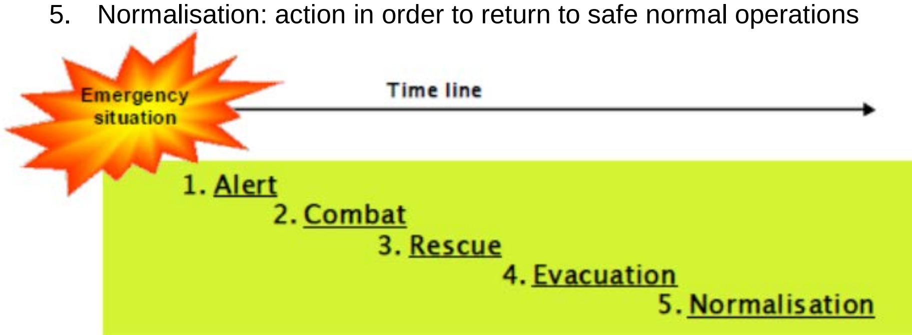
Table 3.2: Workshop Participants

	Name	Company	Discipline	E-mail Address
1	Captain Marco Aguirre	CAMS	Marine advisor	marcoernestoa@yahoo.es
2	Captain John E. Keon	CAMS	Local marine advisor	elsalmar1@msn.com
3	Alonso Valdemar Sarania	STPP	Electrical engineer	asarania@presidencia.gob.sv
4	Ernesto Mendez	STPP	Electrical engineer	amendez@ presidencia.gob.sv
5	Mario Chavarría	MINEC	Legal advisor	mchavarria@minec.gob.sv
6	Manuel Aicides Mejía Valiente	MINEC	Inspector	mmejia@minec.gob.sv
7	Salvador Eliú Avendaño Vásquez	MINEC	Inspector	savendano@minec.gob.sv eliuaven@gmail.com
8	Jesús Ricardo Andrade Hernández	MINEC	Technical coordinator, supervision and control	jandrade@minec.gob.sv
9	José E. Hernández	CEPA	Pilot	josehernandez_67@hotmail.com
10	Roberto Mendoza	CEPA	Manager of port of Acajutla	roberto.mendoza@cepa.gob.sv
11	Tatiana Chacón	AMP	Port infrastructure	echacon@amp.gob.sv
12	Yid Zelada Quán	MARN	Environmental evaluation	yzelada@marn.gob.sv
13	Lisbia Teresa Jarquin	Eco Ingenieros	Consultant, environmental management	l.jarquin@eco-ingenieros.com
14	Luc Saerens	Exmar	HSE	luc.saerens@exmar.be
15	Ashwini Kumar	Exmar	Project manager	ashwini.kumar@exmar.be
16	Eric Smith	M&N	Coastal, navigation engineering	esmith@moffattnichol.com
17	Bob Beasley	M&N	Project manager	rbeasley@moffattnichol.com
18	Horacio Larios	EDP	Project manager	hlarios@invenergyllc.com
19	Javier Mina	EDP	Engineering	lmina@edp.com.sv
20	Rupal Soni	Invenergy	Engineering	rsoni@invenergyllc.com
21	Diego Canal Sáez	Invenergy	Project engineer	dcanalsaez@invenergyllc.com
22	Felipe Mazzini	Invenergy	Project director	fmazzini@invenergyllc.com
23	Rhey Lee	LR	Technical safety/risk	rhey.lee@lr.org
24	Danielle Chrun	LR	Facilitator	danielle.chrun@lr.org

3.2.3 Contingency Planning Worksheet

The worksheet is attached in Appendix A. The worksheet columns are described in Table 3.3.

Table 3.3: Contingency Planning Worksheet Fields Description

Worksheet Field	Description
ID	Unique identification number for each item discussed.
Defined Hazard and Accident Scenario	Hazards normal operation, as identified in the HAZID [1] or marine HAZID [2].
Description of Scenario	Description of scenario and of potential escalation of the scenario.
Consequences	Consequences to personnel, environment, and third party (public).
Main Focus Areas for the Emergency Response	General response to accident scenario, such as securing/evacuating accident scene, alerting authorities, and ensuring asset integrity.
Response Procedure/Main Strategy	Response as it relates to the following, when applicable (see Figure 3.2, which presents the timeline for the response to an emergency situation): 1. Alerting relevant authorities 2. Combating accident 3. Rescuing personnel 4. Evacuating personnel or population 5. Normalisation: action in order to return to safe normal operations  **Figure 3.2: Response to an emergency situation.**
Response Equipment	Equipment involved in the response to accident, including equipment on board or at the port, when applicable.
Response Personnel	Personnel involved in the response to accident and can include LNG import terminal personnel or firefighters.
Interfaces and Requirements	Actions by authorities, including port authority.
Comments [C]/ Recommendations [R]	Comments and recommendations are stated in this column.

4 LNG

The EDP LNG import terminal will be the first installation in the port of Acajutla to handle and process LNG. This chapter presents general description of LNG, for an understanding of its properties and the hazards associated with it.

LNG is liquefied natural gas (predominantly methane) that is odorless, colorless, and nontoxic. It will be transported by an LNGC in a liquid form and delivered to the LNG import terminal. The liquid form of LNG allows for easier and safer storage and transportation than its form as a gas. The LNG will then be processed into natural gas at the LNG import terminal: its volume increases by a factor of 600 as it changes from liquid to gas form. Natural gas will be transferred from the LNG import terminal to the power plant onshore via riser and pipeline.

Given LNG is stored at a very low temperature (approximately -160°C) in its liquid form, it can cause frostbite as it enters in contact with the skin. In gas form, LNG can cause asphyxiation and damage to the eyes. LNG vapors mixed with air are flammable and could be explosive in confined spaces.

Due to the nature of LNG, the following events need to be prevented and controlled:

- Spill
- Gas cloud formation
- Brittle fracture when in contact with deck plating
- Fast warm-up
- Ignition
- Fires—high-heat radiation, and pressure
- Explosion (Vapor cloud explosions are not found relevant due to open areas and no confined entrapment of gas from the defined spill scenarios.)

For the project, hazards are identified and documented in the HAZID and marine HAZID reports [1] [2]. Contingency planning includes mitigation measures and measures to prevent escalation of the occurrence of these events. Examples of mitigation measures include not permitting any ship to enter the port when a loss of containment has been identified at the LNG import terminal to prevent a fire escalation. Some of the safety equipment to control and prevent escalation includes the following:

- Deck water spray system on the tanker
- Dry chemical system on the tanker or terminal
- High-expansion foams and dual agent systems to suppress and control LNG vapor clouds on the tanker or at the terminal
- Water monitors on the tanker or at the terminal

5 LNG Import Terminal-Oriented Contingency Planning

The contingency plan for the LNG import terminal will be developed in detailed engineering. The contingency plan should provide guidance on response organization and procedures to enable the organization to efficiently respond in a coordinated manner to any accident involving the LNG import terminal. Accidents covered by the contingency plan should address, at a minimum, the following hazards:

- Loss of life
- Serious injury
- Tsunami
- Seismic activity
- LNG leakage
- Fire if LNG is ignited
- Explosion if found relevant
- Collision with another vessel
- Grounding if found relevant
- Spill of other hydrocarbons such as diesel
- Security threats
- Leak of hydrocarbons or fire from another ship

Contingencies at the LNG import terminal were discussed during the contingency planning workshop. The main discussions are summarized below:

- Communication system: The Vessel Traffic Service (VTS) system will ensure that the accident is broadcasted to other ships and to the port.
- Emergency response team: At a later stage, key roles in the emergency response team will be identified and assigned. For example, a salvage master may be appointed.
- Tsunami/Swells/Seismic activity: The project will evaluate the need for the LNGC and FSU to leave the LNG import terminal in the event of a tsunami, swells, or seismic activity. The project will consider a self-powered FSU or dedicated tugs to move the FSU in the event where the FSU needs to be moved to a safe location.
- Fire on board LNG import terminal: A fire on board the LNG import terminal may escalate to other areas. The LNG import terminal will be equipped with firefighting capabilities. Fire and gas detection and protection will be part of fire and explosion analysis in detailed engineering.
- Hydrocarbon (other than LNG) spill: A spill response plan will be developed at a later stage of the project to cover contingency in the event of a release of other hydrocarbons such as diesel.
- Security threats: A port facility security assessment (PFSA) will be developed in detailed engineering. The PFSA will cover security issues at the port and address contingency in the occurrence of a security threat.
- Emergency shutdown (ESD) system: The ESD system will be one of the main response equipment to isolate a leakage of LNG and mitigate the consequences quickly.
- Evacuation of personnel on board: Evacuation of personnel will depend on the situation.
- Normalization: After the accident, if operations at the LNG import terminal were stopped, operations will resume in accordance with international standards, local requirements, and operating permit.

6 Port Contingency Planning

The port of Acajutla has developed a contingency plan for the port's current operations that defines procedures to follow in the occurrence of an accident for all traffic entering, approaching, or exiting the port. During the workshop, it was discussed that the plan should define the actions to undertake in the occurrence of such events, including alerting, combatting the event, rescuing personnel on board or onshore, and evacuating. The plan should also define all the parties to be involved. It is a joint effort between the port authority, firefighters, and AMP. At the time of the contingency workshop (June 2016), the plan was not available for review. It was, however, submitted to and was being reviewed by the fire department and AMP. Once the project evolves, its operations will be included in the port contingency plan. Current contingency at the port is discussed below.

In the event of an accident, such as fire on board a vessel, the port authority will be alerted via the VTS system. The port will decide the remedial actions at the port, such as alerting firefighters, putting tugs on standby, adjusting ongoing operations, stopping operations, or evacuating to the port of refuge. The port of Acajutla will prioritize port traffic and coordinate the firefighting support. Given that the LNG import terminal will most likely be the last on the priority list, dedicated, adequate, standalone firefighting capabilities, such as a dedicated security/firefighting tug, are currently being evaluated for the project.

Currently, in the occurrence of an abnormal event at the port, the warning from a loud audible alarm is provided to the port. The port authority will inform the civil protection group. The civil protection group will assess the situation and decide whether to evacuate or muster in place. Municipalities will be notified in the case of evacuation and will coordinate the evacuation of people to safety. The project's contingency response will be approved by the civil protection group through the fire department to ensure timely notification and coordination.

In the event of a fire, CEPA will coordinate the effort at the port. Currently, the port of Acajutla has firefighting crew and ambulance available. The city of Acajutla does not have firefighting capabilities and ambulance. In an emergency, firefighters and ambulance from Sonsonate (15-20 minutes away from the port) could also respond to assist onshore.

The control tower at the port of Acajutla uses aids to be kept informed on the sea and weather conditions. The National System of Territorial Studies (Servicio Nacional de Estudios Territoriales – SNET) is used to monitor the weather conditions such as the speed of current and the Pacific Tsunami Warning Center (PTWC) in Hawaii is used to alert and warn authorities. In the event of a tsunami, the control tower and the port operations receive notification to evacuate to a safe location.

In the event of an evacuation, the port will coordinate the effort to leave to a safe location. The port will prioritize traffic and ensure all vessels reach a safe location. Current movement in the port is limited to one vessel at a time due to current pilot and tug capabilities.

7 Recommendations from Contingency Planning Workshop

Recommendations that were identified in the workshop are listed in Table 7.1. All recommendations should be followed up and closed out by the responsible party.

Table 7.1: Recommendations

ID	Recommendations	Responsible
1.1	It is recommended that the project is plugged into the civil protection communication network.	EDP
2.4	Consider dedicated tugs for the project.	EDP
2.4	Consider additional thrusters to allow FSU to move away from LNG import terminal upon tsunami warning.	EDP
2.4	Consider implementing a redundant warning system, in addition to the Pacific Tsunami Warning Center (PTWC) system.	EDP

8 References

[1] Lloyd's Register, "Invenergy Power to Shore Project, LaPaz, El Salvador – HAZID Report", Report No. US4122.1, Rev. Final B, 03 March 2016.

[2] Lloyd's Register, "Invenergy Power to Shore Project, LaPaz, El Salvador – Marine HAZID Report", Report No. US4122.2, Rev. Final, 03 March 2016.

Appendix A

Contingency Planning Worksheet

#	Defined Hazard and Accident Scenario	Description of Scenario	Consequences	Main Focus Areas for the Emergency Response	Response Procedure/Main Strategy	Response Equipment	Response Personnel	Interfaces and Requirements	Comments [C]/Recommendations [R]
1	**Major Events**								
1.1	Hydrocarbon leakage (LNG) / Gas dispersion	Large leakage of LNG to the environment (spill on water) reaching the port. Case of no ignition.	- **Personnel:** Potential fatalities. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** Possible consequences primarily from gas dispersion to 3rd parties and population in the proximity.	- Secure accident scene - Evacuate personnel from exposed area - Medical assistance - Control release - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources, notify civil protection entity. - **Combat:** According to emergency response plan - **Rescue:** If necessary - **Evacuation:** If necessary - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Fire and gas detection - Fire and gas protection - Firefighting tugs - ESD system	- Emergency response team - LNG import terminal crew - Salvage master if required - Fire fighters/first responders from port of Acajutla if necessary - Tug operators	- **Port authority:** Notification of emergency, evacuation of port if necessary, stop/manage traffic in the effected area. - **Other terminals:** N/A - **Power plant:** If necessary, notification / communication to the power plant.	[C] An assessment will evaluate the extent of the leak, ability to isolate the leak, gas cloud, weather condition and as a result, which areas are at risk. Recommendation to the port will be made accordingly. Project will evaluate the need to move out LNGC or FSU and the need for thruster for FSU, pending availability of tugs to assist LNG import terminal on demand. [C] Currently, port of Acajutla has fire fighting crew and ambulance available in the event of an emergency situation. The city of Acajutla does not have fire fighters and ambulance. If more resources are required in an emergency event (e.g. two simultaneous emergency events), fire fighters and ambulance from Sonsonate could respond (15-20 minutes away from the port) to assist onshore. [R] It is recommended that the project is plugged into the civil protection communication network [EDP]. [C] In the event of an emergency, the port of Acajutla will prioritize port traffic and coordinate the firefighting support. Given the LNG import terminal will most likely be the last on the priority list, dedicated, adequate, standalone firefighting capabilities should be considered for the project. Dedicated security/firefighting tug is currently being evaluated. [C] Fire and gas detection and protection will be part of fire and explosion analysis in detailed engineering.
1.2	Fire (if LNG is ignited)	Leakage of LNG to the environment (spill on water). Fire if ignition source ignites gas cloud.	- **Personnel:** Potential fatalities. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** Possible consequences primarily only from flash fire (not pool or jet fire) to 3rd parties and population in the proximity.	- Secure accident scene - Evacuate personnel from exposed area - Medical assistance - Control release - Control/extinguish release and/or fire - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** If necessary - **Evacuation:** If necessary - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Fire and gas detection - Fire and gas protection - Firefighting tugs - ESD system	- Emergency response team - LNG import terminal crew - Salvage master if required - Fire fighters/first responders from port of Acajutla if necessary - Tug operators	- **Port authority:** Notification of emergency, evacuation of port if necessary, stop/manage traffic in the effected area. - **Other terminals:** N/A - **Power plant:** If necessary, notification / communication to the power plant.	[C] Currently, port of Acajutla has fire fighting crew and ambulance available in the event of an emergency situation. The city of Acajutla does not have fire fighters and ambulance. If more resources are required in an emergency event (e.g. two simultaneous emergency events), fire fighters and ambulance from Sonsonate will respond (15-20 minutes away from the port). [C] Dedicated security/firefighting tug is currently being evaluated. [C] Fire and gas detection and protection will be part of fire and explosion analysis in detailed engineering.
1.3	Rapid phase transition (RPT)	Large leak of LNG to sea and conditions for RPT are present. **Escalation:** Potential cold explosion. Consequence depends on LNG composition, water temperature, spill amount and flow rate into water. The right conditions to be present to have RPT, likelihood is very low for a well designed facility	- **Personnel:** Potential fatalities. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** None anticipated due to local effects.	- Secure accident scene - Evacuate personnel from exposed area - Medical assistance - Control release - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** If necessary - **Evacuation:** If necessary - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Fire and gas detection - Fire and gas protection - Firefighting tugs - ESD system	- Emergency response team - LNG import terminal crew - Salvage master if required - Fire fighters/first responders from port of Acajutla if necessary - Tug operators	- **Port authority:** Notification of emergency, evacuation of port if necessary, stop/manage traffic in the effected area. - **Other terminals:** N/A - **Power plant:** If necessary, notification / communication to the power plant.	[C] Currently, port of Acajutla has fire fighting crew and ambulance available in the event of an emergency situation. The city of Acajutla does not have fire fighters and ambulance. If more resources are required in an emergency event (e.g. two simultaneous emergency events), fire fighters and ambulance from Sonsonate will respond (15-20 minutes away from the port).
1.4	Toxic or flammable chemical leakage	Diesel stored at the FSRU is flammable and can lead to potential fire if ignited. **Escalation:** Fire if ignition source ignites diesel	- **Personnel:** Potential fatalities due to fire. - **Environment:** Diesel spill; impact to the marine environment. - **Public:** None anticipated due to local effects.	- Secure accident scene - Evacuate personnel from exposed area - Medical assistance - Control release - Control/extinguish release and/or fire - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan and to spill response plan - **Rescue:** If necessary - **Evacuation:** If necessary - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Fire and gas detection - Fire and gas protection - Firefighting tugs - ESD system	- Emergency response team - LNG import terminal crew - Salvage master if required - Fire fighters/first responders from port of Acajutla if necessary - Tug operators	- **Port authority:** Notification of emergency, evacuation of port if necessary, stop/manage traffic in the effected area. - **Other terminals:** N/A - **Power plant:** If necessary, notification / communication to the power plant.	[C] Currently, port of Acajutla has fire fighting crew and ambulance available in the event of an emergency situation. The city of Acajutla does not have fire fighters and ambulance. If more resources are required in an emergency event (e.g. two simultaneous emergency events), fire fighters and ambulance from Sonsonate will respond (15-20 minutes away from the port). [C] Dedicated security/firefighting tug is currently being evaluated. [C] Fire and gas detection and protection will be part of fire and explosion analysis in detailed engineering.
1.5	Explosion	N/A	N/A	N/A	N/A	N/A	N/A	N/A	[C] Based on the FEED design, the structure will be open; hence, there are no confined areas and no potential for explosions. No potential for explosions are considered in FEED. In Detailed Engineering, explosion events will be analyzed further in fire explosion analysis. Confined spaces will be limited but may not be completely eliminated.
2	**Natural Hazards**								
2.1	Short period sea movement	Local atmospheric conditions such as cyclones can lead to sea movement for a short period of time, creating waves of up to 3.6 m high. **Escalation:** This can lead to excessive movement of the LNGC and/or FSU.	- **Personnel:** Potential injuries depending on magnitude of the waves. - **Environment:** No anticipated consequence. - **Public:** No anticipated consequence.	- Medical assistance - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** For medical emergency only - **Evacuation:** For medical emergency only - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Tugs potentially - ESD systems	- Emergency response team - LNG import terminal crew - Salvage master if required - Tug operators	- **Port authority:** Notification of emergency if applicable, coordination of resources. - **Other terminals:** N/A - **Power plant:** N/A	[C] Coordination of emergency response resources (ambulance, fire fighters, etc..) to be determined at a later stage.
2.2	Long period swells	Climate, storms and hurricane activity can lead to long period swells with waves of up to 2.4 m high. Advanced warning not provided. **Escalation:** This can lead to excessive movement of the LNGC and/or FSU	Refer to item 1.1						
2.3	Tsunami, near-field	Climate, subduction zone outside coast of El Salvador, or seismic activity can result in a tsunami. Advanced warning not provided and/or exceeds design event **Escalation:** This can lead to excessive movement of the LNGC and/or FSU. Worst case scenario FSU breaks away and collides with LNG terminal or Cenérgica mooring buoys leading to loss of containment (only if impact energy >28 mJ).	- **Personnel:** Potential injuries depending on magnitude of the waves. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** No anticipated consequence.	- Medical assistance - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** For medical emergency only - **Evacuation:** For medical emergency only - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Tugs potentially - ESD systems - Anchors	- Emergency response team - LNG import terminal crew - Salvage master if required - Tug operators	- **Port authority:** Notification of emergency if applicable, coordination of resources. - **Other terminals:** Alerted via emergency channel. - **Power plant:** N/A	

#	Defined Hazard and Accident Scenario	Description of Scenario	Consequences	Main Focus Areas for the Emergency Response	Response Procedure/Main Strategy	Response Equipment	Response Personnel	Interfaces and Requirements	Comments [C]/Recommendations [R]
2.4	Tsunami, far-field	Climate, subduction zone outside coast of El Salvador, or seismic activity can result in a tsunami. **Escalation:** LNGC and FSU may leave the terminal upon advanced warning. Other vessels can collide in LNGC/FSU, leading to loss of containment (only if impact energy >28 mJ). No anticipated damage to FSRU given cofferdam structure. Potential damage to cofferdam structure.	- **Personnel:** Potential injuries depending on magnitude of the waves. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** No anticipated consequence.	- Medical assistance - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** For medical emergency only - **Evacuation:** LNGC and FSU may leave - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Tugs potentially - ESD systems - Anchors	- Emergency response team - LNG import terminal crew - Salvage master if required - Tug operators	- **Port authority:** notification of emergency if applicable, coordination of resources. - **Other terminals:** alerted via emergency channel. - **Power plant:** N/A	[C] In the situation where vessels need to leave to safe location, port will assist departure of vessels at the port first. [R] Consider dedicated tugs for the project [EDP]. [R] Consider additional thrusters to allow FSU to move away from LNG import terminal upon tsunami warning [EDP]. [R] Consider implementing a redundant warning system, in addition to the Pacific Tsunami Warning Center (PTWC) system [EDP].
2.5	Seismic activity, earthquake	Climate, subduction zone outside coast of El Salvador can result in seismic activity or earthquake. **Escalation:** Other vessels can collide in FSRU; no anticipated damage to FSRU given cofferdam structure. Potential damage to cofferdam structure , pipeline, fixed equipment/infrastructure. Potential fire.	- **Personnel:** Potential injuries depending on magnitude of seismic activity. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** Possible consequences primarily from gas dispersion from onshore pipeline to 3rd parties and population in the proximity.	- Medical assistance - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** For medical emergency only - **Evacuation:** None - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - ESD systems	- Emergency response team - LNG import terminal crew - Salvage master if required	- **Port authority:** notification of emergency if applicable, coordination of resources. - **Other terminals:** N/A - **Power plant:** If necessary, notification / communication to the power plant.	[C] Emergency Response Plan will be developed by the project.
2.6	Electrical storm	Chubascos in the region can cause electrical storms. **Escalation:** This can lead to damage to the infrastructure and potential fatalities.	- **Personnel:** Potential injuries depending on magnitude of the waves. - **Environment:** No anticipated consequence. - **Public:** No anticipated consequence.	- Medical assistance - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** For medical emergency only - **Evacuation:** For medical emergency only - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary	- Emergency response team - LNG import terminal crew - Salvage master if required	- **Port authority:** Notification of emergency if applicable, coordination of resources. - **Other terminals:** N/A - **Power plant:** N/A	[C] The LNG import terminal installation should be designed such that operations can be continued safely in the occurrence of electrical storms (e.g. mitigating measures venting)
2.7	High wind	Chubascos in the region can cause high winds. **Escalation:** This can lead to breakage of mooring lines.	- **Personnel:** No anticipated consequence. - **Environment:** No anticipated consequence. - **Public:** No anticipated consequence.	N/A	N/A	N/A	N/A	N/A	[C] The LNG import terminal installation should be designed to withstand high wind and continue operations in the occurrence of high wind conditions
3	**Dropped Objects**								
3.1	Dropped objects during crane lifting or while transferring cargo from supply vessel to FSRU	N/A	N/A	N/A	N/A	N/A	N/A	N/A	[C] Design of the installation should be such that no objects will be lifted over live equipment.
3.2	Dropped objects during crane lifting on FSU	Dropped objects during crane lifting due to human error or mechanical failure. **Escalation:** Damage to LNG transfer system or topside equipment on FSU.	- **Personnel:** Potential injuries - **Environment:** No anticipated consequence. - **Public:** No anticipated consequence.	- Medical assistance - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** For medical emergency only - **Evacuation:** For medical emergency only - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - ESD systems	- Emergency response team - FSU crew - Salvage master if required	- **Port authority:** Notification of emergency if applicable, coordination of resources. - **Other terminals:** N/A - **Power plant:** N/A	[C] Design of the installation should be such that no objects will be lifted over live equipment.
3.3	Dropped object on subsea pipeline to shore	Dragged and/or dropped anchor from another vessel on the subsea pipeline. **Escalation:** Damage to subsea pipeline. Potential loss of containment.	- **Personnel:** None anticipated. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** Potential effect due to gas dispersion nearby shore.	- Secure accident scene - Control release - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** For medical emergency only - **Evacuation:** None - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- ESD systems	- Emergency response team - LNG import terminal crew - Salvage master if required	- **Port authority:** Notification of emergency, evacuation of port if necessary, stop/manage traffic in the effected area. - **Other terminals:** N/A - **Power Plant:** If necessary, notification / communication to the LNG import terminal.	[C] Pipeline should be protected by design. [C] No anchoring zones are shown on nautical charts.
4	**Riser and Subsea Pipeline**								
4.1	Gas leakage to environment, subsea source (subsea pipeline or riser under water)	Rupture of riser subsea. **Escalation:** Release of gas to the environment. Case of no ignition	- **Personnel:** None anticipated. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** Potential effect due to gas dispersion nearby shore.	- Secure accident scene - Control release - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** For medical emergency only - **Evacuation:** None - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- ESD systems	- Emergency response team - LNG import terminal crew - Salvage master if required	- **Port authority:** Notification of emergency, evacuation of port if necessary, stop/manage traffic in the effected area. - **Other terminals:** N/A - **Power Plant:** If necessary, notification / communication to the LNG import terminal.	[C] Pipeline should be protected by design. [C] No anchoring zones are shown on nautical charts.
4.2	Gas leakage to environment, topside source (connection to FSRU, riser part above sea)	Rupture of riser due to ship collision in riser. **Escalation:** Release of gas to the environment. Potential jet fire if high pressure gas is ignited.	- **Personnel:** Potential fatalities due to fire. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** None anticipated due to the distance between the LNG import terminal and 3rd parties/population.	- Secure accident scene - Evacuate personnel from exposed area - Medical assistance - Control release - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources, notify civil protection entity. - **Combat:** According to emergency response plan - **Rescue:** If necessary - **Evacuation:** If necessary - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Fire and gas detection - Fire and gas protection - Firefighting tugs - ESD system	- Emergency response team - LNG import terminal crew - Salvage master if required - Fire fighters/first responders from port of Acajutla if necessary - Tug operators	- **Port authority:** Notification of emergency, evacuation of port if necessary, stop/manage traffic in the effected area. - **Other terminals:** N/A - **Power plant:** If necessary, notification / communication to the power plant.	[C] Design of the riser will be such that collision of a small vessel and the riser is prevented.
5	**Security**								
5.1	Security threats	Local security threats can have impact on safety of personnel and on assets and production.	- **Personnel:** Potentially, depending on situation. - **Environment:** None anticipated. - **Public:** None anticipated.	As needed: - Secure accident scene - Evacuate personnel from exposed area - Medical assistance	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to security plan - **Rescue:** If needed - **Evacuation:** If needed - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary	- Emergency response team - Port of Acajutla - Military/police	- **Port authority:** N/A - **Public agency:** Depending on initial emergency situation. - **Other terminals:** If necessary, notification / communication to the LNG import terminal.	[C] Security threats at the LNG import terminal will be addressed in the Port Facility Security Assessment (PFSA), which will be developed in the detailed engineering phase of the project.

#	Defined Hazard and Accident Scenario	Description of Scenario	Consequences	Main Focus Areas for the Emergency Response	Response Procedure/Main Strategy	Response Equipment	Response Personnel	Interfaces and Requirements	Comments [C]/Recommendations [R]
6	**Other**								
6.1	Leak of hydrocarbons of fire from another ship (e.g. sailing, or berthed in port of Acajutla, berthed in Cenérgica terminal, berthed in Rasa, terminal, berthed in Alba terminal)	Leakage of hydrocarbons from a ship. **Escalation**: Potential fire if ignited.	**- Personnel:** Potentially, depending on situation. **- Environment:** Potentially from other vessel, depending on situation. **- Public:** Potentially from other vessel, depending on situation.	As needed: - Secure accident scene - Evacuate personnel from exposed area - Medical assistance - Asset integrity	**- Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources, notify civil protection entity. **- Combat:** According to emergency response plan **- Rescue:** If necessary **- Evacuation:** If necessary **- Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Fire and gas detection - Fire and gas protection - Firefighting tugs - ESD system	- Emergency response team - LNG import terminal crew - Salvage master if required - Fire fighters/first responders from port of Acajutla if necessary - Tug operators	**- Port authority:** Notification of emergency, evacuation of port if necessary, stop/manage traffic in the effected area. **- Other terminals:** N/A **- Power plant:** If necessary, notification / communication to the power plant.	[C] Due to the distance between the LNG import terminal and the port / Cenérgica terminal / Rasa terminal / Alba terminal, localized fire not expected to impact the LNG import terminal.

Energía del Pacífico

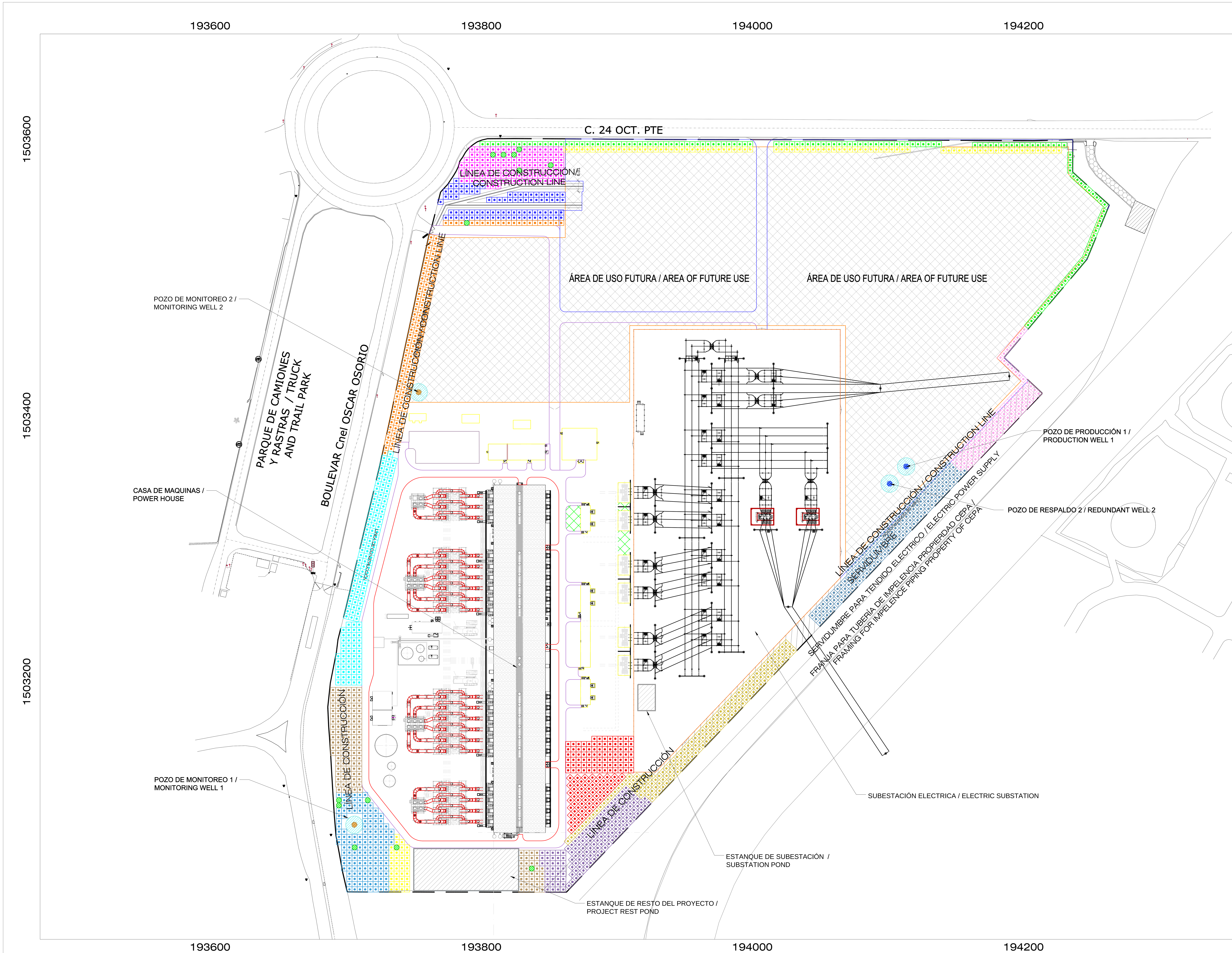
Appendix Chapter 10

December 2016 16-3489

ECO INGENIEROS
LÍDERES EN CONSULTORÍA AMBIENTAL

DILLON CONSULTING

Appendix 10A–
Revegetation Layout



Energía del Pacífico

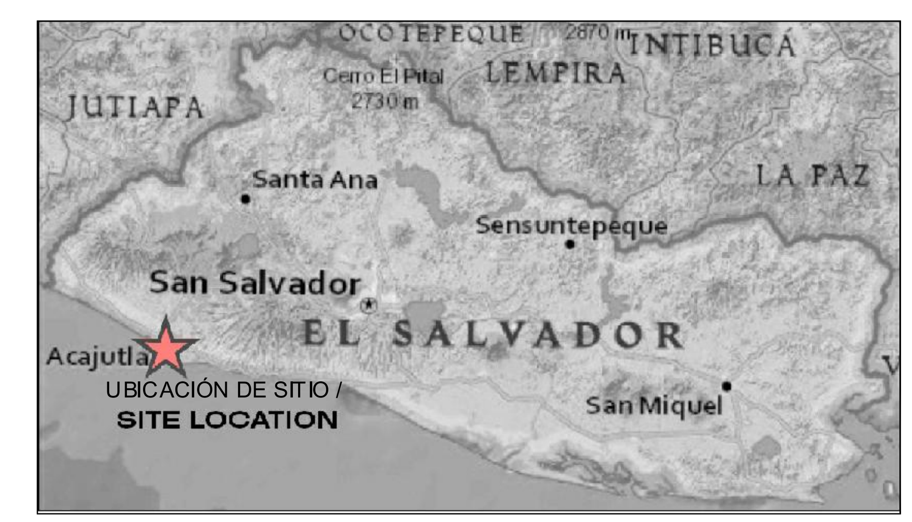
Energía del Pacífico

LNG TO POWER PROJECT

ARBORIZACIÓN EN EL PROYECTO / TREE PLANTING IN THE PROJECT

FIGURA 10.7 / FIGURE 10.7

CUADRO DE ÁRBOLES/ TABLE TREES			
NOMBRE COMÚN/ COMMON NAME	NOMBRE CIENTÍFICO/ SCIENTIFIC NAME	DISTANCIAMIENTO/ DISTANCING	CANTIDAD/ QUANTITY
"anona poshte"	Annona cherimola	3,00	122,00
"coco"	Cocus nucifera	3,00	142,00
"limón persa"	Citrus latifolia	3,00	133,00
"limón indio"	Citrus aurantifolia	3,00	90,00
"mandarina"	Citrus reticulata	3,00	150,00
"marañon"	Anacardium occidentale	3,00	150,00
"naranja valencia"	Citrus sinensis var. Valencia	3,00	150,00
"naranja victoria"	Citrus sinensis var. Tehuacan	3,00	150,00
"morro"	Crescentia alata	3,00	150,00
"madrecacao"	Gliricidia sepium	3,00	149,00
"naranja"	Citrus sinensis	3,00	150,00
Achiote	Bixa orellana	3,00	148,00
Casco de cabro	Bauhinla purpurea	3,00	97,00
TOTAL DE ÁRBOLES			1.781,00



0 10 20 30 40m

N W E S

FUENTE / SOURCE:
PLANOS WÄRTSILÄ / WÄRTSILÄ SITE PLAN

MAPA CREADO POR / MAP CREATED BY: ECO INGENIEROS
PROYECCIÓN DE MAPA / MAP PROJECTION :
UTM ZONA 16 WGS84 / UTM ZONE 16 WGS84
ARCHIVO / FILE
C:/CAP 10 ,ECO,DRAWING 1, EL SALVADOR/ ECO INGENIEROS
C:/CAP 10 ,ECO,DIBUJO 1, EL SALVADOR/ ECO INGENIEROS
PROYECTO / PROJECT: 14-9114
ESTADO / STATUS : FINAL / FINAL
FECHA / DATE: 12/01/2016

DILLON CONSULTING

ECO INGENIEROS
LÍDERES EN CONSULTORÍA AMBIENTAL

Appendix 10B–

Description of Land for Revegetation of the Mayor's Office of Acajutla

Energía del Pacífico
LNG to Power
Land proposed for revegetation

November 2014

Energía del Pacífico, LNG to Power: Land proposed for revegetation

November 2014

Prepared for:
ENERGÍA DEL PACÍFICO S.A. DE C.V.
El Salvador

Prepared by:

DILLON CONSULTING LIMITED	ECO INGENIEROS SA DE CV
Canada	El Salvador

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Appendix

1.0 Revegetation Sites

1.1 Site request

As part of the management for compensation through reforestation, the request was made to the Municipal Authority of Acajutla for available land that can be reforested. The Mayor's Office responded with a note dated November 7, 2014, providing a series of lands with possibilities for reforestation, including some with proposed projects for reforestation of mangroves, nine sites in total, which are monitored by the Municipal Environmental Unit of the Mayor's Office of Acajutla. See Annex A.

From the proposed lands, each one was evaluated to determine the available area and the feasibility of making use of them, selecting 6 of the 9 proposed to proceed to determine the number of trees that can be planted based on a distribution of trees with spacing 5 X 5, i.e. 25 m^2. These lands were selected for their physical characteristics of accessibility and closeness to the project in addition to the availability of land for afforestation since the 3 unselected had very little area for reforestation.

The following table 1.1 presents the selected land with the areas available for planting according to the inspections carried out and taking into account the sites already planted or used for other purposes. All terrains were checked to evaluate their conditions.

Table 1.1 – Land and number of trees to be planted (5 x 5)

NAME OF THE LAND	AVAILABLE AREA FOR PLANTING			NUMBER OF POSSIBLE TREES
	M2	V2	MZ	
LAND 1 METALIO	253,907.86	363,291.37	36.33	10,156.00
LAND 2 METALIO	146,657.47	209,837.51	20.98	5,866.00
LAND 3 ARENERO	10,463.48	14,971.15	1.50	418.00
LAND 4 PLAYA COSTA AZUL	10,103.31	14,455.82	1.45	404.00
LAND 5 BARRIO LA PLAYA	19,426.33	27,795.19	2.78	777.00
LAND 6 CARRETERA LA HACHADURA	12,337.77	17,652.88	1.77	493.00
TOTAL	452,896.22	648,003.91	64.80	18,114.00

The following figure 1 shows a general map of the selected terrains.

Figure 1 Location of proposed sites for reforestation

Source: Own Elaboration, 2014

The proposed sites are listed below.

1.1.1 Site: Metalío 1

The land denominated Metalio 1 is predominantly flat with the presence of a forest with a considerable density towards the south, is separated at an average of 600 ms from the coast, the land currently available for planting of trees is of 253,907.86 m2 on which a planting of approximately 10,156 trees with a spacing of 5 x 5 m can be done.

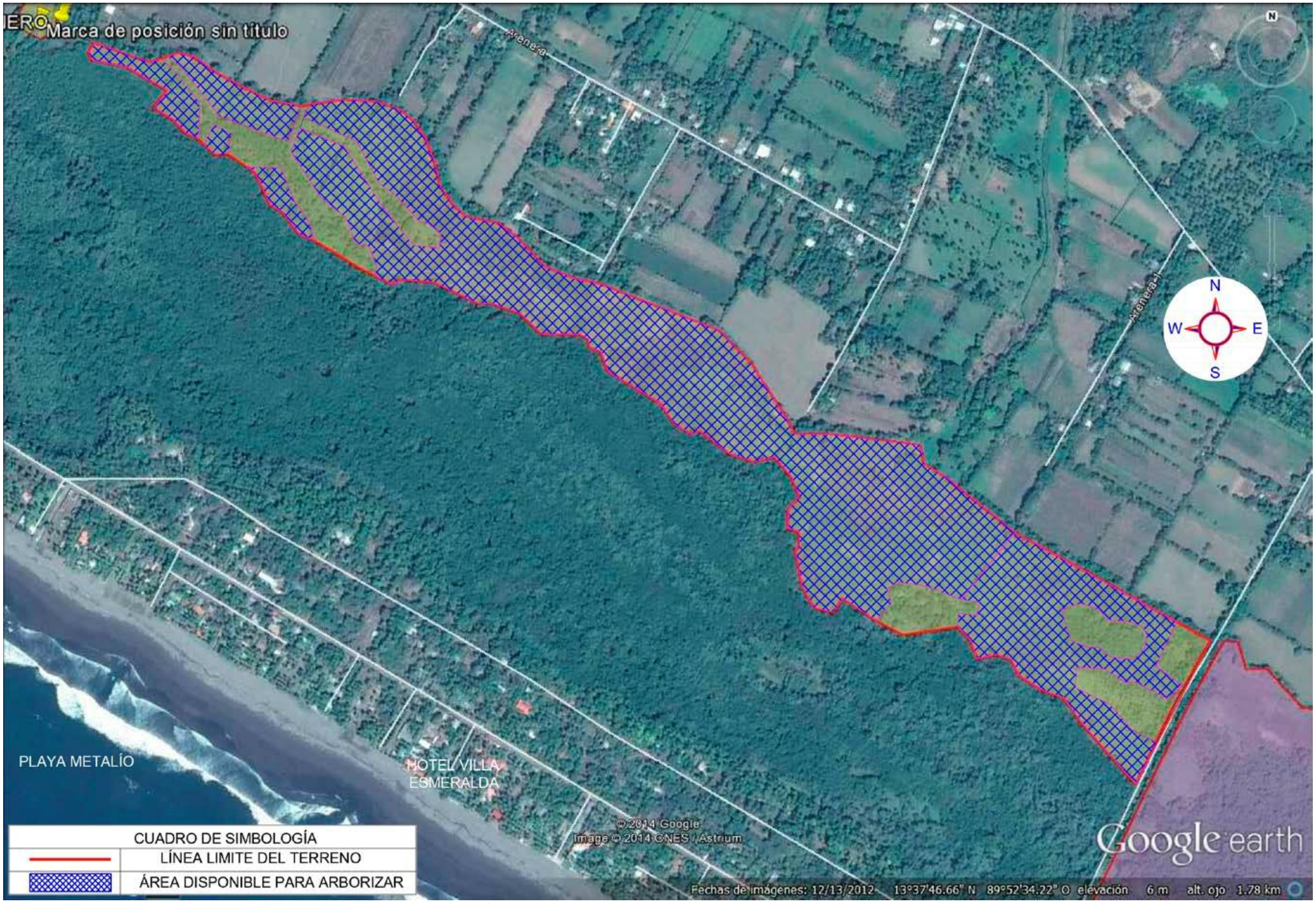
This is the land that can house as many trees as proposed by the Municipality of Acajutla and is located at a distance of approximately 6 km from the project site. Afforestation in the area, would give continuity to the existing wooded area.

Photographs 1 show different views of the proposed reforestation land and the surrounding area with existing trees.

Photo 1 – Different views of the site located playa Metalío

Figure 2 shows the location of the land with the location coordinate 13°37’51.59” N, 89°52´32.15” O; south of Metalío.

Figure 2 Location Metalio 1



Source: Own Elaboration, 2014

1.1.2 Site 2: Metalío 2

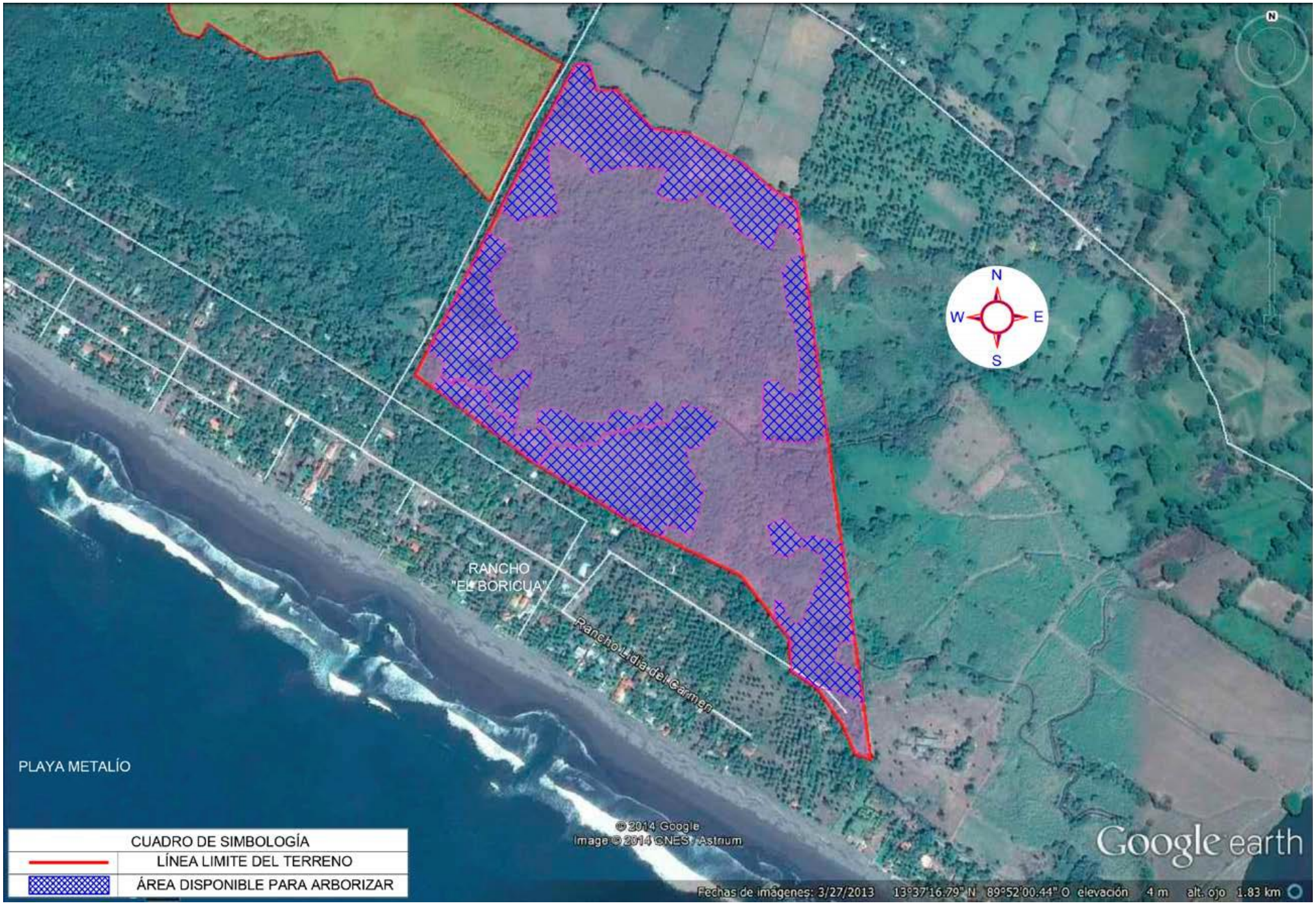
The second land is called Metalío 2 and has an area of 146,657.47 m^2 available for reforestation, which can hold up to 5,866 trees. This area is to the northeast of the first proposed land, and about 5.5 km from the project site.

As in the previous land, there are free zones and others with dense vegetation, mainly in the central area of the terrain as seen in photo 2.

Photo 2 – Views of Metalío 2 Site

Figure 3 shows part of the Metalio 1 site and the areas available for reforestation within the Metalío 2 site.

Figure 3 Location Metalio 2



Sourcee: Own Elaboration, 2014

1.1.3 Site 3: El Arenero

The third site is called ''El Arenero'', and it is located northwest from Metalío 1 and near SON 24S street, which leads from Metalío to the beach. It consists of two areas, totaling an area of 10,463.48 m^2 available for reforestation, wich makes it available for planting approximately 418 trees

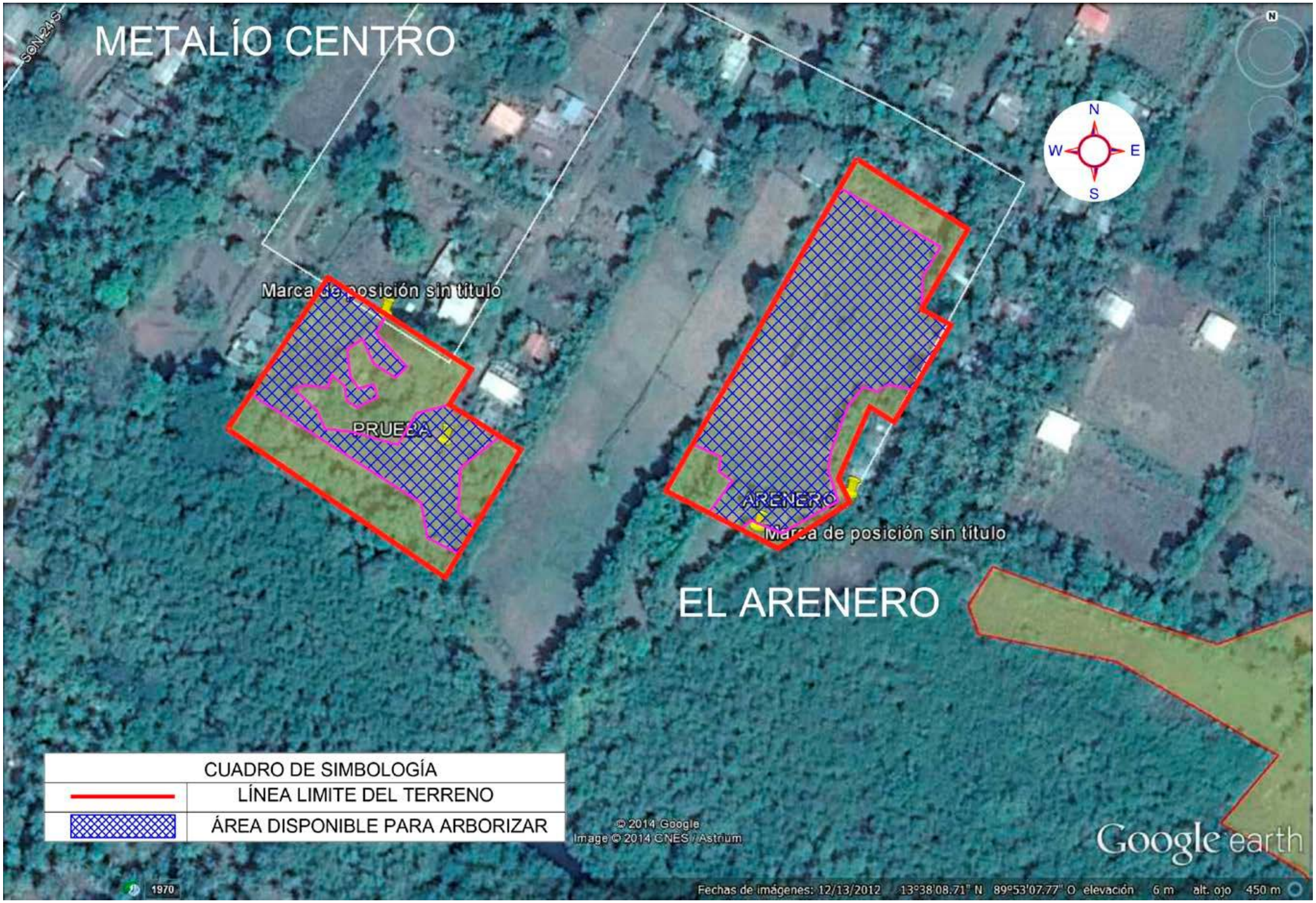
In photograph 3 you can see the land of El Arenero that currently do not have specific use and can give continuity to the revegetation of the area with the two previous lands.

Photo 3 – Views of El Arenero Site

These lands are at the coordinates of 13 ° 34'09.33 "N, 89 ° 53'11.28" W and 13 ° 38'10 ", 89 ° 53'05.58 ° C; Northwest of Metalío 1 and 8 km from the project site.

Figure 4 shows the two lands that form the site of El Arenero and part of the land Metalío 1 to the southeast.

Figure 4 Location El Arenero



Fuente: Elaboración Propia, 2014

1.1.4 Site 4: Costa Azul Beach

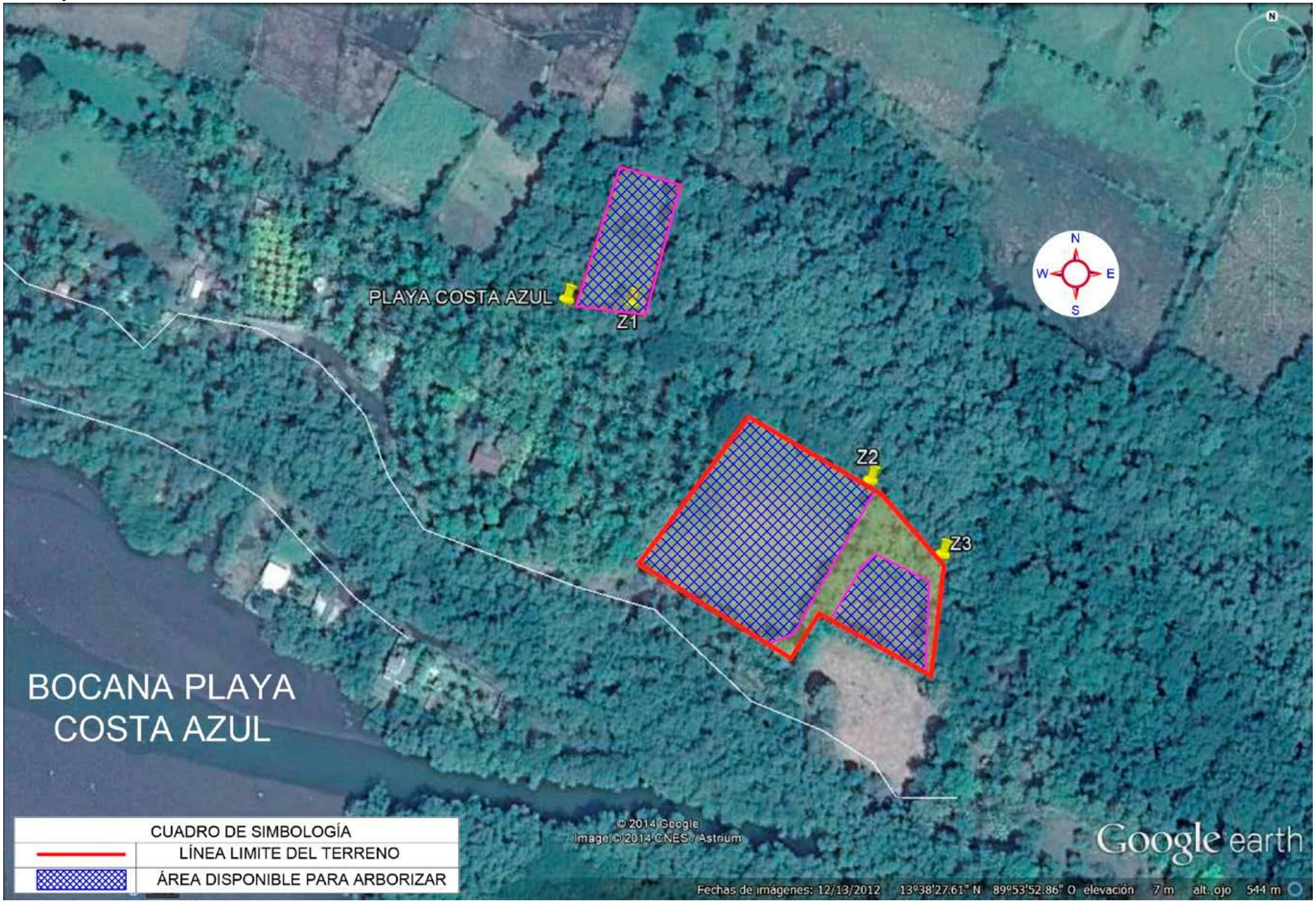
The site named Costa Azul Beach is formed by two portions with approximately 10,103.31 m2 inside which can be reforested with 404 trees with separations, as in the previous cases, of 5 X 5 m.

The land is mostly flat as can be seen in photograph 4. It currently has little vegetation and is located approximately 100 m from the mouth of Costa Azul beach, about 9.2 km from the project site.

Photograph 4 - Views of Playa Costa Azul Site

These lands are located at the coordinates 13°38´25.94” N, 89°53´50.42”W y 13°38’30.72”, 89°53´53.29” W; to the northwest of El Arenal.

Figure 5 Playa costa azul Site location



Fuente: Elaboración Propia, 2014

1.1.5 Site 5: Barrio la Playa

Another area proposed for reforestation is called Barrio La Playa which has an area of 19,426.33 m^2 available for planting approximately 777 trees, more than half the land is already vegetated and would complement the central area that has not yet dense vegetation.

This site is located in the City of Acajutla less than 1 km from the project site, there are some projects by the City Hall that can be integrated for tree compensation.

Photographs 5 show part of the land where there is afforestation surrounding the proposed area.

Photograph 5 - Views of the Barrio La Playa site




The terrain reference coordinates are 13 ° 35'41.93 "N, 89 ° 50'01.94", and it is less than one kilometer from the project site.

Figure 5 Location Barrio La Playa

Source: Own Elaboration, 2014

1.1.6 Site 6: El Milagro Lotification

The site of the Milagro Lotification is located northwest of the city of Acajutla and is available in the green area of the warehouse where there is an availability of 19,426.33 m2 where up to 493 trees can be planted.

The photographs show various views of the proposed site 3.8 km from the project site.

Photo 6 - Views of El Milagro Property

The location of the 13°35´39.84”, 89°48´36.56”O, shown in Figure 7.

Figure 7 Property El Milagro

Source: Own Elaboration, 2014

Municipality Authorization for properties for tree planting

ACT NUMBER ONE DATE: TWO-JANUARY-2015. AGREEMENT NUMBER TWENTY-NINE: The Municipal Council of the City of Acajutla, in use of the legal powers conferred by Article 203 and 204 of 18 Constitution of the Republic of Salvador and articles 30, clause 4 and 34 of the Municipal Code, CONSIDERING: I. As written written by the person in charge of the Municipal Environmental Unit in which he presents details of places to Reforest Partially and total within the Municipality of Acajutla, the company ENERGIA DEL PACIFICO, SA DE C.V., for after having analyzed the situation exposed, by all members of the Municipal Council, MAYORIA AGREE: I. AUTHORIZE AND APPROVE: That ENERGIA DEL PACIFICO, S.A. DE CV, in coordination With the Head of the Municipal Environmental Unit, carry out Reforest Partially and total within the Municipality of Acajutla, the following places: a.- Canton EI Suncita, Caserío La Brecha: 100% to reforest mangrove, total area to To verify in plane, this zone has been intentionally deforested by the villagers, disrespecting the marks that define the area of the tree. B.- Canton El Suncita, The Three RRR: 100% to reforest mangrove, total area to verify in flat area has been deforested in an intentional way by the villagers, disrespecting the landmarks that define the mangrove area. C.- Canton Punta Remedios Los Cobanos, Green Zone to measure, 10OOA. To reforest with fruit trees, d.- Canton El Coyol, Lot. El Milagro, El Milagro School, area 8 reforest 40% of the total area, shade trees and ornamental. D.- Canton EI Coyol, Lot. The Miracle, wide EI Miracle, total area to reforest, with shade trees. R.- Canton Metalio, Caserío Monzón, area to reforest 40% of 8 manzanas this area has been intentionally deforested by the villagers, Disrespecting the landmarks that define the mangrove area, g.- Metalla Canton, Bocana San Juan Puente, To reforest 30% of 10 Apples, the area has been intentionally deforested by the villagers, disrespecting the landmarks that define the mangrove area. H.- Metallo Canton, Costa Azul Beach, Antenna Setting Claro, area to reforest 100% of 8 Apples, this area has been intentionally deforested by the villagers, disrespecting the landmarks that define the area of the landscape. I.e. Barrio La Playa, Acajutla to reforest 40% of 6 Apples, this area has been intentionally deforested by the villagers, disrespecting the landmarks that define the mangrove area. D.- That José Arturo Flores, Decimo Regidor Propietario, Vilma Estela

Alvarenga of German, Third Regidora Propietaria, Iris Ivette Carolina Godoy de Ramírez, Sixth Regidora Proprietary and Julio Cesar Cabrera Guardado. Fourth Regidor Owner, abstain from voting; Making use of the right that assists him, according to article 45 of the Municipal Code, sal they vote for not agreeing on the decision taken. CERTIFY AND COMMUNICATE for the other administrative and legal effects thereof. And there being no more to record, the present we sign is closed. //////D.G.A.///////W.A.P.Calderon/// ///J.E.J.L/E.DI.HPB//varengadeAlmenan/JJC/DGMA//IICGR/JAOrtega//E.A.G.B./B.N.M. C.//J.Arturo//MTCastaneda//A.O// VHSorianoM//BE.Contreras/Sria. //////////////////////

""RUBRlCADAS ""

DONE IN THE SESSION ROOM OF THE MUNICIPAL MAYOR OF ACAJUTLA, TO THE FIVE YEARS OF THE MONTH OF JANUARY YEAR TWO THOUSAND FIFTEEN.

IT IS ACCORDING TO YOUR ORIGINAL WITH WHICH IT IS CONFIRMED.

ES CONFORME CON SU ORIGINAL CON EL CUAL SE CONFRONTO.----------

DARIO ERNESTO GUADRON AGREDA,
ALCALDE MUNICIPAL.

BLANCA ESTELA CONTRERAS,
SECRETARIA MUNICIPAL.

Appendix 10C–

Proposed Project Profiles for Fishermen

Energía del Pacífico

Project: LNG to Power
Appendix 10C: Summary of Compensation Projects for the Fishermen

December 2016 – 16-3489
14-9114

Project LNG to Power
Appendix 10C: Summary of Compensation Projects for Fishermen

December 2016
Project Reference: 16-3489

Prepared for:
ENERGÍA DEL PACÍFICO, S.A. DE C.V.
El Salvador

Prepared by:
DILLON CONSULTING LIMITED
Canadá

ECO INGENIEROS, S.A. DE C.V.
El Salvador

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1.0 Compensation Projects Summary

The construction activities, and finally, the presence of the dock, could generate the following impacts:

- Loss of fishing areas located nearby the coast and interference with artisanal fishing activities, both cooperative as well as independent (oyster and “tubero” fishermen).
- Make the fishermen from the artisanal pier, travel longer distances when they move to other fishing zones located near Punta Remedios.

Therefore, the following compensation measures have been determined to mitigate the impacts on this group, and the selected measures are listed below.

To benefit all fishermen in general and to compensate the members of the cooperatives affected by an increase in the distance of their journey:

- Installation of fish aggregating devices (FAD- "Fish Aggregating Device").
- Installation of a new winch.
- Artificial oyster reefs.

To compensate independent fishermen (oyster and “tubero” fishermen) they will be allowed to choose between:

- Participating in the construction of a cayuco (small canoe), complete safety training (including fishing methods), and receiving necessary implements and equipment for fishing.

- Receive training in an alternative line of work with the aim of leaving the fishing industry.

Below we describe the projects.

1.1 Installation of Fish Aggregating Devices

1.1.1 Background

With the installation of fish aggregating devices, new habitats are generated, allowing the fish to feed, develop and reproduce, which also increases catching possibilities in the area, thus generating higher incomes for the families of local fishermen. The installation of aggregators also protects the environment, as fishing is not allowed with illegal methods and fishing is carried out by hook.

At present, the capture levels of the marine resources have been reduced, not only in this local area, but also in all the coastal zone of El Salvador, due to climatic factors, disorderly exploitation of resources and pollution. These are the main causes in the reduction of the fishing and extraction of marine organisms, which contributes to the levels of poverty in many of the communities of fishermen, since in the majority of the cases, fishing is their only source of economic income. In the search of solutions to poverty levels, to the reductions in catches, and high costs of resources needed for fishing activities, the installation of Fish Aggregating Devices serves as a tool to increase fish population, which is reflected in the Increase of catches and economic incomes.

As of now, the use of Aggregating Devices, to increase marine production, provides substrate for algae and invertebrate settlement and growth, increases shelter and protection for juveniles during growth and development, as well as provides areas suitable for adults during reproduction time.

1.1.2 General Objective for the Project

- Create proper conditions for the reproduction, growth and development of fish with the installation of Fish Aggregating Devices (FAD).

1.1.3 Specific Objectives

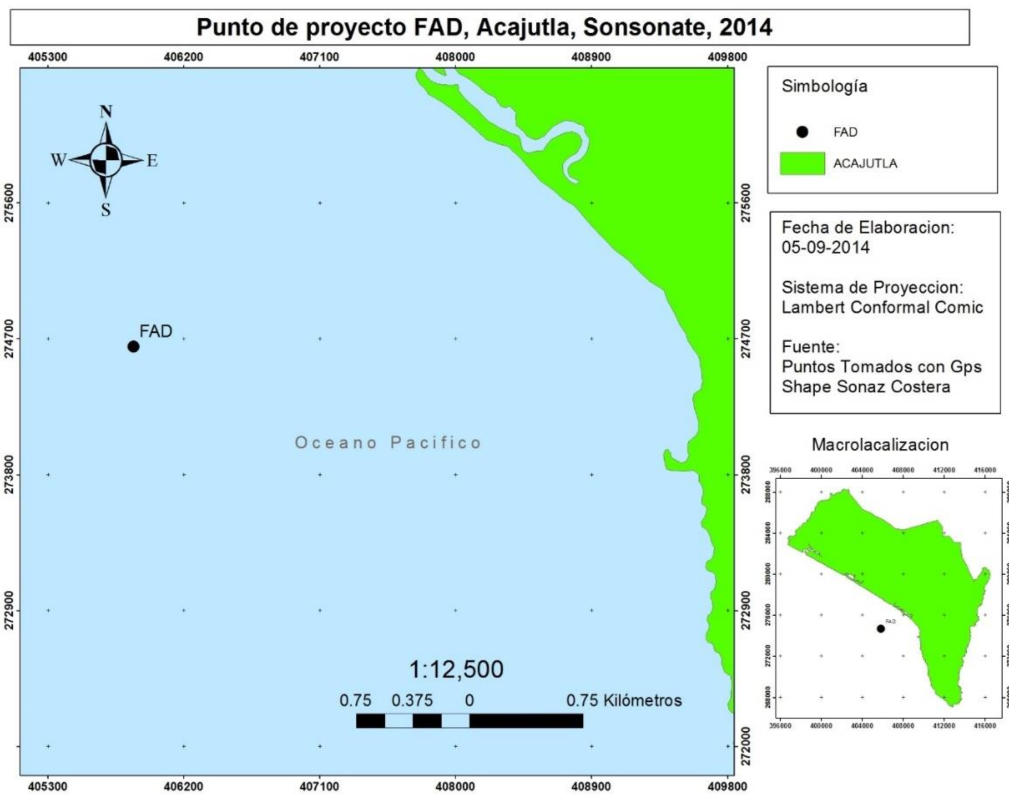
- Contribute to the recovery of fishing in the area, with the installation of floating aggregators.
- Reduce the current pressure in fish population, by installing hook-type fishing aggregators.
- Develop fishing and tourism activities by implementing the environmental regulations.

1.1.4 Project Description

The project will be located in Acajutla, Sonsonate, the area has the following coordinates: 13 ° 20'42.34¨LN 88 ° 58'26.99¨LO and 13 ° 20'46.55¨LN 88 ° 58'34.31¨LO, at an average depth of 10 to 20 meters, with a sand substrate and a mixture of small rock particles (Fig. 1: Project Location). In order to contribute to the creation of own habitats for fish reproduction and development, in communities interested in this type of project, especially in open sea areas, the use of FAD (Fish Aggregating Device) work best there (Figre 1.2: Design of Floating Fish Aggregating Device).

The total of Aggregators that are intended to be installed for this project are 15, and they are made of polyduct materials split in half through longitudinal cuts and will be fastened with ¾ silk lanyard as these provide longer life and their design does not cause potentially negative impact on the surrounding areas by the effect of currents and carry a concrete base (60 lb. Gramaquin) to keep them anchored vertically towards the float.

Figure1.1 – Proposed Location for FAD Project

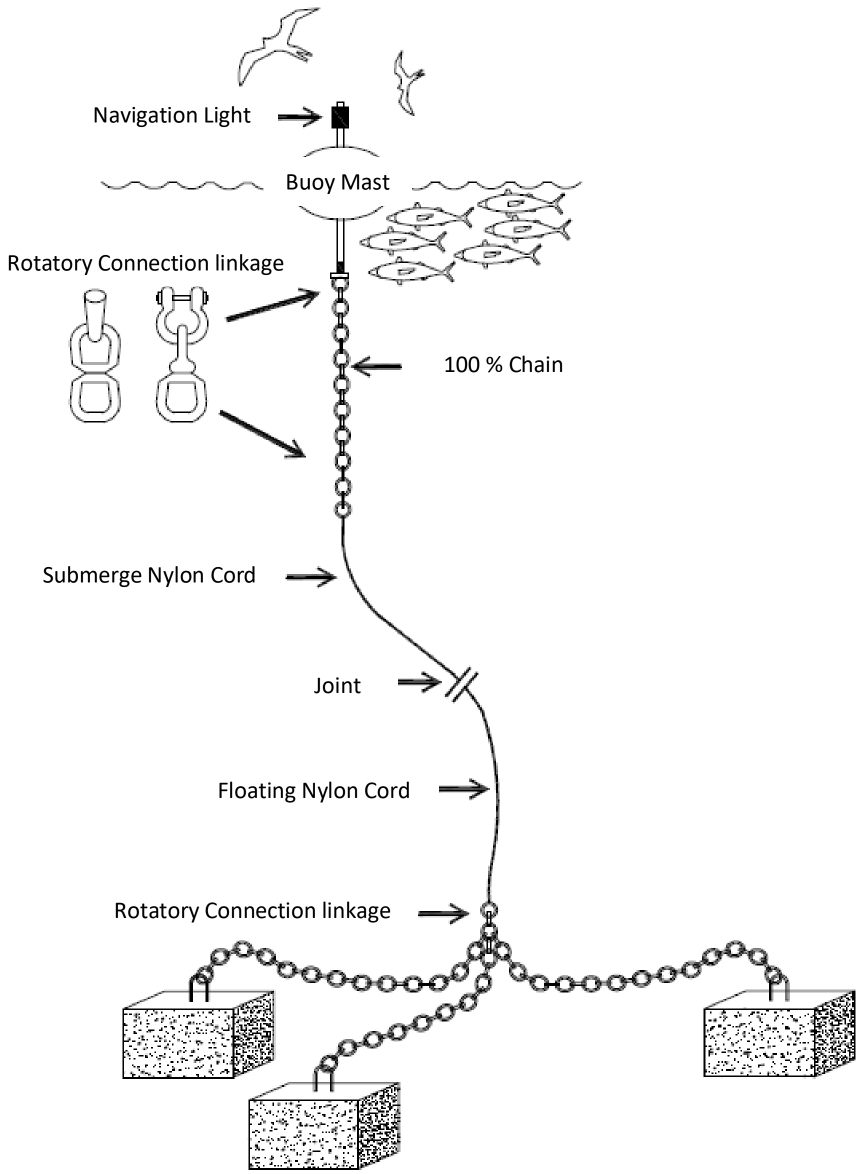


Source: Own elaboration

1.1.5 Components

- Floating fish aggregating devices
- Hooks
- Signs that signal de FAD zone

Figure 1.2 – FAD Device Design



Source: Own elaboration

Within the measures of restoration and rehabilitation of coastal ecosystems, the devices are used as open sea fishing tools. There are numerous examples worldwide where these devices have been used to perform important functions such as: physical protection of sensitive and fragile ecosystems and the replacement of a socio-economic resource. One of the important features is the protection and/or restoration of natural marine habitats, which is why they represent a great potential for habitat improvement.

1.2 Installation of new winch in artisanal dock

1.2.1 Background

There are two winches at the artisanal dock. One of them is completely rusty and needs to be replace. This one is located in the southwest, and there is only one working at the moment, which is located in the northeast. Below you can appreciate some images of both winches:

Photo 1-1– Image of only winch in use

Source: Picture taken by the consulting team

Photo 1-2– Image of the deteriorated winch

Source: Picture taken by the consulting team

1.2.2 Objectives

Installation of new winch to replace the deteriorated one, located southwest of the artisanal dock.

1.2.3 Description

Next, there is a detail of the components of the new winch that will be installed:

Table 1.1 – Detail of the components of new winch that will be installed	
Quantity	**Description**
2	H beams 6 meter long by 16 inches tall
4	Sheets of 1/2 inch thick of 1 by 2 meters
8	Carbon Steel Pulleys
150	Meters of steel wire of 5/8
4	Schackles of 1 inch thick
1	Stringer Steel wire
1	Hook Cashew shaped of 1 1/2 inches for 12 Tons
2	Adjustable tensioners 1 inch thick
1	Diesel engine of 28 HP and 1800 RPM
1	Motor reducer of 28 HP
1	Battery Diesel Engine 90 amps

Table 1.1 – Detail of the components of new winch that will be installed	
Quantity	**Description**
1	Diesel Engine Ignition Battery Cable
6	Sheets of 1/8 Tear Strips of 3 Meters
5	Tubes of 5-in. 1/4-inch thick
2	Tubes of 6.5-inch of carbon steel of 6 meters long
2	Tubes of Carbon Steel of 12 inches of diameter by 1/2-inch thick
19	Cutting Iron Discs of 9-inch
19	Polishing Iron Discs 9-inch
100	Pounds of Sweet Iron Electrode
50	Pounds of Stainless Steel Electrode
80	Pounds of electrode for Pipe 6010
8	Angles of 3-inch and 1/4 in thickness
1	Sprocket type pinch with 57 3/4 pitch teeth
1	3.5 Inch Sprocket of Step 3/4
1	Steel bar for 2-inch shaft
1	1 1/2 inch steel shaft bar
12	Gallons of Anticorrosion paint and plastic paint or FAST DRY paint
12	Gallons of strong thinner to dissolve paint
8	Gallons of Gray colored of MINIO Paint
	Other materials to use (oxigen and acetylene)
	Lathe Work Pay for the parts to be used
NOTES: * This crane does not include any electrical system because its design is for a Diesel Engine.	

Source: Own elaboration

1.3 Installation of artificial reefs nearby the area to Acajutla's oyster bank near the artisanal dock

An artificial reef is a submerged structure placed deliberately on the sea bed to imitate some of the characteristics of a natural reef. They may be partially exposed in some tide movements.

It is a fact that the deliberate sinking of objects in the sea by man, with a different objective than to get rid of them, is something that historically has been carried out with multiple purposes. From the recreation of habitats that could have a favorable effect in fish resources, to the defense of the coast against the erosive action of the sea, through the installation of structures that protect sensitive ecosystems against aggressive fishing practices, such as trawling, or disposition in the bottom, of elements that can be attractive for recreational diving, the reasons that can motivate the creation of an artificial reef are diverse, and in many cases, complementary.

Within the measures of protection, restoration and rehabilitation of marine-coastal ecosystems, artificial reefs appear as management and protection tools from a social and ecological perspective. There are numerous global examples where these structures have been used to perform various functions, for example: the physical protection of sensitive and fragile ecosystems, the addition or replacement of habitat complexity, the creation of new substrates, or the replacement of a socioeconomic resource. One of the most important functions of artificial reefs is the protection and/or restoration of natural marine habitats, mainly in the face of the danger posed by illegal fishing techniques (fishing tools prohibited by national regulations), which threaten to reduce critically the biodiversity of species within the continental shelf.

The main purposes of the use of artificial reefs have been, in this order, increased production of species associated with hard substrates (macroalgae, invertebrates and fishes) and to favor or increasethe species catches associated with reefs. There are many possible materials to achieve the same purpose. Concrete blocks of different morphology, breakwater dikes, ship hulls, simple or complex structures, branched, ceramic, PVC, mesh, etc. are some of the structures used as artificial reefs.

1.3.1 Main Objective of the Project

- Promote fishing with enviromentally friendly practices and improve the economy and quality of life of its beneficiaries.

1.3.2 Specific Objectives

- To achieve efficiency in the use of marine resources with the implementation of fishing techniques appropriate to the ecosystem.
- Protect biodiversity with the implementation of environmentally friendly practices.
- Search for new forms of fishing that guarantee economic sustainability.

1.3.3 Project Justification

- Low productivity, increased the operating costs deficiencies in the market due to lack of product on critical dates.
- The natural resource (oysters), has decreased in quantity and quality, loss of genetic diversity. The production is delivered to toponeros or is auction in the market due to the lack of constancy in the quantity and quality of products; the greatest profit is obtained by

the intermediary for reasons such as the absence of installed capacity to process or to refrigerate the production.
- Improvement of the livelihoods of the local population.
- Regulation of water flows, maintenance and increase of hydrological resources.
- Protect the country's food security.

The activity carried out by the project is justified by the social and economic situation that dominates the area. The activity aims to contribute to improving the living conditions of the population and the natural reproduction of marine species.

The fundamental criteria:
- Technical and scientific basis
- Active participation of users and stakeholders and normative-based attachment
- The regulation that allows the harmonious use of resources.

The project is located in Acajutla, department of Sonsonate, and is located at an average depth of 6 meters at low tide, with a substrate of talpetate. In order to contribute to the creation of adequate habitats for the reproduction of marine fish, in each community we intend to install 100 artificial concrete reefs in the form of a cube (Fig. 2). The artificial reefs that are intended to be installed are concrete because they provide longer life and its design does not impact the surrounding areas by the effect of the currents.

Needs of the Project (Economic and Social Justification):
Economic:
- Shortage of job sources for income generation.
- Low profitability in fishing activities and agriculture.
- Decrease in population subject to artisanal fisheries exploitation during some times of the year.

Social:
- Lack of job opportunities.
- High rates of poverty and illiteracy that generate low levels of human development.
- Lack of technical advice for the sustainable use of fishery resources.

Impact:
- Implementation of alternative methods of sustainable extraction of fishery resources.
- Creation of opportunities to improve the beneficiary’s family income levels.
- Strengthening local capacities on sustainable management of fishery resources.

Expected benefits from project's execution/implementation:

Artificial reefs are used as management and protection tools from an ecological perspective. They have been used to perform important functions such as: physical protection of sensitive and fragile ecosystems, addition or replacement of habitat complexity, creation of new substrates, or replacement of a socioeconomic resource. One of the important features of artificial reefs is the protection and / or restoration of natural marine habitats (oyster beds). They represent a great potential for habitat improvement and contribute to three important factors: (i) Restoration, which consists in returning a habitat to its original condition; Ii) rehabilitation, returning a habitat to another state; Iii) improvement, by adding something different to the ecosystem.

The shape and materials used for the construction of artificial reefs, due to management and placement issues, are important to consider due to the size and shape of the artificial reefs to be placed. Immediately after the artificial reefs are placed the fish are the first to colonize them and later the algae and small organisms like mollusks and crustaceans. For artificial reefs to be an important tool, it is necessary to develop and implement a management plan in the area of artificial reefs, as a tool for the management of fisheries from the following points of view: commercial, sporting and scientific.

One of the important features of artificial reefs is the protection and / or restoration of natural marine habitats, which is why they represent a great potential for habitat improvement and contribute to four important factors, such as:

- Restoration, which consists in returning a habitat to its original condition;
- Rehabilitation, returning a habitat to another state;
- Improvement, by adding something different to the habitat.
- Pressure, reducing the pressure of use towards a particular species (oyster bank), through new adaptive practices of environmentally friendly fishing (handline or hook fishing).

In many countries artificial reefs are built of wood, which can be bamboo, dry mangrove trees, or washed by the currents at the mouths of the rivers, forming trunks. In some cases it is observed that many fishermen in view of the limitation of dry mangrove trees, cut them green to dry them and thus to be able to use them, creating with this a problem in the search of a solution. This time, it is intended to install concrete reefs which are widely used for the creation of artificial ecosystems, because in addition to not being harmful to the environment, they are very effective and have a longer life (between 15 to 20 years).

All of the above, will give back to increase production, improve economic conditions of those involved in the project, increase purchasing power, solidification and business equipment, incursion into new markets, improvement of supply and demand and increase in the price of its products, experiences in the management and distribution of resources and local development.

1.3.4 Reasoning (Backgrounds and Expected Results)

Artificial reefs are used to increase populations of marine organisms because they create habitats that provide them with food and shelter in their stages of growth, development and reproduction. In addition to contributing to the recovery of the marine populations, because they protects areas of trawling; artificial reefs also contribute to fisheries organization and management by facilitating the implementation of resource management plans.

The fish in their juvenile stages are the first to arrive and little by little, others of greater size incorporate until they become colonized by adult individuals.

With the installation of artificial reefs in these communities, it is intended to expand habitats for marine organisms, which will allow them to feed, develop and reproduce. This will increase catches in the area, generating better economic income for the families concerned. In addition, fishing will be reduced with illegal methods, such as bombs, since in the area of the artificial reef, fishing will only be possible with a hook, which ensures an adequate and sustainable management in the area and an increase in catch sizes, increased productivity and diversity of species.

1.3.4.1 Product Extraction

In the artificial reef only the members of each beneficiary community will be able to fish and the commitments for the implementation of the use and management of this artificial ecosystem will be the following:

a) Only fishing with hand line (hook);
b) Nets or traps, floating or deep, with a maximum of FIVE per boat, regardless of size;
c) Fishing rods of any kind floating and deep;
d) Underwater fishing is only permitted without oxygen tanks, using harpoons without explosive tips; and
e) Diving with eco-diving equipment is allowed, provided that no extraction is carried out,

Inside the artificial reef area, the following won't be allowed:

a) To carry out extractions of organisms whose sizes are smaller than those authorized
b) To carry out trawling fishing within the area of artificial reefs;
c) Execute fishing using explosives;
d) Use in their extractive activities, no fishing gear made by netting, except for traps.

1.3.4.2 Commitments

- Fishermen who in the act of their activities catch live species with sizes smaller than those authorized by CENDEPESCA, must return them to their natural habitat.
- Any other art and method of unauthorized fishing that fishermen intend to implement in their days of extraction, must be previously evaluated and authorized by CENDEPESCA.
- In order to assess hydrobiological resources from reefs, each group will keep a record of fisheries, in order to monitor the productivity and effectiveness of artificial reefs in increasing fish stocks (populations).

Any violation to the previously stated agreements will be sanctioned according to the General Law of Management and Promotion of Fishing and Aquaculture.

1.3.5 Design

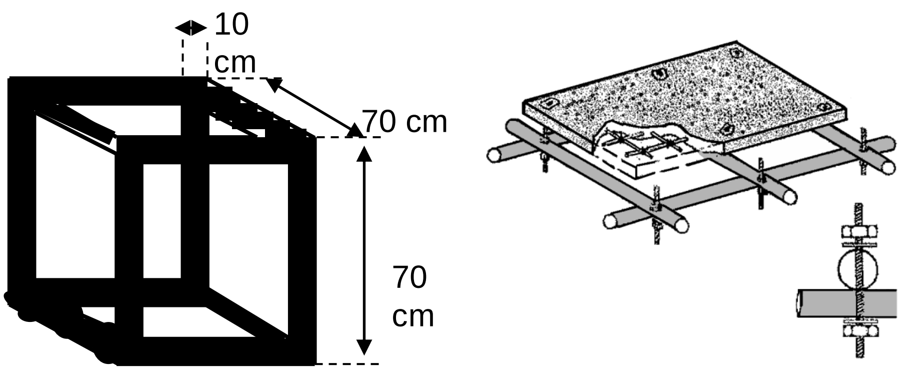
The objectives and characteristics of the reefs mainly respond to habitat protection, ecological restoration, control of fishing access, protection of marine reserves, and as a bonus, they improve fishing, separate conflicts between fishermen, protect breeding habitats and environmental mitigation.

Every AA must follow these 4 conditions:

- Functionality: related to the suitability of the chosen material in terms of being able to meet the desired goal.
- Compatibility: in relation to its possible toxicity and contamination of the environment.
- Durability: over the average lifetime of the material, which must be in line with the time it is intended to remain submerged and with the ability to perform its function.
- Stability: to maintain the structure in place and with the desired configuration.

This time, the most suitable material for this project are concrete blocks, which are composed of reinforced concrete materials and solid in various morphologies normally cubic, although there also exist cylindrical and pyramidal designs. These structures, due to their mass and design, tend to be very stable. For this project cubic forms will be installed.

Figure1.3 – Artificial concrete reefs for the restoration and settlement of species of commercial interest.



Source: Consulting team's drawing

1.3.6 Project Budget

Project's budget, detailing its main components:

Execution time: Fourth months.

Project amount: $ 10,650.90

Table 1.2 – General Budget for the Project				
No	**Description**	**Units**	**Unit Value**	**Total**
1	Purchase of artificial reefs			
1.1	Cube shaped reefs	100	60.00	6,000.00
1.2	Polyethylene rope roll 1" to install the reefs on the seabed.	1.00	265.00	265.00
1.3	1/2" polyethylene rope roll for buoy placement.	4.00	78.00	312.00
1.4	Signaling buoys for the area of artificial reefs	12.00	25.00	300.00
1.5	Installation of advertising poster in the area of artificial reefs	1.00	125.00	125.00
1.6	Construction of raft for transfer of artificial reefs1	1.00	200.00	200.00
1.7	Purchase of 12 plastic barrels	12.00	27.00	324.00
1.8	6-sided scantlings	40.00	1.70	68.00
1.9	6-rod flat ruler	6.00	1.40	8.40
1.10	1/2 " polyethylene rope roll to moor barrels	3.00	78.00	234.00
1.11	Construction of metallic support to install the artificial reefs in the bottom of the sea	1.00	200.00	200.00
1.12	Resin for sealing barrel plugs	1.00	15.00	15.00

Table 1.2 – General Budget for the Project				
No	**Description**	**Units**	**Unit Value**	**Total**
1.13	Fiberglass for sealing barrel plugs	5.00	1.50	7.50
1.14	Construction of supports for buoys	12.00	5.00	60.00
1.15	Construction of anchors for the raft	4.00	75.00	300.00
2	Supplies			
2.1	Boat rental	8.00	50.00	400.00
3	Facilitation			
3.1	Training on the importance of artificial reefs	3.00	50.00	150.00
3.2	Training to establish a regulation for fishing in the artificial reefs	4.00	50.00	200.00
3.3	D / H raft construction	12.00	10.00	120.00
3.4	Installation of D / H reefs	120.00	10.00	1,200.00
3.5	D / H buoy installation	4.00	10.00	40.00
3.6	Training on fishing logging (registry keeping) on artificial reefs	1.00	50.00	50.00
3.7	Construction of raft to transfer artificial reefs D / H	9.00	8.00	72.00
			TOTAL	10,650.90

Source: Own elaboration

1.4 Manufacturing of boats and training for independent fishermen

1.4.1 Backgrounds

Independent fishermen currently have very few opportunities to improve their situation and the methods they use to obtain the products they sell are rudimentary, because due to their economic situation they can not purchase their own fishing vessel and equipment.

These uses float and swim to obtain their products, mainly oysters and lobsters, which they take out manually with chisel or harpoon. They usually swim in an approximate area of up to 3km offshore. They are attracted to buoys like the one for CENÉRGICA to have a point to which to tie to. The activities they carry out are more dangerous. This group fishes in the proposed area for the pier, south of the craft (artisanal) pier, so its activity would be restricted due to the project.

1.4.2 Objetives

- Provide independent fishermen (oysters, tuberos who do not belong to any of the local cooperatives) with the necessary tools to carry out their activities in a more efficient and low risk way, through the contribution of a boat and equipment, and proper training.
- Provide another option for some of them to change their source of income, through training in other tasks.

1.4.3 Description

To the independent fishermen identified during the process of citizen participation carried out for the present EsIA (See also appendix on small-scale fisheries in Chapter 5), they will be given two options described below:

a) Ship delivery, safety training and fishing techniques:
A local company dedicated to the field of boat manufacturing will be hired to manufacture boats or canoes, in which process the beneficiaries will actively participate, as well as adequate training in the different fishing methods, as well as safety. They will also receive equipment and implements necessary to put all the fishing techniques learned into practice.

b) Training in an alternative line of work:
For fishermen who no longer want to continue to dedicate themselves to this industry, they will be offered the option of training in other jobs or trades, possibly related to activities during the construction and operation stages of the Project. Having the opportunity to apply to some of the jobs that could be opened for the Project or for other industries that require the same type of services. The following are examples of potential training that could be included or trades that fishermen could learn.

⇒ Surveillance Training
⇒ Gardening
⇒ Maintenance Activities
⇒ Masonry, carpentry, and others related to construction.
⇒ Literacy
⇒ Among others to define in the future, due to previous analysis

2.0 List of Fishermen

Next, we list the fishermen by groups in tables 2.2 to 2.7.

2.1 Cooperativa de Rederos de Acajutla (ACPPRA) (Cooperative of Net Fishermen of Acajutla)

Table 2.1 – Cooperativa de Rederos de Acajutla (ACPPRA) 2016			
No.	First Name	Last Name	Age
1	MIGUEL ANTONIO	MARTÍNEZ RAMÍREZ	39
2	MANUEL ANTONIO	NAVARRETE	41
3	VICTOR JOEL	ESPINOZA ÁVILA	34
4	GUILLERMO	GONZÁLEZ CORDERO	38
5	SAMUEL	LÓPEZ MEJÍA	38
6	EMMER CRUZ	GALLARDO	47
7	FIRMO ANTONIO	ÁVALOS RAUDA	47
8	JOSÉ MAURICIO	CANALES	36
9	RENÉ ERNESTO	CORDERO	35
10	JUAN FRANCISCO	BONILLA PÉREZ	39
11	JUAN PABLO	MANCÍA ARGUETA	27
12	JUAN MOISÉS	MEJÍA BERNARDINO	41
13	HENRY SALVADOR	OSORIO	33
14	WILBER ALBERTO	CANDELARIO ALVARADO	32
15	CARLOS NAPOLEÓN	JOVEL RODRÍGUEZ	25
16	ESWIN ALEXANDER	ARGUERA GALLARDO	29
17	ELMER RICARDO	JOVEL RODRÍGUEZ	32
18	JUAN ANTONIO	GONZÁLEZ ROSA	55
19	RUPERTO AURELIO	GARCÍA MELÉNDEZ	49
20	JOSÉ MARÍA	GONZÁLEZ CORDERO	32
21	ALFREDO	DUBÓN LÓPEZ	54
22	BYRON ALEXANDER	MEMBREÑO ASTRO	35
23	FRANCISCO	ÁLVAREZ	72
24	GUILLERMO EDWIN	RIVAS POLANCO	47
25	JESÚS ALFREDO	HERNÁNDEZ	48
26	JOSÉ ANTONIO	CORDERO	43
27	JOSÉ MARÍA	VARGAS PÉREZ	44
28	JOSÉ SANTOS	VANEGAS MENJÍVAR	65
29	JULIO NELSON	JOVEL FLORES	48

Table 2.1 – Cooperativa de Rederos de Acajutla (ACPPRA) 2016			
No.	**First Name**	**Last Name**	**Age**
30	MANUEL DE JESÚS	REYES	54
31	MIGUEL ÁNGEL	RODRÍGUEZ MENJÍVAR	65
32	SANTOS INOCENTE	FLORES	52
33	WILLIAM ALEXANDER	CASTELLANOS MUNGUÍA	32
34	YANIRA DEL CARMEN	SÁNCHEZ MORALES	29

Source: Own elaboration

2.2 Asociación Cooperativa de Producción Pesquera del Puerto de Acajutla (ACOOPPAC) (Cooperative Association of Fishing Production for Acajutla Harbor)

Table 2.2 – Asociación Cooperativa de Producción Pesquera del Puerto de Acajutla (ACOOPPAC) 2016			
N°	**NAME**	**LAST NAME**	**AGE**
1	PEDRO	AGUILAR	67
2	ANDRÉS	AGUILAR AGUILAR	62
3	MIGUEL ÁNGEL	ALVARENGA	67
4	MAGDIEL	ASCENCIO CONTRERAS	66
5	JOSÉ ROBERTO	AYALA	67
6	GONZALO	BERNAL CASTRO	56
7	JOSÉ ÁNGEL	CARBAJAL GONZÁLEZ	77
8	EUGENIO	CASTELLANOS	78
9	OSCAR ORLANDO	CORTEZ RIVERA	50
10	JORGE	CRUZ	69
11	MARIO NELSON	CUÉLLAR MARTÍNEZ	54
12	PABLO DE JESÚS	DERAS HUEZO	29
13	MANUEL NAPOLEÓN	DHEMING JUÁREZ	79
14	JOSÉ IGNACIO	FLORES	54
15	JUAN CARLOS	GARCÍA	48
16	KELVIN ALEXANDER	GARCÍA JOVEL	26
17	JESÚS	GARRIDO ZALDAÑA	84
18	VICENTE	GARRIDO ZALDAÑA	76
19	MARCOS HILARIO	GONZÁLEZ NAJARRO	66
20	JOSÉ DAVID	HERNÁNDEZ VELÁSQUEZ	58
21	MANUEL OSCAR	HERRERA	57
22	NICOLÁS ANTONIO	HERRERA GODOY	44
23	RICARDO NAPOLEÓN	JOVEL FLORES	54

Table 2.2 – Asociación Cooperativa de Producción Pesquera del Puerto de Acajutla (ACOOPPAC) 2016			
N°	NAME	LAST NAME	AGE
24	JULIÁN	LÉMUS	70
25	JOSÉ SALVADOR	LÓPEZ	50
26	JOSÉ ADÁN	LÓPEZ FUNES	55
27	MIGUEL ÁNGEL	MENJÍVAR MADRID	80
28	JUAN REINALDO	MERCADO HERNÁNDEZ	54
29	WILFREDO	MOLINA GONZÁLEZ	54
30	RICARDO	MERLOS	57
31	WILFREDO	MOLINA GONZÁLEZ	54
32	PEDRO ERNESTO	MORALES MORÁN	60
33	ANDRÉS	MORALES RAMOS	60
34	SALVADOR	OSORIO BONILLA	67
35	CARLOS ERNESTO	PINEDA	53
36	EDWIN ORLANDO	RAMÍREZ MOLINA	30
37	NICOLÁS	REINADO	73
38	JESÚS JORGE	REYNALDO ÁBREGO	72
39	ADRIÁN	RIVAS BARCO	56
40	CARLOS SANTOS	RODRÍGUEZ	54
41	LUIS ARNOLDO	RODRÍGUEZ	52
42	ISABEL	RODRÍGUEZ MORALES	41
43	MATILDE	TREJO	80
44	JORGE ALBERTO	VELÁSQUEZ	48
45	JOSÉ ANTONIO	VELÁSQUEZ ALVAYERO	61
46	ELIGIO ANDRÉS	TIJERINO	28
47	RICARDO ANTONIO	URÍAS TIJERINO	28
48	EDUARDO ENRIQUE	TIJERINO GUERRA	24
49	MAURICIO ALEXANDER	JOVEL RAMÍREZ	40
50	FRANKLIN ALBERTO	CORTEZ RAMÍREZ	25
51	JOSÉ UTIEL	ALFARO ELÍAS	49
52	JULIO	LEMUS	
53	FERNANDO GALINDO	LEMUS	
54	VANESSA	JOVEL	
55	SILVIA	ENRIQUEZ	
56	MAYRA GUADALUPE	GUILLÉN	
57	PATRICIA	RAMOS MORÁN	

Source: Own elaboration

2.3 List of Asociación Cooperativa de Producción Pesquera Tiburoneros de Alta Mar Responsabilidad Limitada

Table 2.3 – List of Asociación Cooperativa de Producción Pesquera Tiburoneros de Alta Mar de Responsabilidad Limitada, 2016

#	Name and Last Name	Place of Birth	Date of Birth	Age	Sex	Personal ID #
1	Ricardo Obdulio Escalante Ruano	Acajutla, Sonsonate	04/07/1968	45	M	01359226-0
2	Ciro Rosembel Andrade	Sociedad, Morazán	24/07/1941	72	m	01589713-7
3	Juan Carlos González	Nahuilingo, Sonsonate	26/04/1973	41	m	00697447-7
4	Erick Osman Mazariego Alas	Acajutla, Sonsonate	01/10/1975	39	m	01821596-0
5	Rosa Humberto Hércules Cuellar	Acajutla, Sonsonate	30/08/1976	37	m	01556115-0
6	José lsrael Martínez	El porvenir, Santa Ana	22/07/1966	47	m	01654798-9
7	Felipe de Jesús Pérez	Sacacoyo, La libertad	25/03/1965	49	m	02580186-1
8	David Antonio Henríquez	Concepción Batres, Usulutan	23/08/1950	63	m	02604862-8
9	Isabel Cuellar Hércules	Acajutla, Sonsonate	05/11/1966	47	m	00664844-0
10	Alfonzo Cortez Huezo	Nejapa, San salvador	02/08/1965	48	m	01601363-9
11	Jorge Mario Contreras Renderos	Ciudad Arce, La Libertad	13/12/1955	58	m	01128600-9
12	José Albedo Ramírez	Sonsonate, Sonsonate	19/03/1951	63	m	00740100-3
13	José Santos Escobar	Colon, La libertad	01/01/1964	50	m	01083162-3
14	José Vidal Santiago Zetino	Acajutla, Sonsonate	15/05/1964	50	m	00912737-0
15	Vicente Antonio Guerra	Acajutla, Sonsonate	15/10/1977	36	m	02075025-1
16	Juan Francisco Pleitez Hércules	Acajutla, Sonsonate	24/05/1961	53	m	01218942-0
17	Juan Alberto Najarro Cárdenas	Acajutla, Sonsonate	27/12/1968	45	m	02943172-3
18	Rafael Antonio Sánchez Rivas	Acajutla, Sonsonate	23/01/1977	37	m	00898621-8
19	Oscar Ovidio Recinos	Armenia, Sonsonate	17/04/1966	48	m	00726653-4
20	Rafael Ãntonio Contreras Gálvez	Acajutla, Sonsonate	19/11/1966	47	m	00948949-7
21	Pedro Albedo Ortiz varez	Santa Ana, Santa Ana	27/04/1975	39	m	02837848-5

#	Name and Last Name	Place of Birth	Date of Birth	Age	Sex	Personal ID #
22	Karen Elizabeth Hernández Aquino	Acajutla, Sonsonate	27/02/1974	40	m	02796248-5
23	Rufino Cuellar Vázquez	Jujutla, Ahuachapán	03/12/1960	53	m	00054575-9
24	Ana Victoria Pleitez Benitez	Acajutla, Sonsonate	12/07/1985	28	F	03496576-1
25	Maryuri Griselda Medrano Arrué	Acajutla, Sonsonate	26/04/1989	25	F	04085827-3
26	Miguel ngel Villeda	Acajutla, Sonsonate	22/09/1962	51	m	00162556-0
27	Karla María Domínguez Codez	Acajutla, Sonsonate	11/01/1988	26	F	04010212-7
28	Juan Carlos Ortega Moran	Juayua, Sonsonate	04/03/1979	35	m	02961721-7
29	Fredy Ernesto Serrano Castaneda	Acajutla, Sonsonate	26/10/1982			

2.4 List of Asociación Cooperativa de Producción Agropecuaria y Pesquera Camaroneros de Acajutla Responsabilidad Limitada

Table 2.4 – List of Asociados de la Cooperativa de Producción Agropecuaria y Pesquera Camaroneros de Acajutla de R.L. 2016						
#	Name and Last Name	Place of Birth	Date of Birth	Age	Sex	Personal ID #
1	Pedro Alfonso Cardona Orellana	Nueva Concepción, Chalatenango	28/07/1943	72	M	03011321-1
2	Margarito Antonio Guardado	La Unión, La Unión	10/06/1946	69	M	0186357-6
3	Pedro Antonio Quijada Contreras	Nueva Concepción, Chalatenango	07/05/1947	68	M	00992793-3
4	Neftalí de Jesús Figueroa Palma	Acajutla, Sonsonate	10/06/1985	30	M	03298220-4
5	Israel Portillo	Zacatecoluca, La Paz	05/12/1951	63	M	02375230-9
6	Godofredo Núñez	Acajutla, Sonsonate	07/08/1967	48	M	02221539-6
7	José Bonillo Trigueros	Sonsonate, Sonsonate	26/08/1957	58	M	01702175-8
8	José Roberto Rivas Moreno	Zacatecoluca, La Paz	26/05/1963	52	M	00303522-4
9	Juan Ángel Miranda Acosta	Coatepeque, Santa Ana	01/04/1958	57	M	00744342-9
10	Fernando Transito Delgado	San Juan Opico, La Libertad	29/05/1936	79	M	01162985-9

Table 2.4 – List of Asociados de la Cooperativa de Producción Agropecuaria y Pesquera Camaroneros de Acajutla de R.L. 2016						
#	Name and Last Name	Place of Birth	Date of Birth	Age	Sex	Personal ID #
11	Genaro Ernesto Navarrete Pleitez	Acajutla, Sonsonate	10/07/1969	46	M	03392543-9
12	Marta Angélica Bonilla Salinas	Acajutla, Sonsonate	20/08/1989	26	F	04144851-8
13	Patricia Figueroa de Miranda	Acajutla, Sonsonate	01/08/1989	29	F	03808562-4
14	Patricia Elisabeth de Recinos	Acajutla, Sonsonate	22/12/1971	43	F	01065298-8
15	Mónica Beatriz Molina	Acajutla, Sonsonate	30/12/1980	34	F	03285334-2
16	Lorena Elisabeth	San Antonio del Monte, Sonsonate	09/08/1981	34	F	05609829-3

Source: Own elaboration

2.5 List of Oyster Catchers

Table 2.5 – List of Oyster Catchers for Project LNG to Power, Acajutla, 2016

#	Name	Personal ID #	# of Family Members	School Grade
1	Juan Ramón Ortiz Rivera	03295698-6	6	7th GRADE
2	Jorge Alberto Vasquez	02985971-9	9	2nd GRADE
3	Pedro Antonio Estrada	03405125-3	4	3rd GRADE
4	Santos Victoriano Lue	01387580-4	9	HIGH SCHOOL GRADUATE/ 2nd YEAR OF ACCOUNTING
5	Oscar Armando García Pacheco	03777583-0	7	5th GRADE
6	Modesto Saravia			

Source: Own elaboration

2.6 List of Tuberos

Table 2.6 – List of Tube Catchers for Project LNG to Power, Acajutla, 2016

#	Name	Personal ID Number	# of Family Members	School Grade
1	Mario Salvador Aguilar Rodríguez	0400978-9	7	3°
2	Julio Cesar Hernández	Menor de edad	9	5°
3	Miguel ängel López Rodríguez	03870450-7	6	5°
4	Kevin Javier Martinez Roman	Menor de edad	5	8°
5	Josue Alexander Recinos R.	04909831-7	5	4°
6	José Alexander Canales Román	04676057-5	4	7°
7	Julio Cesar Portillo Perez	01808967-8	6	4°
8	José Andrés Somoza Melara	04286196-3	5	7°
9	Miguel Ortiz Barahona	04493560-3	5	2°
10	Julio Cesar Echeverria Arevalo	00549931-9	4	5°
11	Santos Inocente Flores	03819178-8	3	0°
12	Juan Antonio trigueros H.	00725042-8	5	9°
13	Alexander Arriola Fuentes	01940801-1	4	4°
14	Fredis Erasmo Arriola Puentes	02190239-8	5	9°
15	Ernesto Pinto Ponce	Menor de edad	5	3°
16	Andrés Francisco Guardado	Menor de edad	5	9°
17	Herber Adonay Flores Hercules	04403059-2	4	5°
18	Josue Alberto Flores Hercules	04777158-3	4	9°

Table 2.6 – List of Tube Catchers for Project LNG to Power, Acajutla, 2016				
#	Name	Personal ID Number	# of Family Members	School Grade
19	Carlos david Flores Hercules	Menor de edad	3	8°
20	Jorge Elias Somosa Melara	04859747-3	5	7°
21	Juan Carlos Ortyega Morán	02961721-4	4	2°
22	José Antonio Pinto Pozo	04805180-9	5	9°
23	Josué Alexander Sibrian Guerra	05247922-1	3	4°
24	Juan Reynaldo Mercado Hernández	02114124-3	4	6°
25	Edín René Abarca Areválo	00311426-4	4	8°
26	Ronaldo Antonio Chávez Jímenez	02933574-9	2	3°
27	Carlos Alberto Ramirez	Menor de edad	8	6°
28	Ricardo Antonio Urias Tijerinos	03665074-4	3	1°
29	Erick Guadalupe Osorto	04472360-8	4	5°
30	Roberto Arturo Morales Sahavedra	04803819-4	4	7°
31	Adrian Antoio Rivas Aguilar	02791129-8	4	6°
32	Alfredo Dubón López	03295713-6	2	0°
33	Sandro Geovani Ardon Peraza	03929326-1	6	7°
34	Roberto Ardón Arias	01075506-3	5	8°
35	Julio Cesar García Hernández	00935356-5	4	3°
36	Carlos Antonio Campos Henriquez	02732911-6	5	3°
37	José Utici Alfaro Elias	02691830-2	4	7°
38	Reyes Canjura Menjívar	03276783-2	3	0°
39	Eduardo Luis Flores Hércules	05179850-9	1	7°
40	Victor Manuel Molina H.	05173043-8	6	0°
41	Juan José Henriquez Tijerino	Menor de edad		3°
42	Eugenio de Jesús Somoza M.	03746335-2	5	0°
43	Luis Alonso Alegría Pérez	04577619-1	2	8°
44	Luis Antonio Alegría	03216419-9	2	0°
45	Bayron Enrique Alegría	04740997-8	3	9°
46	Oscar Mauricio Mejía Guerra	03529186-3	3	9°
47	Santiago Flores Valle	05106810-8	3	9°
48	José Noe Rodríguez	05216961-4	7	High School Graduate
49	Miguel Ángel Mejía Cuéllar	05145347-0	8	High School Graduate
50	Julián Tovar			
51	Santos Jesús Alegría			

Source: Own elaboration

3.0. Environmental Considerations

Artificial reefs and FADs do not have basic regulations that cover the full spectrum of possible uses and purposes under which they can be conceived. It is part of the concept of areas for marine conditioning and fishing protection areas, which aim to promote the protection and regeneration of living marine resources.

Increasing biomass and biodiversity as a usable resource is one of the main objectives (production-concentration or fish aggregating devices) and will be used to enhance tourism and recreational activities such as diving, fishing, etc.

Both structures present the purpose of promoting recreational diving where they will provide the surrounding communities with new leisure spaces. It aims to improve areas where the practice of recreational diving is tradition, and even, it can be achieved to enhance this sport in places considered as not usual with regard to its practice.

Both structures are built or assembled on land:

For artificial reefs

1. Artificial reefs require the use of a platform to move the structures to the open sea, using a boat, which moves the floating platform, from the sailing sites (craft dock of Acajutla), which facilitates its transfer and installation.

2. At the moment of bringing the blocks to the anchoring site, it should be launched one by one by means of slings or loops and supported by SCUBA equipment for proper placement in the bottom, proper management of structures is required, since generally in this one step is when the blocks usually break or become damaged.

3. It is recommended to place them in groups of 5 forming units of 10 blocks maximum, ordering them in pyramidal form and distancing the groups 50 m from a central group of blocks.

4. Once placed, loops should be removed and structures should be marked with buoys and labels.

5. It is important to leave mooring sites for boats, that is to say, special places marked with buoys that allow the anchoring of boats to perform the fishing operations better.

For FADs

1. The FADs require the use of a boat of at least 30 feet in length, to move the structures armed or assembled on land, to placement, which facilitates their installation.
2. At the moment of carrying the armed structures (one by boat), to the anchoring site, the float must first be thrown, then with a minimum carrying speed, the silk lanyard is slowly launched with its branches spaced from PVC pipes and finally, the concrete grid is launched, so that it pulls and vertically places the structure.
3. It is recommended to place them apart at a distance of at least 20 meters, since the depth of the site is 15 meters.
4. Once placed, structures should be marked with buoys and labels.
5. It is important to leave mooring sites for boats, that is to say, special places marked with buoys that allow the anchoring of boats to perform better the fishing operations.

2.7 Special Recommendations

Both structures are far from:

- Incubation and hatching pens of sea turtle eggs.
- Beaches with high turtle nestings (more than 200 turtles per season).
- Locations identified as foraging areas for sea turtles.
- Adjacent or nearby human settlements, docks, restaurants and hostels.
- Over very soft seabeds and communities of marine phanerogams (seagrass).

2.8 Environmental effects

Water quality

Water contamination will be minimal as artificial reef mooring will be by flotation and scuba and FADs during the placement work and the volume of the concrete grid will produce a minimum resuspension of the sediments. These effects can be considered specific and reversible (it is assumed by natural means), manifesting directly on water quality and indirectly on biota, especially affecting organisms with little or no movement capacity (benthic flora and fauna).

Sound levels and vibrations

The affectation derived from the increase of sound levels and vibrations will only be manifested during the anchoring work of the structures, not detecting differential or cumulative effects.

Principles for placing the alarm signal devices:

Engine hall	Visual alarm devices (flashing light) are placed so that they can be seen in all locations where people stay more than temporarily
Control room	One audible alarm device (alarm bell).
Other rooms	Audible alarm devices are placed so that they can be heard in all rooms where people stay more than temporarily.
Outdoors	One audible alarm device on each side of the power house is installed. Additional alarm devices shall be provided when there are other buildings or other obstructions which may limit the hearing of the alarm.

Fire alarm signaling loops

All alarm devices in the plant should be activated at a fire alarm. (Exception: alarms clearly meant only for separated area or building not having immediate impact on plant operation).

The fire alarm loops are arranged so that a fault message is obtained at cable break or short circuit.

Fire alarm centre power supply

There will be at least two independent power supplies:

- AC taken from the LV switchgear (or public grid)
- One or more batteries (generally 24 VDC) with battery charger.

Each of them must be able to feed the power required when the system is in alarm state and the current for 30 minutes in alarm state.

Connecting to other systems

Available potential free contacts are arranged to open at a fire alarm or fault (normally closed). The contacts can be used for transferring alarm and fault signals to the plant control system.

A2.10.1 FIRE PROTECTION, COMMON

1 Fire water system building (combined with water treatment building)

The fire water building contains a fire fighting pump main unit and its control system. The fire water pump main unit supplies water from the water tank for fire hydrants and hose reels. There are two centrifugal type fire pumps, one diesel engine driven and one electric motor driven. Each pump is capable of delivering the total quantity of water for firefighting purposes.

Minimum pressure at rated flow is 8 bar. The indicative volume flow rate demand is 300 m^3/h.

Appendix 10D–

Fire Protection System

A2.10 FIRE PROTECTION SYSTEM

General

The specification below is for Wartsila standard fire protection based on NPFA. Local codes may require changes to this specification. Specific requirements, if any, of the Owner's insurance company will be considered. Deviations in local or insurance requirements may require an amendment to the scope of supply. Such changes will be subject to the appropriate provisions in the Agreement.

The stand pipe system inside the power house follows "NFPA14 class II stand pipe system" requirements. Additionally, mobile foam units are provided. For immediate action against small local fires, the power house is equipped with a number of 6 kg and 12 kg dry powder extinguishers at strategic locations, and 5 kg CO2 extinguishers for electrical fires (spacing as per NFPA10).

The fire main is built using "NFPA24 Private fire service main" as a design guideline.

The tank area design — concerning e.g. the safety distances — is based on NFPA30, with cooling water streams for exposure protection.

The fire pump capacity is chosen according to specific protection requirements, and will be not less than 1890 l/min (approx 120 m^3/h), which is the minimum hose stream requirement by NFPA850.

Although the protection system philosophy is based on widely recognized NFPA standards, piping and equipment may still follow standards used by the fire protection equipment supplier.

Fire areas should be separated from each other by fire barriers, spatial separation, or other approved means.

The design philosophy described above aims for avoiding interruption of power generation due to false alarms and failures in automation system — and is based on the following assumptions:

- Competent personnel attend the Power Plant 24 hours a day.
- The personnel operating and maintaining the plant are trained in correct operation procedures on regular basis, and are trained in fire prevention and response
- The plant, including installed fire protection equipment, is well maintained and kept in good order. The equipment is periodically tested.
- Maintenance work, including welding and cutting, shall be done with appropriate precautions and instructions

Fire detection system

The fire alarm system typically includes the following main components (see **¡Error! No se encuentra el origen de la referencia.** below):

- **a fire alarm centre** including a supervision unit, a display unit, input and output terminal units, a power supply unit, and a message transfer unit
- fire detectors and manual call points connected to the fire alarm centre
- **alarm devices** (bells, sirens, flashing lights) connected to the fire alarm centre

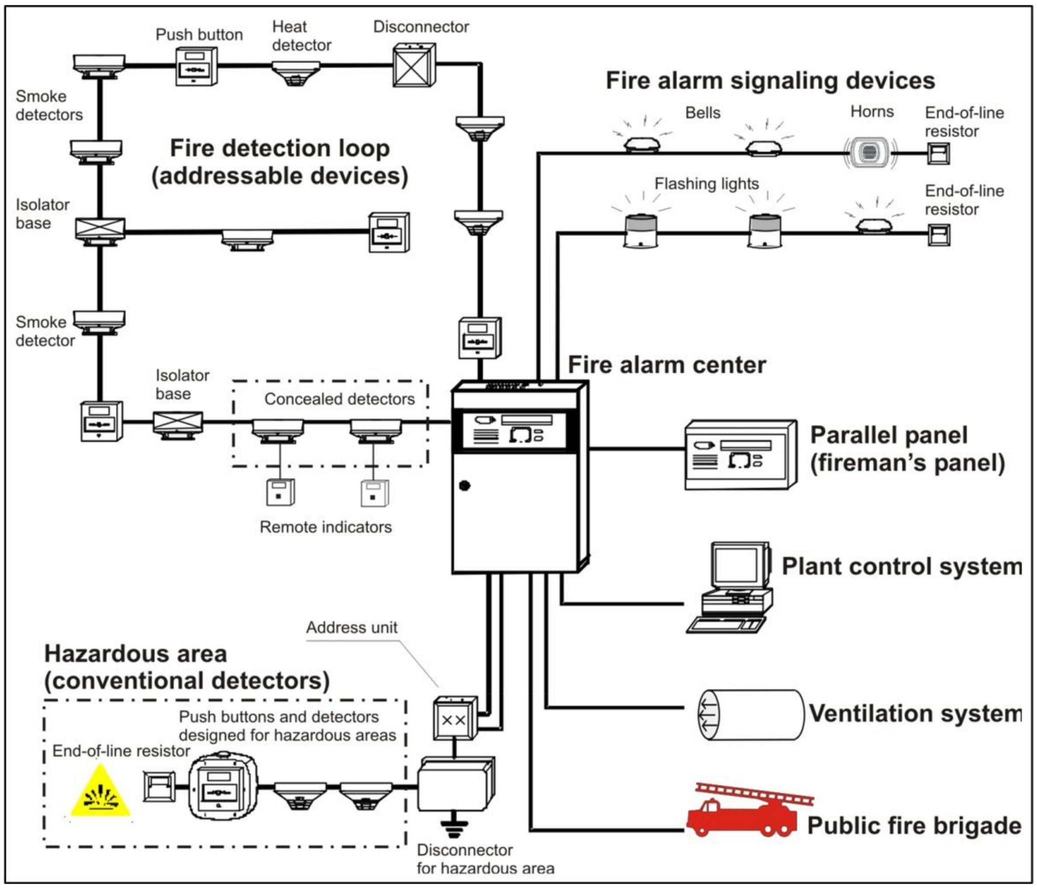


Figure 1 Typical setup of an addressable system

The fire alarm system is designed considering the following basic principles:

- The fire alarm centre shall be placed in a continuously manned room (the control room).
- The supervised rooms will be divided into alarm zones to ease locating the fire.
- Every room/zone is provided with an adequate amount and type of detectors.
- Alarm bells, sirens and flashing lights shall be situated so that they can easily be heard or seen.

Fire alarm zones

The purpose of fire alarm zones is to group the fire detectors in order to ease the fire location at an alarm.

At least the following areas will defined as separate fire alarm zones:

- Separate buildings
- Separate floors (except stairways which may encompass several floors)
- Rooms separated by fire walls
- Areas of different fire classes
- Rooms or areas of essentially different heights
- Rooms that cannot be accessed without passing through other zones

Type of detectors

The basic principle is to install the type and amount of fire detectors that detects fires without causing false alarms during normal operation conditions.

Optical smoke detectors are used in the engine room, auxiliary space, switchgear rooms, offices, stores and control rooms. In workshops and similar rooms, where smoke may appear as a result of normal use of the room, differential maximum heat detectors are used.

Manual call points

In a manual alarm device, the fire alarm is activated with a push button, protected with a cover that can be crushed.

Push buttons for manually activating fire alarms manually should be placed close to each exit route and close to the fire alarm panel or alarm centre. Each fire detection loop has at least one push button. There is at least one manual call point within 30 meters from any spot in the buildings.

Fire detection loops

The fire detectors and fire call buttons are located along one or more closed loops, starting and ending in the fire alarm centre. Each detection loop will be partitioned by a number of disconnecting devices. At a possible line break or short circuit on the loop, the faulty section is isolated at the two closest disconnecting devices — while the other detectors on the loop will stay in contact with the fire centre.

Alarm signaling system

The following types of alarm signaling devices are used:

- Alarm bells
- Flashing lights (mandatory in engine hall and auxiliary space)
- Alarm sirens (where feasible)

Principles for placing the alarm signal devices:

Engine hall	Visual alarm devices (flashing light) are placed so that they can be seen in all locations where people stay more than temporarily
Control room	One audible alarm device (alarm bell).
Other rooms	Audible alarm devices are placed so that they can be heard in all rooms where people stay more than temporarily.
Outdoors	One audible alarm device on each side of the power house is installed. Additional alarm devices shall be provided when there are other buildings or other obstructions which may limit the hearing of the alarm.

Fire alarm signaling loops

All alarm devices in the plant should be activated at a fire alarm. (Exception: alarms clearly meant only for separated area or building not having immediate impact on plant operation).

The fire alarm loops are arranged so that a fault message is obtained at cable break or short circuit.

Fire alarm centre power supply

There will be at least two independent power supplies:

- AC taken from the LV switchgear (or public grid)
- One or more batteries (generally 24 VDC) with battery charger.

Each of them must be able to feed the power required when the system is in alarm state and the current for 30 minutes in alarm state.

Connecting to other systems

Available potential free contacts are arranged to open at a fire alarm or fault (normally closed). The contacts can be used for transferring alarm and fault signals to the plant control system.

A2.10.1 FIRE PROTECTION, COMMON

1 Fire water system building (combined with water treatment building)

The fire water building contains a fire fighting pump main unit and its control system. The fire water pump main unit supplies water from the water tank for fire hydrants and hose reels. There are two centrifugal type fire pumps, one diesel engine driven and one electric motor driven. Each pump is capable of delivering the total quantity of water for firefighting purposes.

Minimum pressure at rated flow is 8 bar. The indicative volume flow rate demand is 300 m^3/h.

Included in the fire water system building:

1	Diesel engine driven pump unit
1	Electric motor driven pump unit
1	Jockey pump
1	Control system
1	Sprinklers (set)
1	Portable fire extinguisher
1	Piping (set)

1 Fire water tank

The total fire water tank volume is dimensioned for approximately 2 hours operation with full fire water pump capacity. 400m^3 capacity is allocated to raw water storage but the full volume can be used for fire fighting if needed.

Volume	1,000	m^3

In the combined raw water tank the raw water for plant service is taken from the top part of the tank in a manner that the fire water capacity cannot be affected by the raw water consumption.

1 Set tank equipment (valves, fittings, level indicators and alarms, inspection ports if applicable, ladders if applicable)

1 Lot Outdoor hydrants

The plant is equipped with exterior hydrants which are located on the site area outside the powerhouse. The outlet connections are typically 2 x 2.5".

1 Lot Outdoor hose cabinets

A hose cabinet is a painted steel cabinet with two folded hoses in a hose rack. The hose length is 20 m, diameter 2.5" and designed for 16 bar pressure. The hoses are equipped with quick couplings. An adjustable water fog nozzle is included in the hose cabinet.

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 12.0 kg. ABC type.

1 Piping and valves fire water system inside engine hall

This includes pipes, valves, flanges and gaskets for the fire water system up to the interconnection point.

1 Underground piping and valves fire water system outside engine hall

This includes pipes, valves, flanges and gaskets for the fire water system up to the interconnection point.

A2.10.2 FIRE PROTECTION, ENGINE HALL

1 Sprinkler system

The engine room is protected with a wet pipe sprinkler system utilising minimum 93°C temperature bulbs to prevent accidental release due to occasionally elevated temperature areas which may occur below the roof.

The sprinkler piping will be also placed below the exhaust and intake air ducts above the piping modules.

The required flow is based on NFPA 13, Area density method and NFPA37 recommendation for the application rate and area:

A design basis using "Extra hazard group 1" with a density (0.3 gpm/ft^2) 12.2 l/min/m^2 for area 232 m^2 (2500 ft^2) shall be used. Hose allowance of 1900 lit/min (NFPA 850).

Maximum Flow = 2830 l/min + 1900 l/min fire hose demand = 5000 l/min = 300 m^3/h.

1 Lot Hydrant valve pairs

The engine hall is equipped with fire pipe network called a standpipe system. From this network there will be outlets for pairs of 1½" hydrant valves with couplings for the fire hoses in vicinity of the hose cabinets inside the engine hall.

1 Lot Standpipe hose cabinets

A hose cabinet is a painted steel cabinet with folded hose in a hose rack. The hose length is 20 m, diameter 1½" and designed for 16 bar pressure. The hose is equipped with quick coupling and an adjustable water combination fog/spray nozzle.

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 12.0 kg. ABC type.

6 Mobile foam units

Each mobile foam unit consists of a low expansion foam branch pipe, inductor, foam concentrate tank and two fire hoses with couplings suitable to be connected to the fire hydrants. Foam can be used to suppress an oil based fire. The foam unit has wheels and can be moved to the location of a fire. Capacity 200 l/min water flow, 100 l foam concentrate tank.

A2.10.4 FIRE PROTECTION, MV/CONTROL BUILDING

1 Lot Portable fire extinguishers (CO2 type)

The plant is equipped with portable carbon dioxide type fire extinguishers which are located in electrical spaces and control room. The capacity of each extinguisher is 5.0 kg.

1 Lot Portable fire extinguishers (CO2 type)

The plant is equipped with portable carbon dioxide type fire extinguishers which are located in electrical spaces and control room. The capacity of each extinguisher is 20.0 kg.

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 12.0 kg. ABC type.

A2.10.4 FIRE PROTECTION, MV BUILDING

1 Lot Portable fire extinguishers (CO2 type)

The plant is equipped with portable carbon dioxide type fire extinguishers which are located in electrical spaces and control room. The capacity of each extinguisher is 5.0 kg.

1 Lot Portable fire extinguishers (CO2 type)

The plant is equipped with portable carbon dioxide type fire extinguishers which are located in electrical spaces and control room. The capacity of each extinguisher is 20.0 kg.

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 12.0 kg. ABC type.

A2.10.8 FIRE PROTECTION, FIRE FIGHTING PUMP HOUSE / WATER TREATMENT BUILDING

1 Wet pipe sprinkler system serving only the fire pump house side

The sprinkler system is equipped as follows:

1	Alarm valve with flow alarm connected to the fire detection/alarm system
1	Fire department connection with locally accepted couplings to facilitate the system feed alternatively from the fire truck
1	Sign plate for fire department connection
1	Closing valve with position indication for system maintenance purposes (normally locked open)
1	Set of sprinkler nozzles
1	Set of galvanized steel piping

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 6.0 kg. ABC type.

A2.10.13 FIRE PROTECTION, GUARD HOUSE

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 6.0 kg. ABC type.

A2.10.16 FIRE PROTECTION, WORKSHOP AND WAREHOUSE

1 Lot Portable fire extinguishers (CO2 type)

The plant is equipped with portable carbon dioxide type fire extinguishers which are located in electrical spaces and control room. The capacity of each extinguisher is 5.0 kg.

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 6.0 kg. ABC type.

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 12.0 kg. ABC type.

2 Hose reels

The hoses are equipped with adjustable water fog nozzles. The hose length is 25 m and diameter 19 mm.

A2.10.17 FIRE PROTECTION, ADMINISTRATION / SOCIAL BUILDING

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 6.0 kg. ABC type.

2 Hose reels

The hoses are equipped with adjustable water fog nozzles. The hose length is 25 m and diameter 19 mm.

1 Fire blanket

A2.10.22 1 FIRE PROTECTION, STEP UP TRANSFORMERS

1 Deluge sprinkler system for step-up transformers.

The step up transformers are equipped with a deluge type fire fighting system using water provided by the main fire pump. The step up transformers will be separated by fire walls