

Formula to calculate the Boil-Off Rate (BOR) as given in Dobrota, 2013:

$$BOR = \frac{V_{BOG} \cdot 24}{V_{LNG} \cdot \rho} = \frac{Q \cdot 3600 \cdot 24}{\Delta H \cdot V_{LNG} \cdot \rho} \cdot 100$$

“Where BOR is in %/day, V_{BOG} volume of BOG in m³/s, V_{LNG} volume of LNG in cargo tanks in m³, ρ density of LNG in kg/m³, Q heat exchange in W, and ΔH latent heat of vaporisation in J/kg.”

Term often used:

NBP: National Balancing Point

Bcm: Billions Cubic Meter

Bcf: Billions Cubic Feet

HH: Henry Hub

mc: Meter Cubic

MMBtu: Millions British Thermal Unit

MT: Millions Tons

MTPA: Millions Tons Per Annum

TPA: third Party Access

TTF: Title Transfer Facility

Table 1.a: Power Plants Air Emissions

Tons per year per thousand households		Biomass (wood)	Coal	Natural Gas	Nuclear/ Renew.
Carbon Monoxide	CO	11	7.2	0.3	0.0
Carbon Dioxide	CO ₂	14,264	9,832	4,076	0.0
Nitrogen Oxides	NOx	5.9	2.9	0.3	0.0
Particulate Matter	PM	0.73	0.48	0.17	0.0
Volatile Organic Comp.	VOC	0.15	0.14	0.17	0.0
Sulfur Dioxide	SO ₂	0.0	4.77	0.03	0.0
Mercury	Hg	0.0	0.0001	0.0	0.0

■ Most Emissions
 ■ Middle Emissions
 ■ Least Emissions

Source: RW Beck (via NGS& API) | Emissions from Powerplant Operations Only ©LNG Allies, 2017

Source: LNG Allies, 2017

Table 2.1: US LNG Export Projects

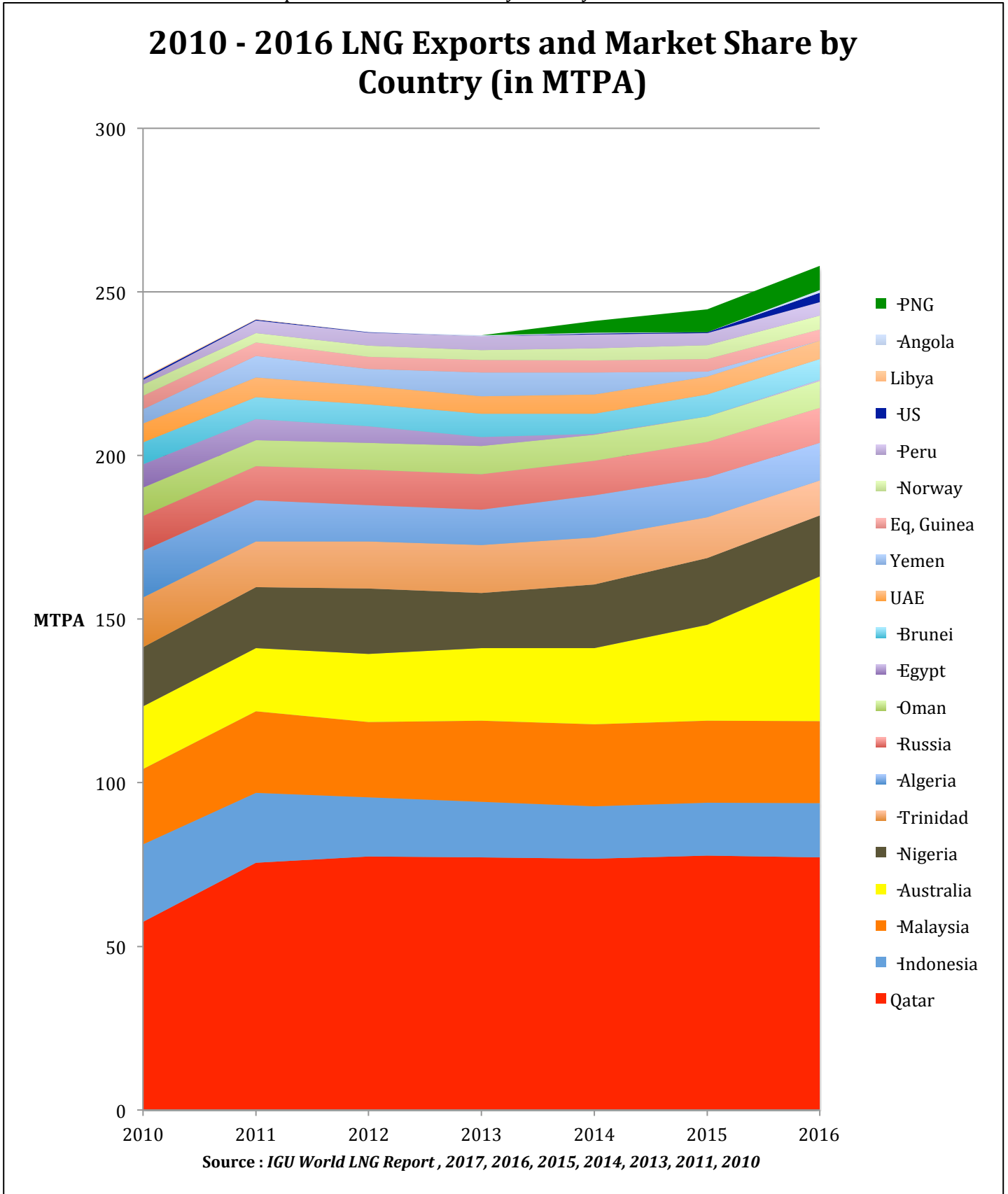
Major U.S. LNG Export Projects				
Project Stage	Projects	MTPA	Bcm/yr	Bcf/day
Operating/Under Construction	6	70.9	97.7	10.0
Permitted - (USA)	4	68.9	95.0	9.7
Permitted (Canada, U.S. Gas)	2	18.0	24.8	2.4
Formal Environmental Review	7	79.0	109.0	10.8
Pre-Environmental Review	5	91.9	126.8	13.3
Total	24	328.7	453.3	46.3

Notes: (1) Projects = individual projects. (2) Additional trains for existing projects not included in the project count, but in the MTPA, Bcm/year, and Bcf/day totals. (3) Two Nova Scotia projects permitted to export U.S. natural gas.

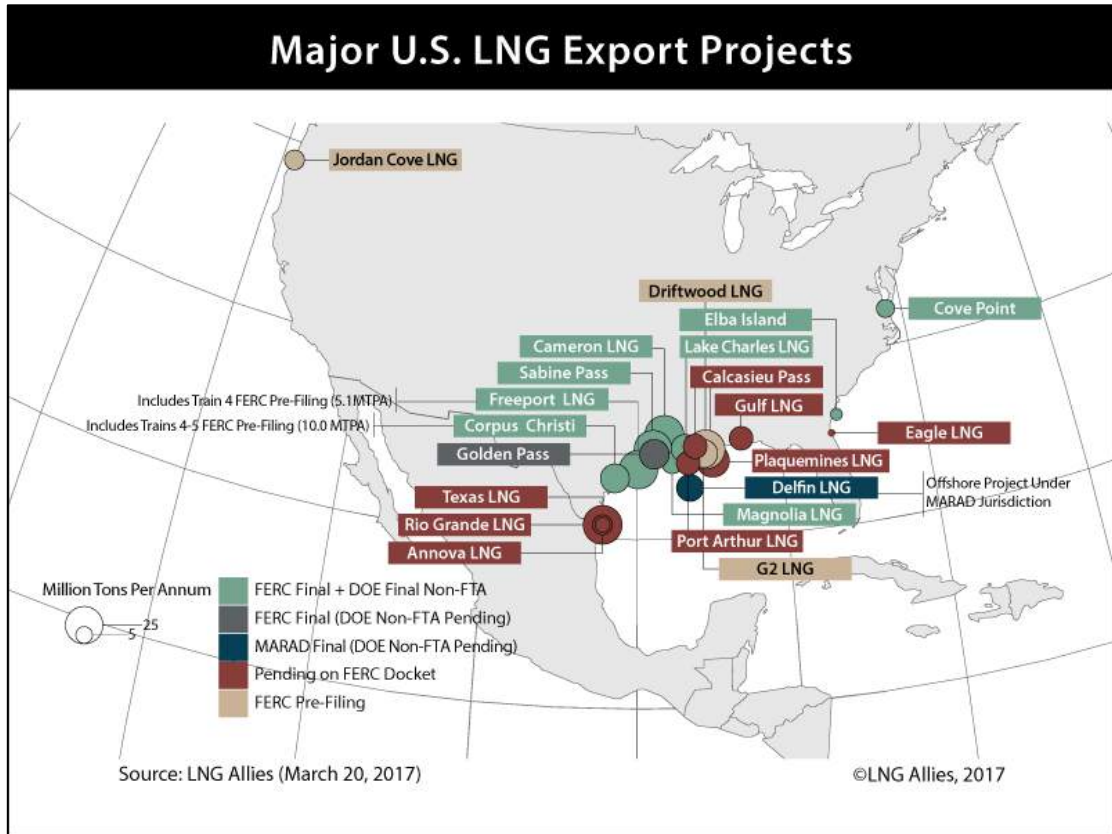
Source: Federal Energy Regulatory Commission & LNG Allies (March 22, 2017) ©LNG Allies, 2017

Source: LNG Allies, 2017

Chart 2.1.1: 2010 - 2016 LNG Exports and Market Share by Country



Map 2.1.2: US LNG Export Projects Map



Source : LNG Allies, 2017

Chart 2.2: 2010 - 2016 LNG Imports and Market Share between Europe and Asia

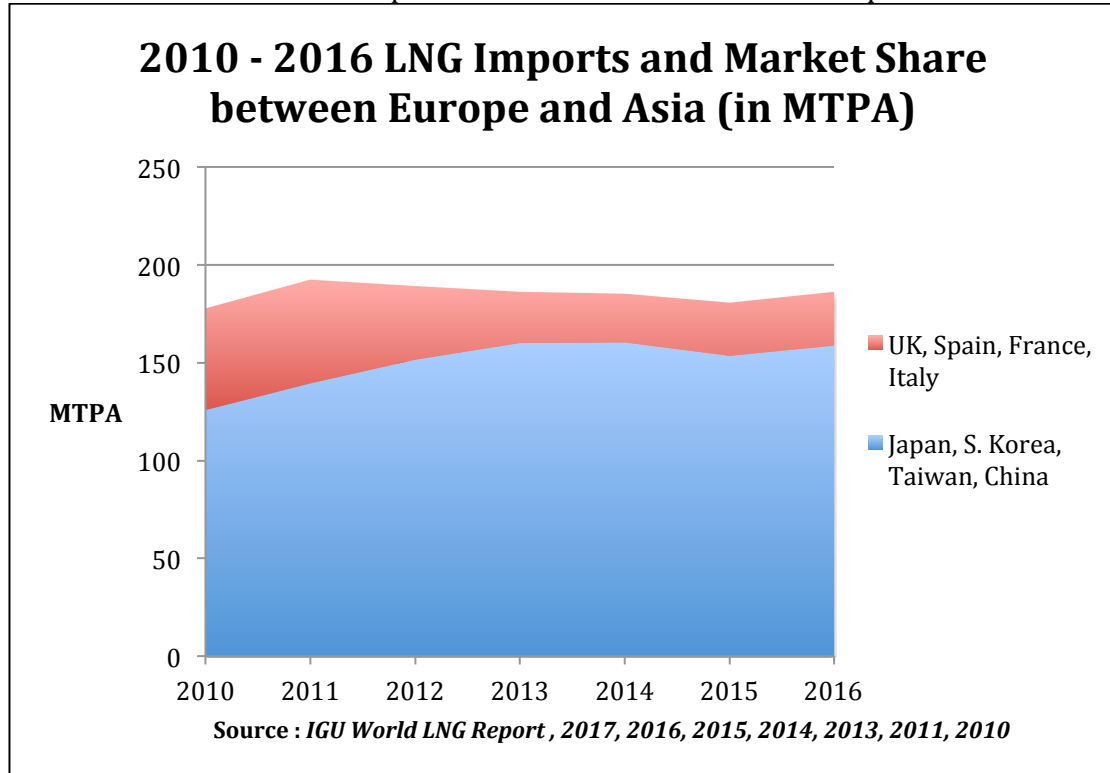


Chart 2.2.1: 2010 - 2016 LNG Imports and Market Share by Country

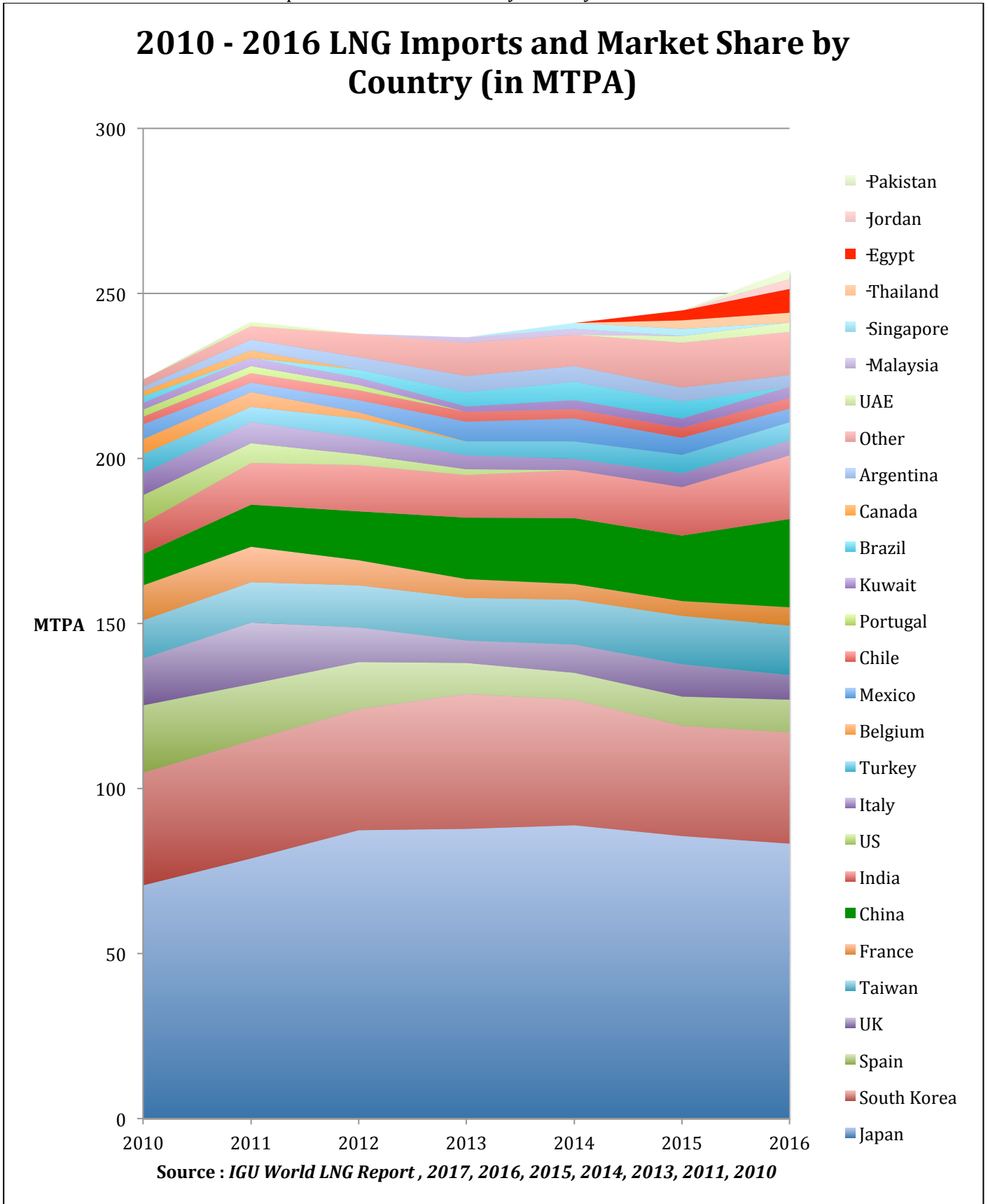
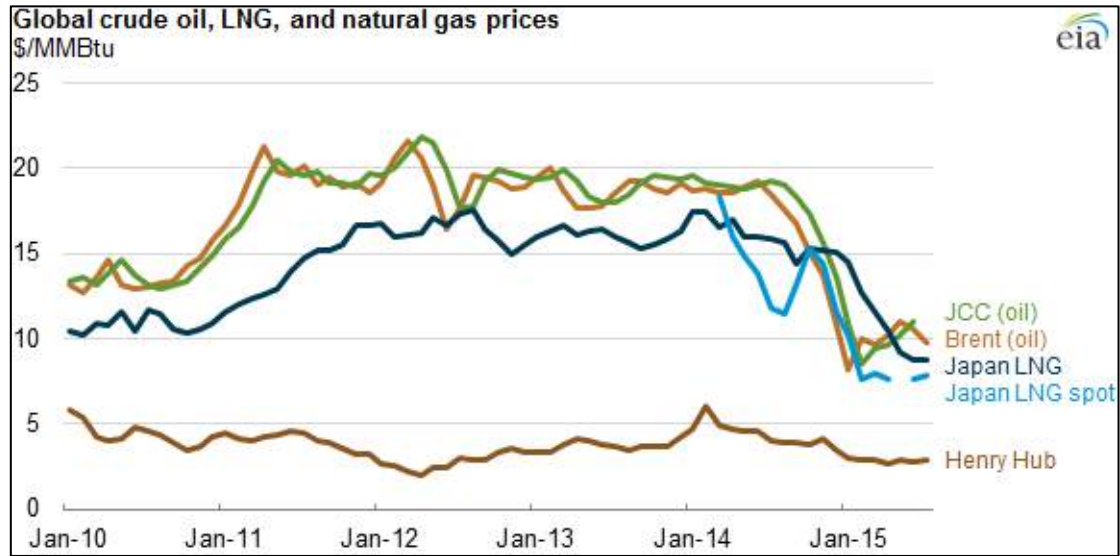


Table 2.4: Regas terminals in Japan

Regas Terminal	Start-up year	Regasification million cm per year of LNG	Regasification billion cm per year of gas	Number of vaporizers	Storage thousand cm of LNG	Number of Tanks	Third Party Access
Chita Kyodo	1977	17,00	10,40	14,00	300,00	4,00	Yes
Chita	1983	25,40	15,60	11,00	640,00	7,00	Negotiates TPA
Chita Midorihama	2001	18,00	11,10	8,00	400,00	2,00	Negotiates TPA
Futtsu	1985	44,60	27,40	13,00	1110,00	10,00	Yes
Hachinohe	2015	2,40	1,50	5,00	280,00	2,00	Yes
Hatsukaichi	1998	2,10	1,30	4,00	170,00	2,00	No
Hibiki	2014	5,00	3,10	5,00	360,00	2,00	Negotiates TPA
Higashi-Niigata	1984	19,90	12,20	14,00	720,00	8,00	Yes
Higashi-Ohgishima	1984	30,90	19,00	9,00	540,00	9,00	Yes
Himeji LNG	1979	18,90	11,60	8,00	520,00	7,00	Yes
Himeji	1984	11,00	6,80	6,00	740,00	8,00	Yes
Hitachi	2016	4,60	2,90	3,00	230,00	1,00	Negotiates TPA
Ishikari	2012	6,30	3,90	4,00	180,00	1,00	Negotiates TPA
Joetsu	2012	5,50	3,40	8,00	540,00	3,00	
Kagoshima	1996	0,50	0,30	3,00	86,00	2,00	No
Kawagoe	1997	11,50	7,10	7,00	840,00	6,00	Yes
Mizushima	2006	9,90	6,10	6,00	320,00	2,00	Yes
Nagasaki	2003	0,30	0,20	3,00	35,00	1,00	Yes
Naoetsu	2013	3,40	2,10	4,00	360,00	2,00	No
Negishi	1969	25,90	15,90	14,00	1180,00	14,00	Negotiates TPA
Ohgishima	1998	23,00	14,10	12,00	850,00	4,00	Negotiates TPA
Oita	1990	12,50	7,70	7,00	460,00	5,00	Yes
Sakai	2006	14,90	9,20	6,00	420,00	3,00	Yes
Sakaide	2010	2,70	1,70	3,00	180,00	1,00	Yes
Senboku I + II	1972	31,9	19,70	20,00	1675,00	20,00	Yes
Shin-Minato	1997	0,70	0,40	3,00	80,00	1,00	No
Shin-Sendai	2015	1,90	1,20	3,00	160,00	1,00	No
Sodegaura	1973	69,30	42,60	3,00	2660,00	35,00	Negotiates TPA
Sodeshi	1996	6,70	4,10	8,00	337,00	3,00	No
Soma	March 2018				230,00		
Tobata	1977	17,70	10,90	9,00	480,00	8,00	Yes
Toyama shinkou	FY 2018				180,00		
Wakayama (planned)	After FY 2025				840,00		
Yanai	1990	5,30	3,30	5,00	480,00	6,00	Yes
Yokkaichi	1987	14,90	9,20	8,00	320,00	4,00	Yes
Yokkaichi Works	1991	5,00	3,10	6,00	160,00	2,00	Negotiates TPA

Source : GIIGNL reports and IEA 2016a

Chart 3.1: 2010 - 2015 Gas Prices



Source : EIA, 2015

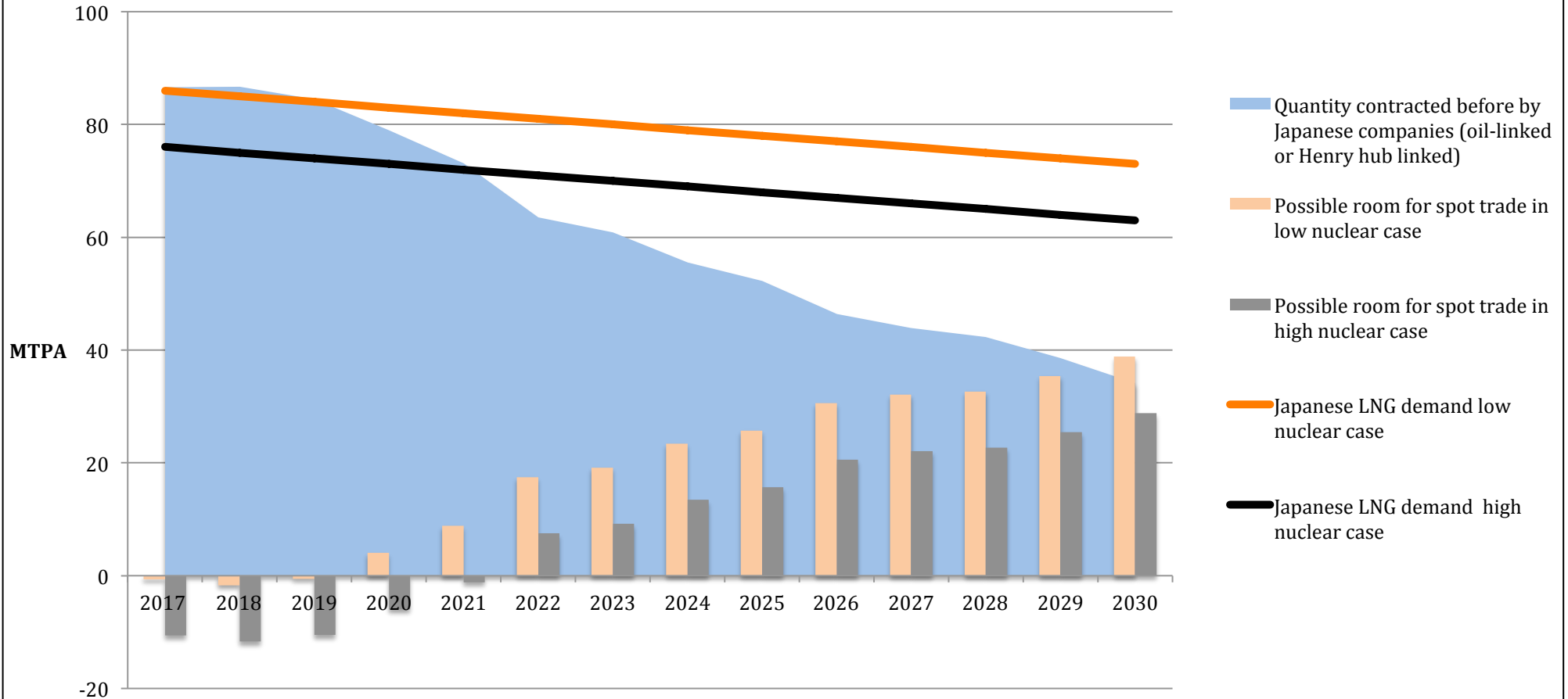
Table 3.2: JOE's new LNG contract

	Physical/LNG	Physical LNG (JKM-differential)	Platts JKM Swap	RIM DES Japan Swap
Settlement Method	Physical delivery		Cash settlement	
Trading Unit	1 cargo/ lot		50,000mmBTU/ lot	
Price quotation	US\$0.001/mmBTU		US\$0.001/mmBTU	
Trading Hours (JST)	9:00-:17:30 (Core time : 16:30-17:30)		17:00-17:30	16:30-17:00
Contract Month	Consecutive 4 half months	Consecutive 12 months	Consecutive 12 months	
First Trading Day	The following business day of the last trading day of the delivery half month	The following business day of the last trading day of the delivery half month	The first business day of the month following the month which the last trading day of the contract month belongs to	
Last Trading Day	15 th or the last day of the month (If such date is not a business day, the business day immediately prior.)	15 th of the month (If such date is not a business day, the business day immediately prior.)	15 th of the month (If such date is not a business day, the business day immediately prior.)	
Settlement	Bilateral settlement		CME clearing	
Settlement Price	Fixed price agreed by seller and buyer	Differential price agreed by seller and buyer against JKM monthly average of the contract month	Arithmetic average of Platts JKM published in respect of the contract month during the settlement period	Arithmetic average of RIM DES Japan published in respect of the contract month during the settlement period

Source : TOCOM, 2017

Chart 3.3: Future room for spot transaction in Japan

LNG 2017 - 2030 supply contracted by Japanese companies before 2017 and contestable demand forecast 2017 - 2030



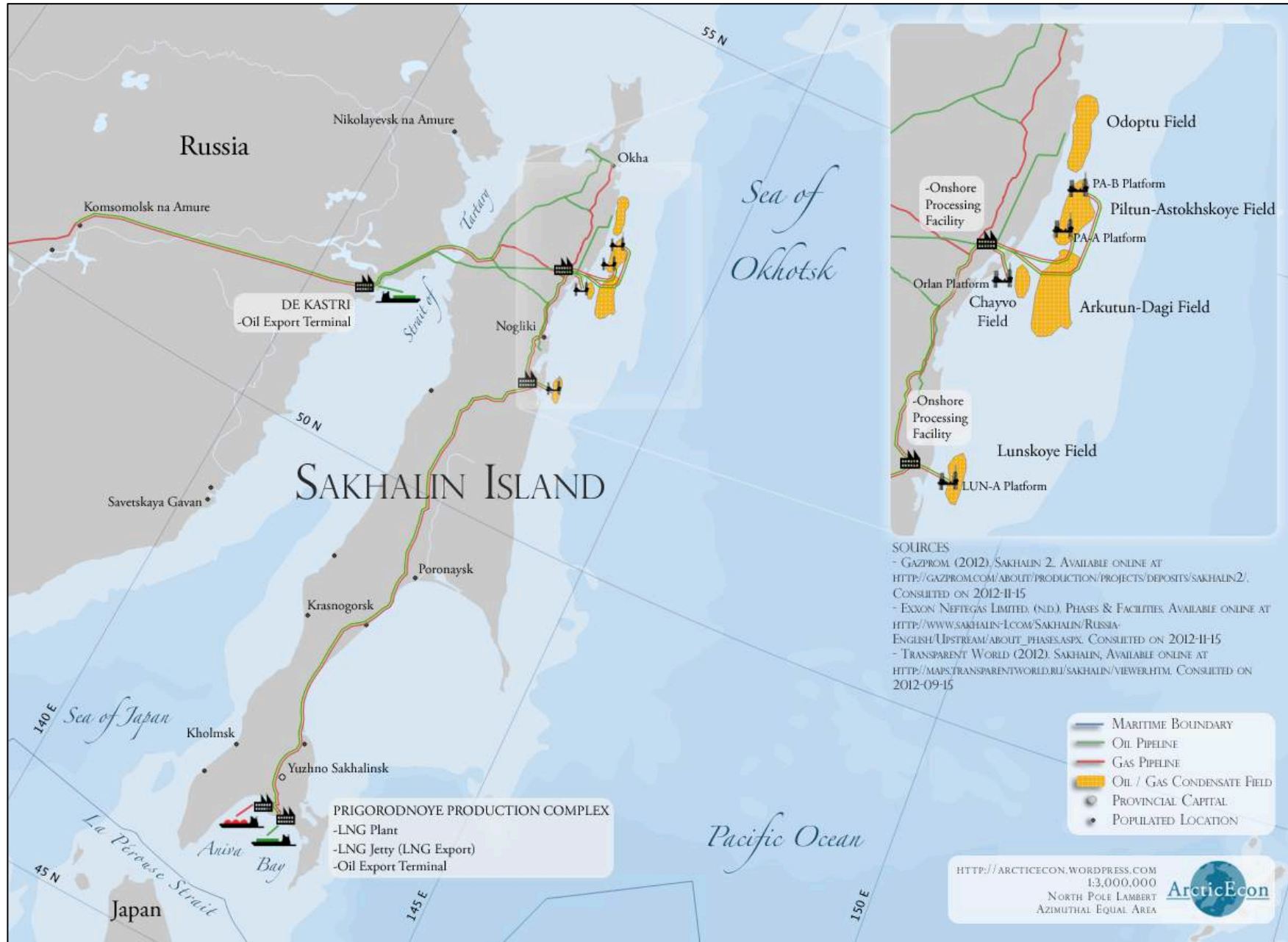
Sources : *GHIGNL annual report 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017 (for quantity contracted), demand based on IEA Global Gas Security Review 2016 and Stern, 2014*

Map: 3.3.1 Japan pipeline map



Source: IEA 2016a

Map 3.5: Sakhalin gas pipeline map



Source: ArcticEcon, 2011