It's time for

LNG

clean and competitive power

WÄRTSILÄ ENERGY SOLUTIONS

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Installed base* – Wärtsilä powering the world

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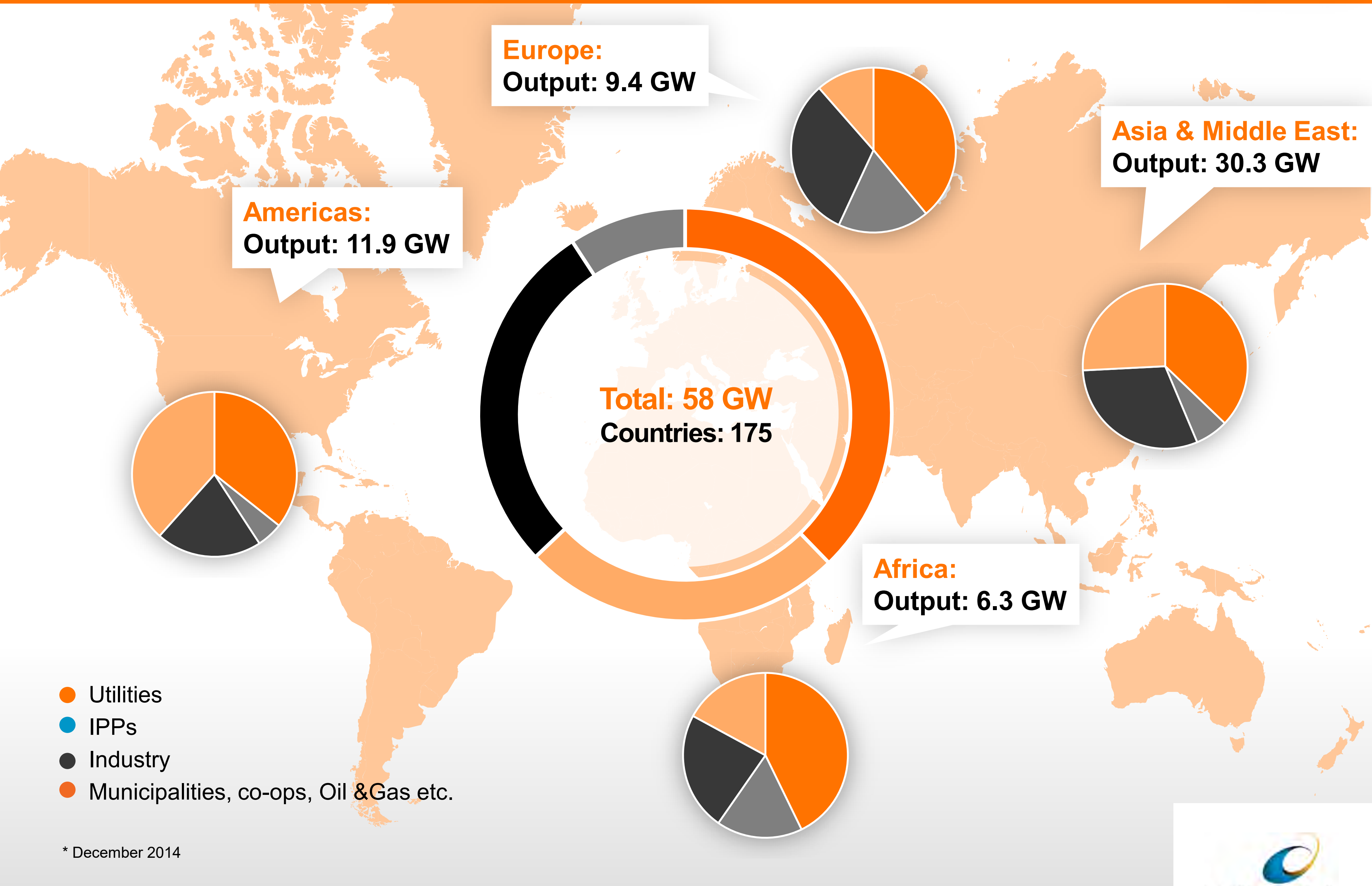

* December 2014

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WÄRTSILÄ DUAL-FUEL REFERENCES






MERCHANT	OFFSHORE	SPECIALS	DF CONVERSION	2-STROKE DF	DF POWER PLANTS
732 ENGINES	**132 ENGINES**	**61 ENGINES**	**28 ENGINES**	**11 ENGINES**	**352 ENGINES**
168 LNG carriers	24 Offshore supply	9 Ferries	4 FPSO vessels	4 Chemical tankers	75 plants
8 Multigas carriers	5 FPSO vessels	6 Tugs	2 RORO vessels	4 Container vessels	Output 4877 MW
2 Product tankers	4 FSRU vessels	3 ROPAX vessels	1 Chemical tanker	3 LNG carriers	Online since 1997
1 Bulk tanker	2 Platforms	1 Navy vessel	1 Ferry		
1 CNG carrier	1 FSO vessel	1 Icebreaker	1 IWW vessel		
		1 IWW vessel			
		1 Guide ship			

>1300 engines >12 million running hours

WÄRTSILÄ GAS ENGINE REFERENCES

INDUSTRY

361 PLANTS

779 ENGINES

3551 MW

53 COUNTRIES

IPP

116 PLANTS

560 ENGINES

4358 MW

22 COUNTRIES

UTILITY

131 PLANTS

501 ENGINES

3993 MW

31 COUNTRIES

>1900 engines

>12,000 MW

>60 countries

How to get LNG? – Conventional LNG supply chain

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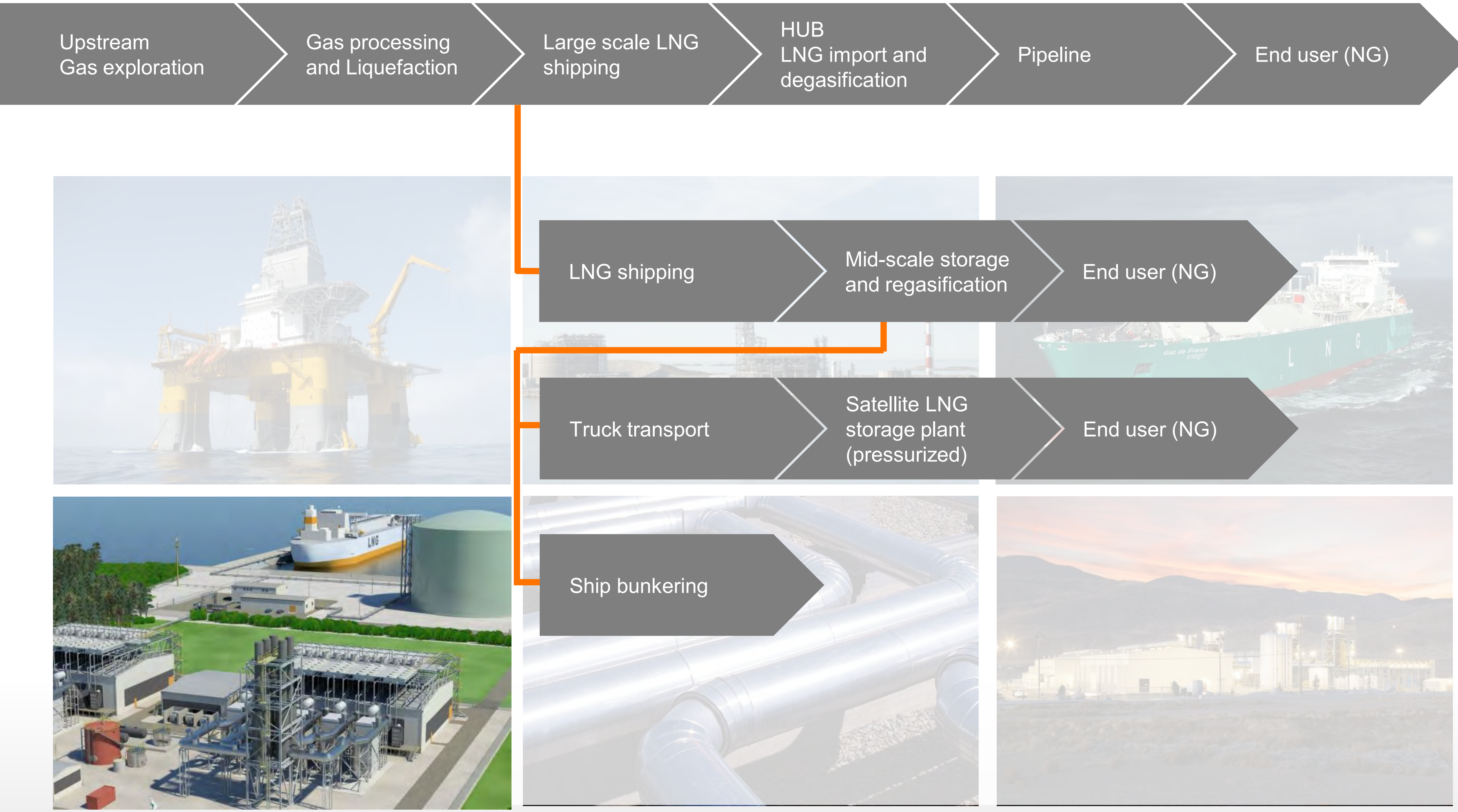
- Upstream Gas exploration
- Gas processing and Liquefaction
- Large scale LNG shipping
- HUB LNG import and degasification
- Pipeline
- End user (NG)

How to get LNG? – Mid and Small scale LNG



LNG supply fleet

- Present LNG fleet have been focusing on transocean supplies, i.e ship sizes are spanning from 120 – 250,000 m^3.
- Small size (1 – 20,000 m^3) supply vessel availability is limited, worldwide fleet about 20 vessels, in general the small-mid scale LNG supply infrastructure is not existing.

LNG Recieving Terminal – Power Plant

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“Does it make sense to invest into a Single Purpose LNG Receiving Terminal - as a fuel system for a Power Plant?”

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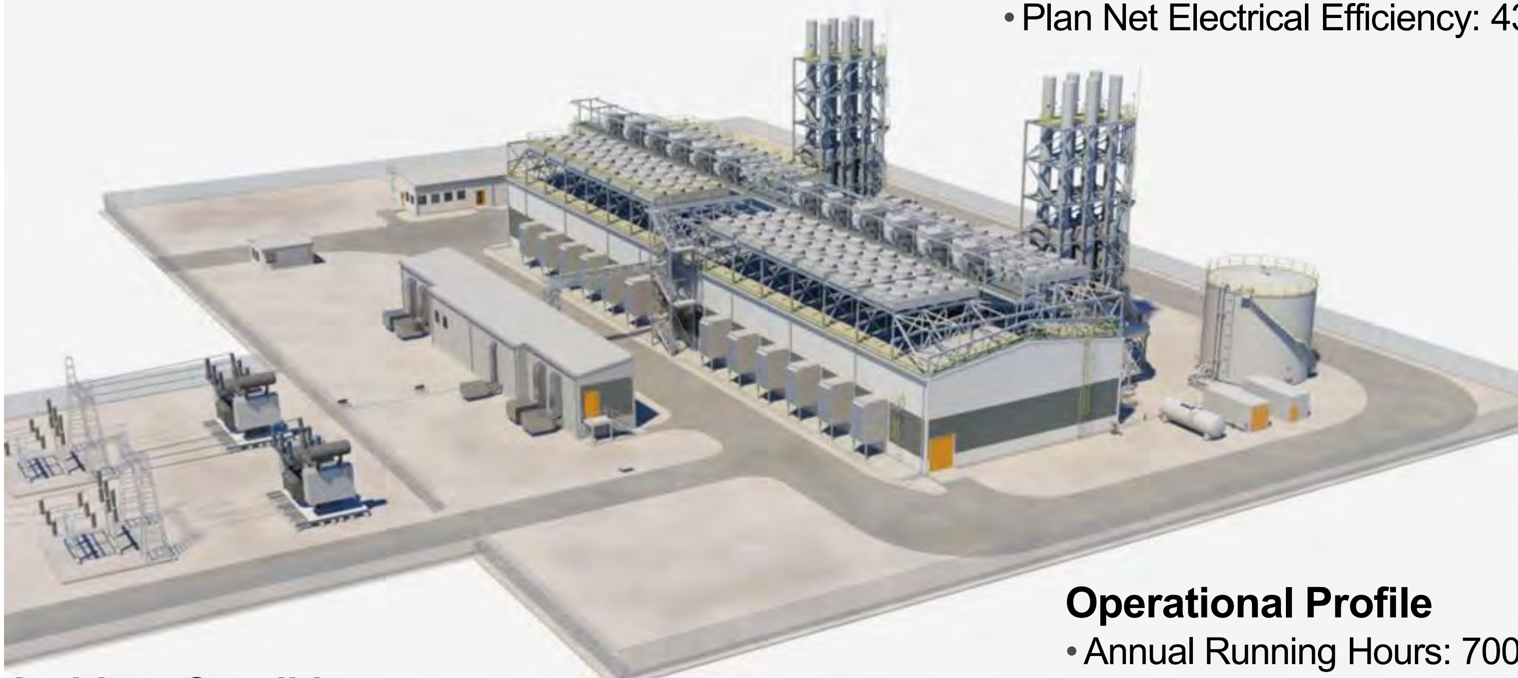
Chosen Power Plant Characteristics for the study

Power Output
- Single Cycle, gas engine 9MW and 18 MW
- Net Power at Step-Up Trafo: 50, **100**, 300 MW
- Outgoing Voltage: 110 kV

Fuel Consumption
- Fuel: LNG (Natural Gas)
- Generator set efficiency: 46%
- Own electrical consumption: 4 MW at 400V
- Plan Net Electrical Efficiency: 43,1 - 44,5%



Operational Profile
- Annual Running Hours: 7000
- Plant average load: 80%
- Utilization factor: 64%

Ambient Conditions
- Average ambient temp: 29 C (min. 10 C, max. 40C)
- Height above sea level: max. 100 m
- Methane number 80

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Power Plant Configuration

Plant Size	50 MWe	100 MWe	300 MWe
Prime Mover	6X20V34SG	12X20V34SG	18X20V50SG
Plant Net Output @site conditions	53 MWe	106 MWe	304 Mwe
Net Electrical Eff. Net Heat Rate	43,1% 8271 kJ/kWhe	43,2% 8250 kJ/kWhe	44,5% 8013 kJ/kWhe

Plant Size	50 MWe	100 MWe	300 MWe
LNG cons/day	511 m3	1022 m3	2840 m3


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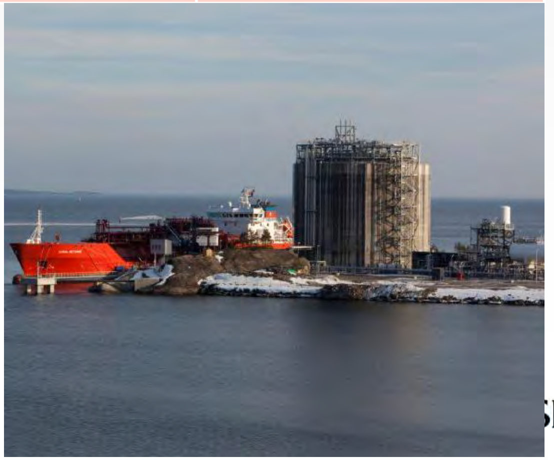
LNG Consumption at max. and average loads

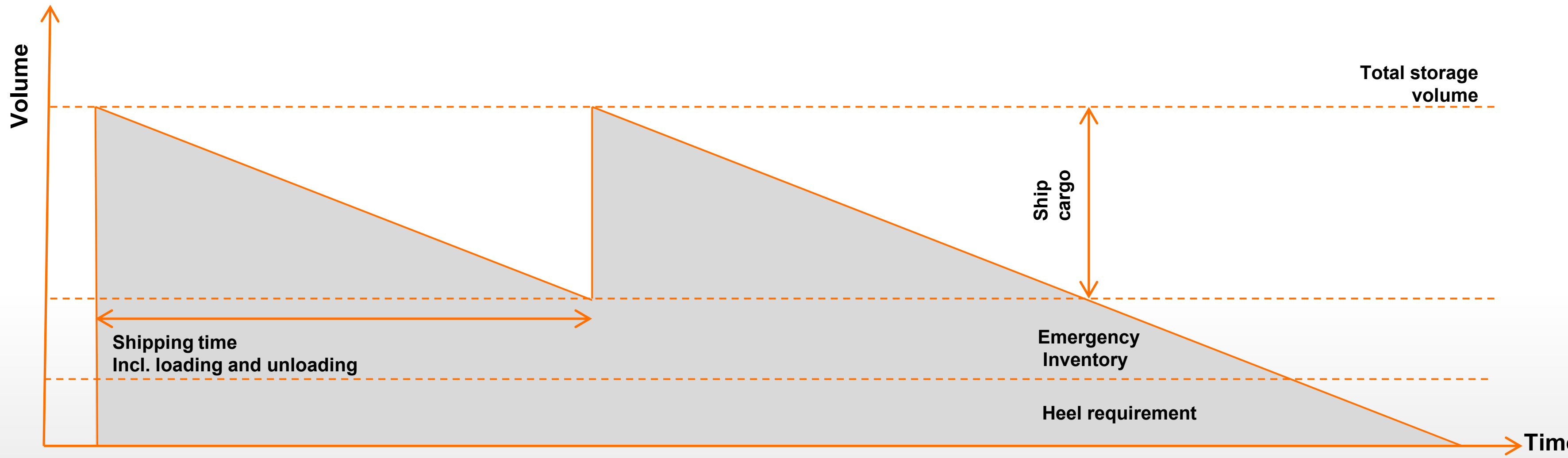
Plant Size	50 MWe	100 MWe	300 MWe
Power Plant Consumption, max. load	511 m3/day	1022 m3/day	2840 m3/day
Additional Gas Take-Off, max. Load	701 m3/day	1360 m3/day	1754 m3/day
Total Gas Consumption, max. load	1212 m3/day	2382 m3/day	4593 m3/day
Total Gas Consumption, average load	677 m3/day	1311 m3/day	2604 m3/day

Plant Size	50 MWe	100 MWe	300 MWe
Annual Consumption, Average load	247.000 m3	478.000 m3	950.000 m3



Terminal optimization

- The most important parameter when optimizing the terminal is the LNG supply. The ship size will determine the cargo that will be received. Shipping time and needed weather margins will determine the time between cargos. But also available HUB slots and costs need to be considered.
- The average consumption requirement will determine the slope of the volume curves and thus the needed re-gasification capacities.
- Heel Requirement is for safe-guarding the cry-temperature in the LNG tank at all times



LNG Carrier Capacity Determination

Main Parameters for carrier capacity determination:

- Transportation Distance: 1500 NM
- LNG Carrier average speed: 15 Knots
- LNG Tank sizes as defined
- Gas consumption as defined
- For average capacity

	Carrier Capacity	
Plant Size	No Gas Off-Take	With Gas Off-Take
50 MWe	6000 m3	13.000 m3
100 MWe	12.000 m3	30.000 m3
300 MWe	35.000 m3	52.000 m3

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LNG Storage Tank Capacity Determination

Main Parameters for storage tank capacity determination:

- Safety inventory: 7 days
- Heel requirement: 10%
- Shipping information as defined
- Gas consumption as defined
- For average gas consumption

	LNG-Tank Capacity	
Plant Size	No Gas Off-Take	With Gas Off-Take
50 MWe	10.000 m3	25.000 m3
100 MWe	20.000 m3	45.000 m3
300 MWe	57.000 m3	90.000 m3

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LNG Recieving Terminal – Power Plant

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Smart Power Generation meets LNG

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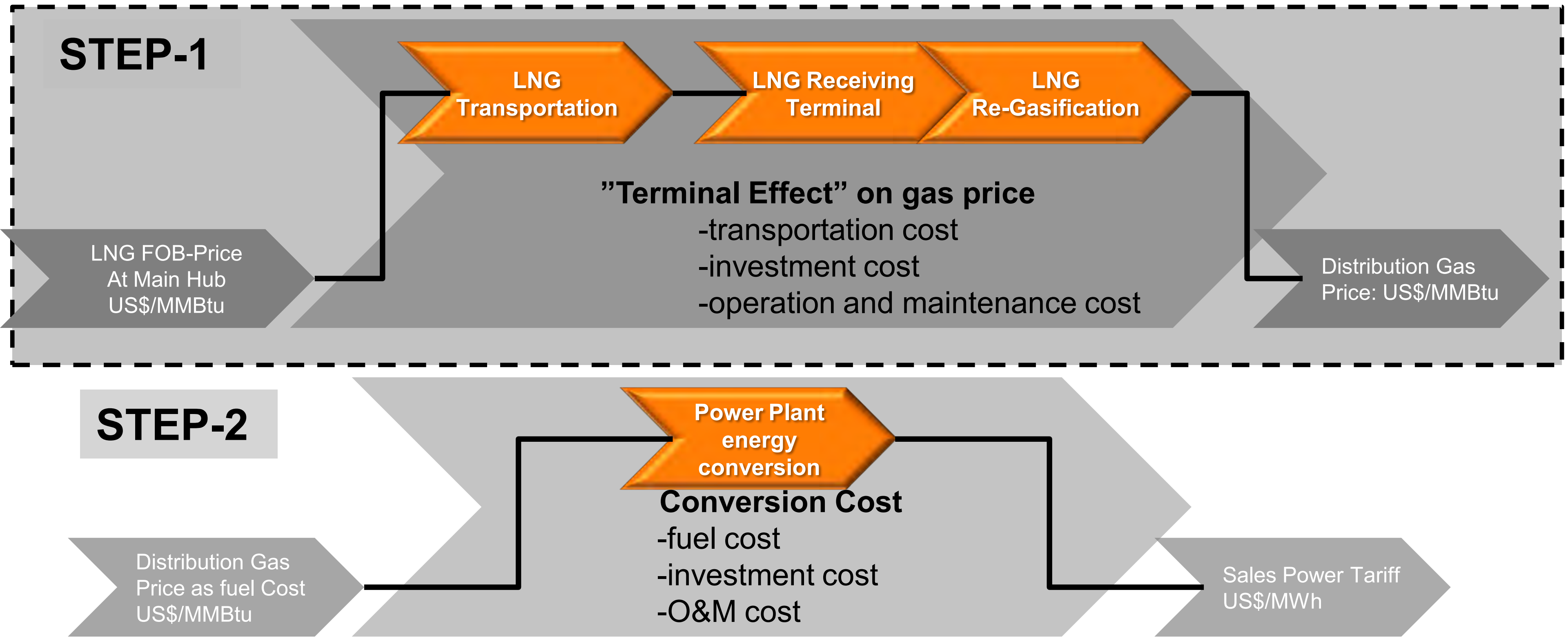
LNG Feasibility Analyze – STEP 1



LNG "Terminal Effect"

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FOB LNG Purchase
LNG Transportation
LNG Storage
LNG Re-Gasification
STEP 1

Power Plant
Power Sales
STEP 2

LNG transportation

- Own LNG carrier operation
- Out-sourced Carrier operation to third party
- Transportation through LNG provider

- All In Cost by LNG provider is considered. Depends according to LNG volume

Terminal Investment

- Tank and main process
- Re-gasification process
- Other: land, on-shore and off-shore infrastructure
- Working Capital, LNG tied in vessel and storage tank

- Considered as total investment

Terminal O&M

- Operational Man Power
- Maintenance Man Power
- Spare parts and Material for maintenance

- Typical estimation 1-2% of the investment in annual bases

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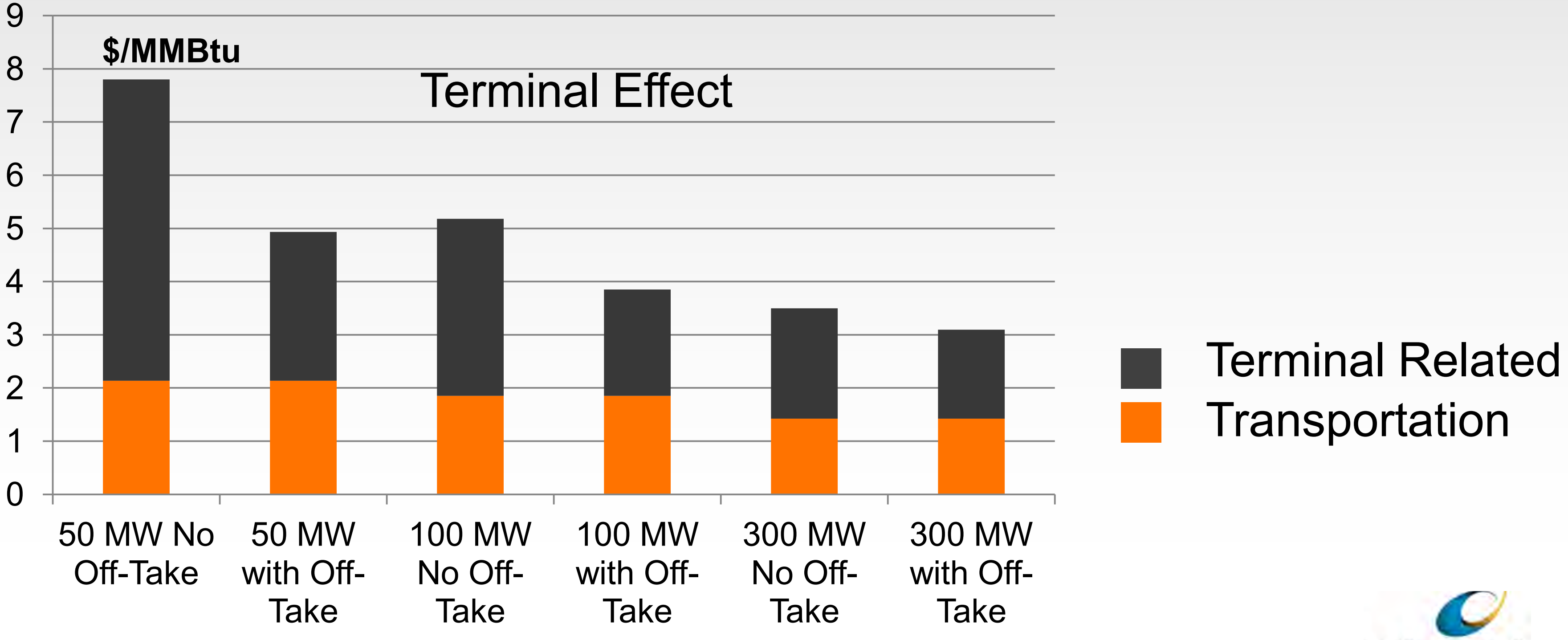
LNG "Terminal Effect"

	Terminal Effect - $/MMBtu	
Plant Size	No Gas Off-Take	With Gas Off-Take
50 MWe	7,80	4,94
100 MWe	5,18	3,85
300 MWe	3,50	3,1



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LNG Based "Power Tariff"

FOB LNG Purchase → LNG Transportation → LNG Storage → LNG Re-Gasification

STEP 1

Power Plant → Power Sales

STEP 2

Power Plant Investment

- EPC cost
- Other up-front costs: land, on-shore infrastructure, licenses, etc.
- O&M mobilisation costs

- Considered as total investment

Power Plant O&M

- Operational Manpower
- Maintenance Manpower
- Spare parts and Material for maintenance

- Fixed O&M cost
- Variable O&M cost

Final Conclusions

It's time for LNG clean and competitive power

Single Purpose Terminal can make sense

- For remote location LNG can be the only acceptable fuel. Alternative would be HFO
- LNG Terminal can serve the regional industry with clean and affordable fuel
- LNG can be a domestic fuel

Terminal economics is case specific

- Each case must be studied indivudually
- LNG FOB-price dominates the Distribution Gas Price structure
- Additional Gas Off-Take will benefit the project feasibility
- Difference between the best FOB-price and Distribution price is around 20%

Gas fired power plant – a natural choice

- For ”Green-Field” power development LNG is preferable vs. HFO
- Power tariff difference is 37% between the two extremities
- At its highist the ”Terminal Effect” will increase the power tariff with around 25%
- At its lowest the ”Terminal Effect” will increase the power tariff with less than 10%

With right LNG FOB price and power tariff a Single Purpose LNG Terminal can make sense...

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Smart Power Generation

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