Small Scale LNG

Emerging Technologies for Small-Scale Grids

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ENERGY STUDIES INSTITUTE
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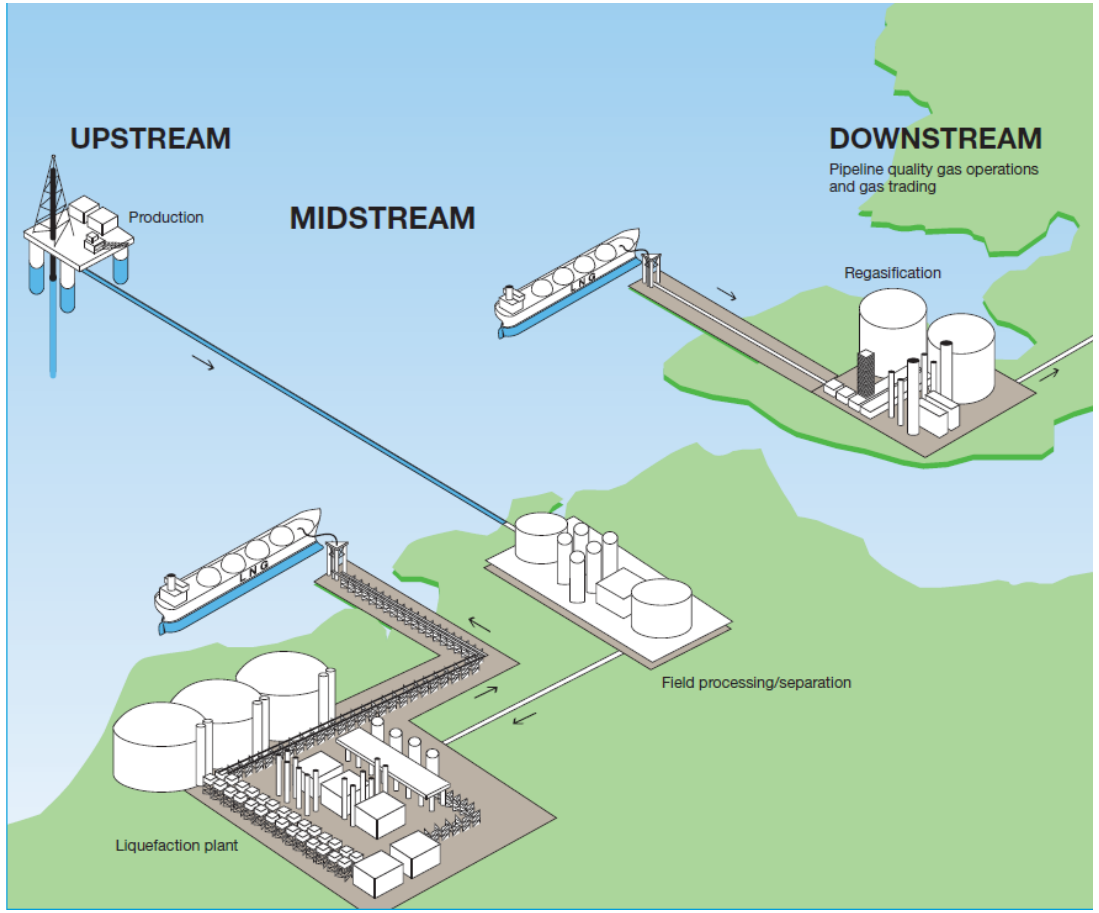
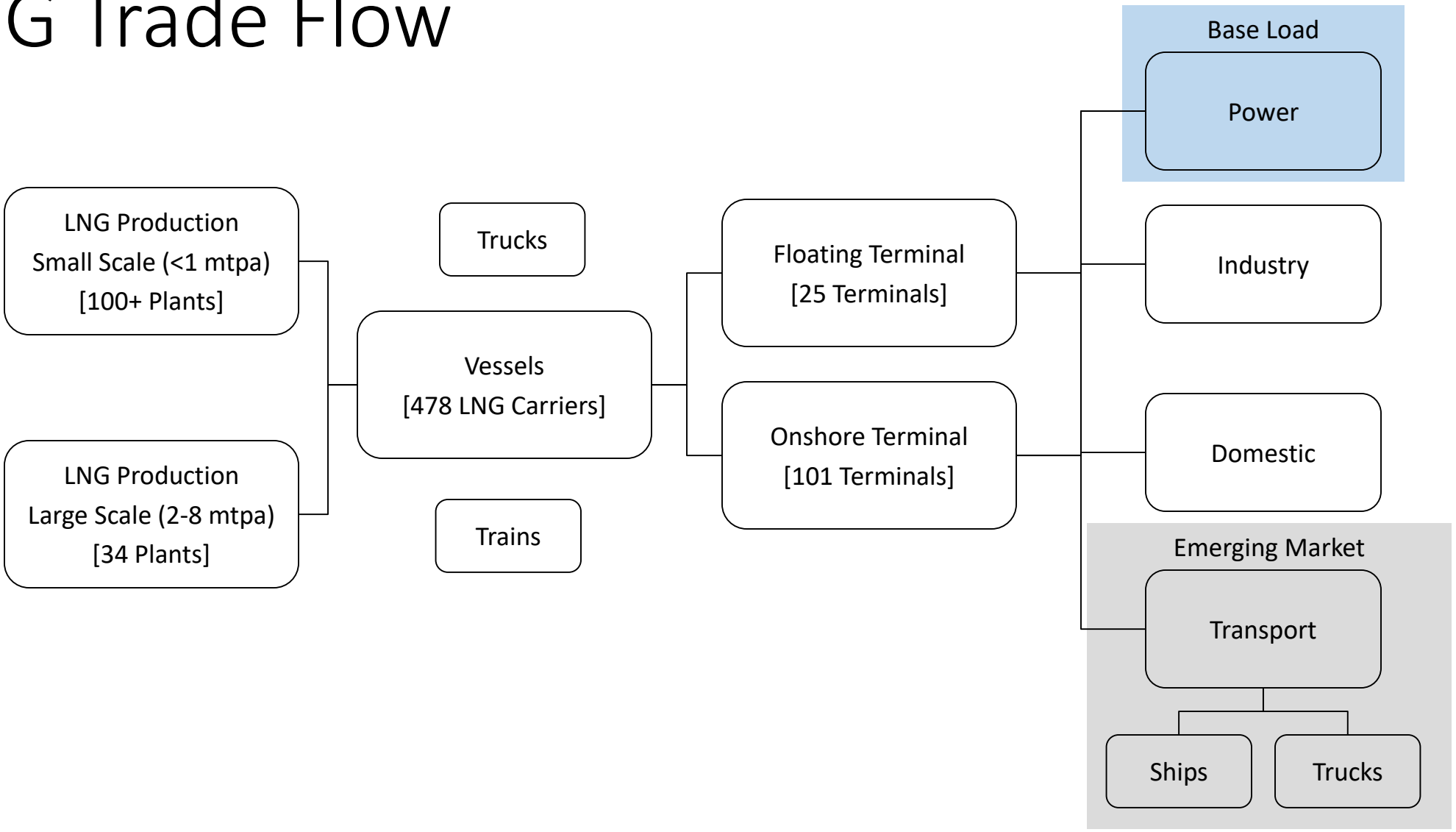
The traditional LNG business model



- **Integrated model**
  - Production/transportation and storage
  - Long term offtake agreements
- **New model emerging**
  - Integration within a country
  - Local production
  - More suppliers
  - Transportation by ship, truck, train
  - Delivery to a single end user
  - Many more buyers
  - Simpler lower cost infrastructure
  - Still underpinned by long term offtake agreement

LNG Trade Flow



Example of small/medium scale LNG market

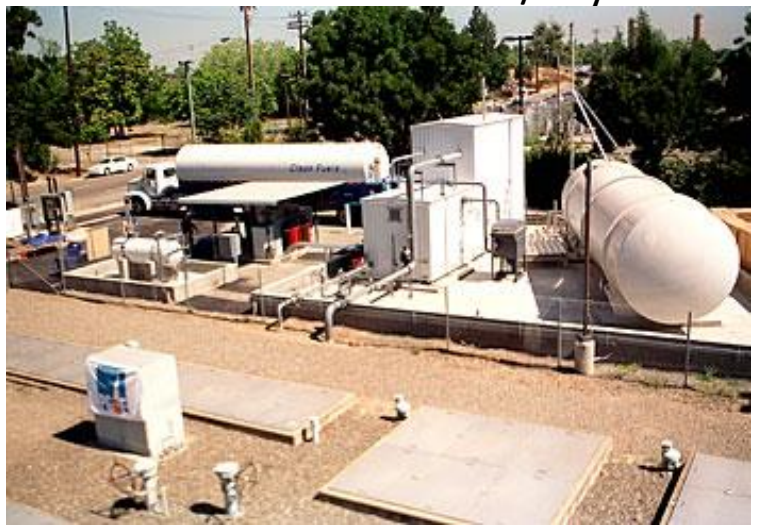
- **Large scale LNG – Snohvit 4.1 million tonnes/annum**
- **Small Scale LNG- 15,000 tpa at Tjeldbergodden, Norway + 3 more**
  - 28 small LNG terminals
  - Small scale storage
  - Feeder vessels – 7,500 – 20,000 cu.m
  - Small LNG carriers – 1,100 – 10,000 cu.m
  - Trucks 20-40 tonnes
  - Rail tank cars – 60-100 tonnes
  - Pipelines
  - 7 LNG bunker terminals
- **Customers**
  - Industry
  - Power
  - Trucking companies
  - Ferries
  - Offshore service vessels/Coastguard

China market developing along these lines, Indonesia could be next

What do we mean by small scale?

32 million tonnes per annum

- Conventional LNG – 3-7 million tonnes per annum trains
- Mini size 20 – 100 tonnes/day
- Small size 100-500 tonnes/day
- Mid size 500 – 3000 tonnes/day



10 tonnes per day

What do we mean by small scale?

Singapore LNG terminal– 11 mtpa

Nynashamn LNG terminal 0.25 mtpa

Large bullets
760 cu.m

What do we mean by small scale?

Conventional LNG carrier – circa 145,000 m^3
Q Flex 220,000 m^3
Q Max 244,000 m^3

Small LNG carriers

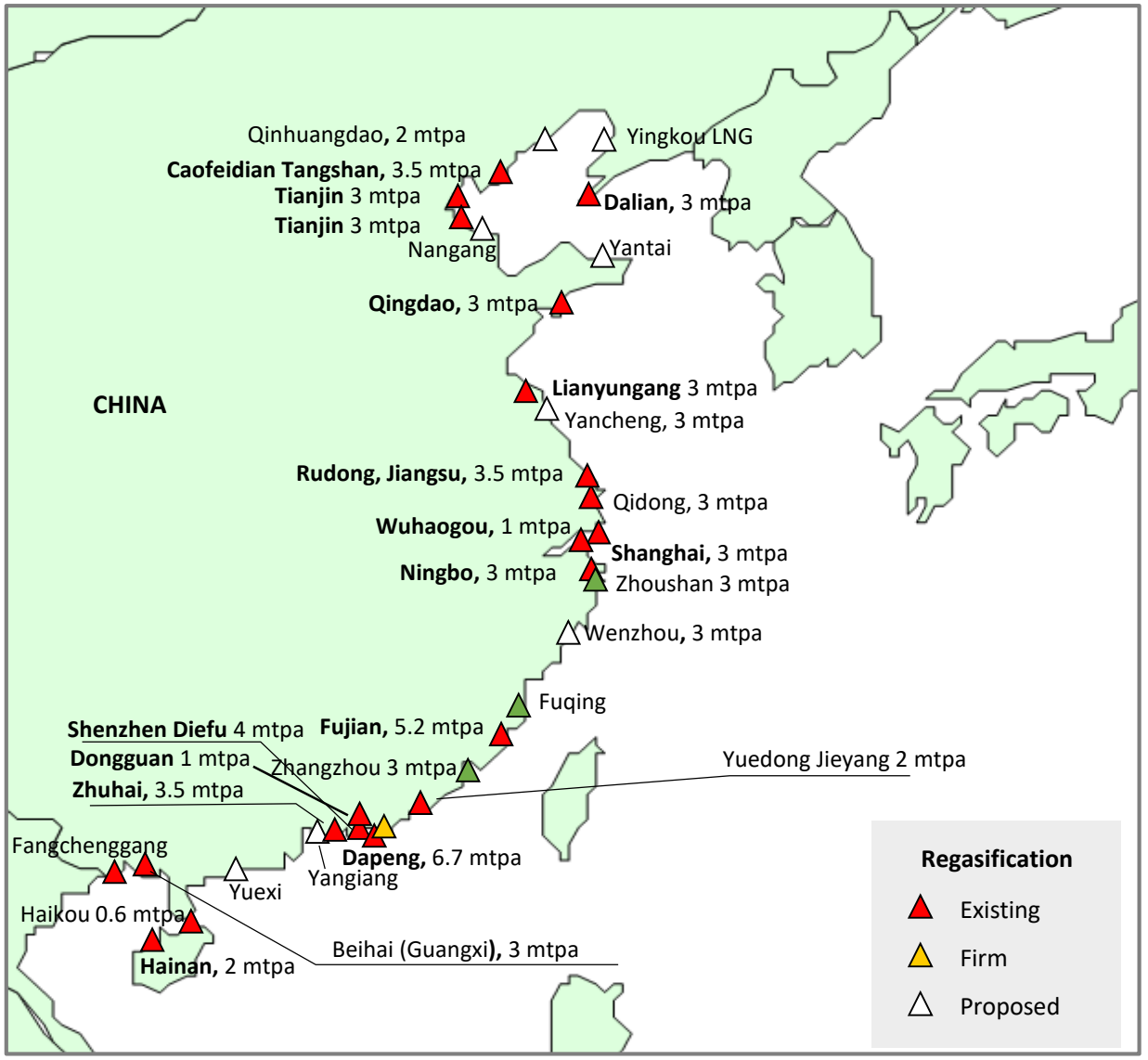
- Coral Methane 7,500 m^3
- Coral Energy 15,600 m^3

What do we mean by small scale?

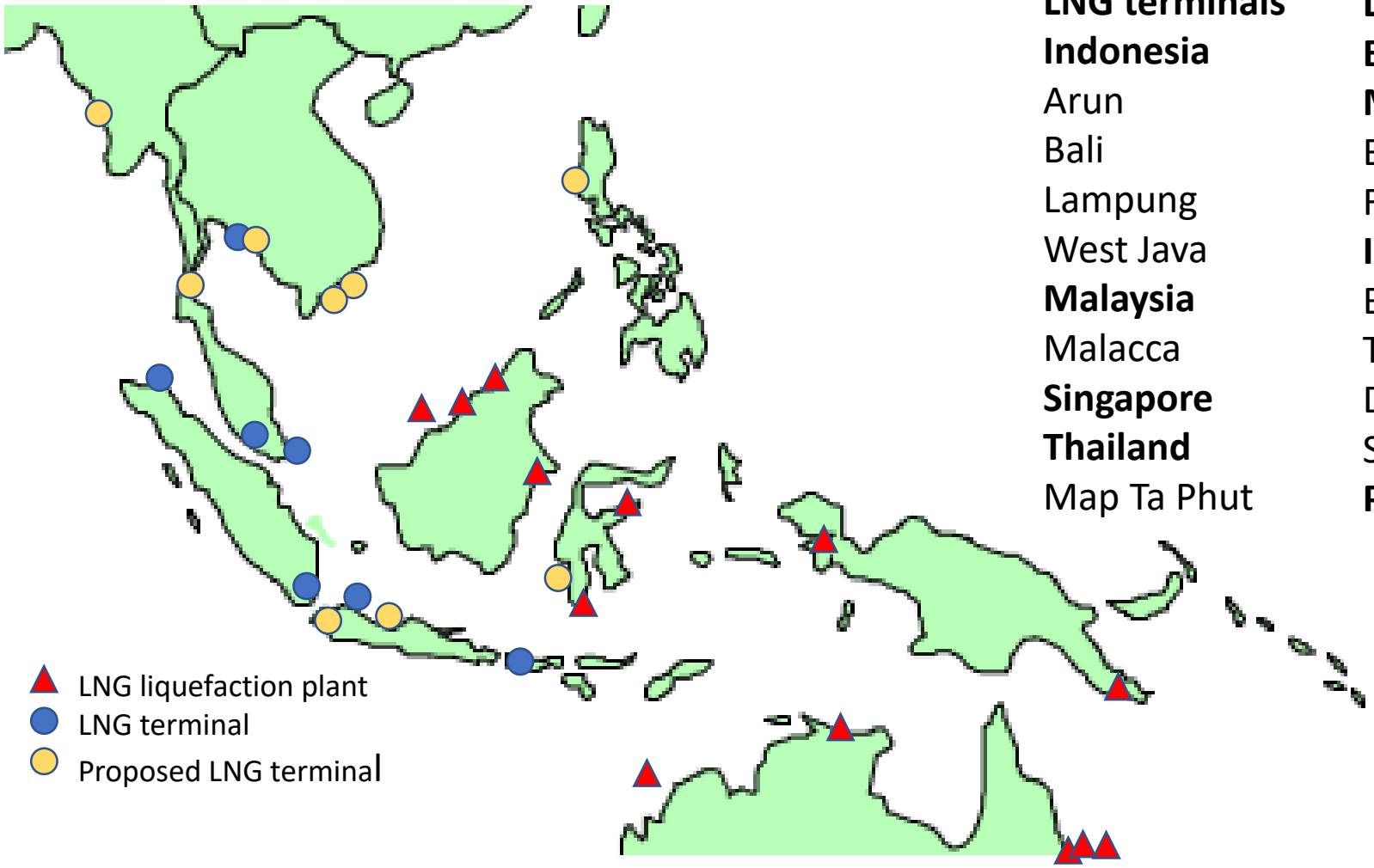
Trucks
Trains
Ships
Iso tanks

China

- 20 LNG receiving terminals
- 4 small scale LNG terminals
- 100+ small scale liquefaction plants
- 5 million NGV's
- 250,000 LNG fuelled trucks
- 3,300 LNG service stations
- 10,000 LNG trucks
- 106 inland river LNG fuelled vessels



SE Asia LNG Infrastructure



LNG terminals
Indonesia
Arun
Bali
Lampung
West Java
Malaysia
Malacca
Singapore
Thailand
Map Ta Phut

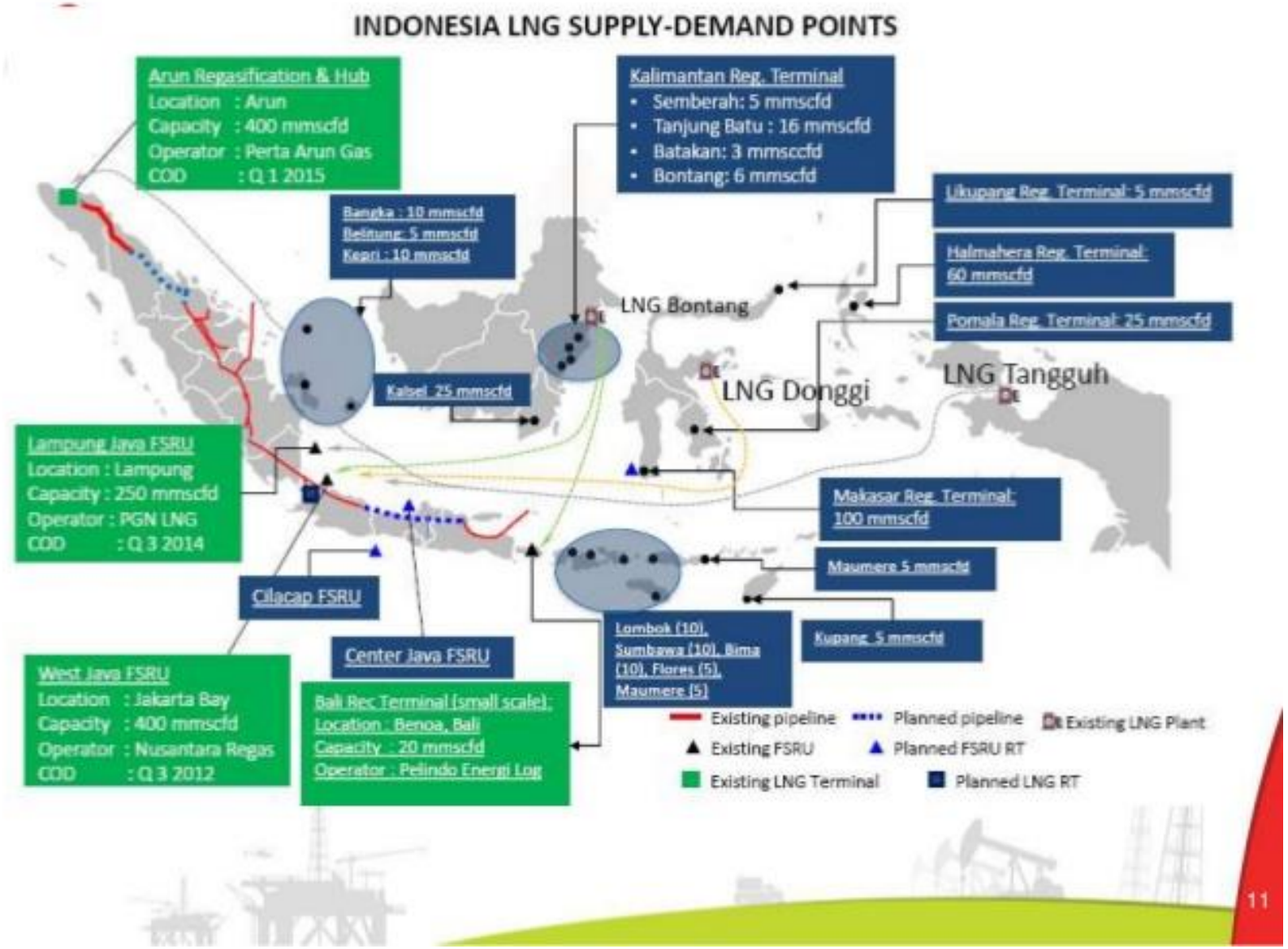
Liquefaction plants
Brunei LNG
Malaysia
Bintang
FLNG Satu
Indonesia
Bontang
Tangguh
Donggi Senoro
Sulawesi
PNG LNG

Substantial large scale infrastructure to support emerging small scale – many supply hubs.

Indonesia

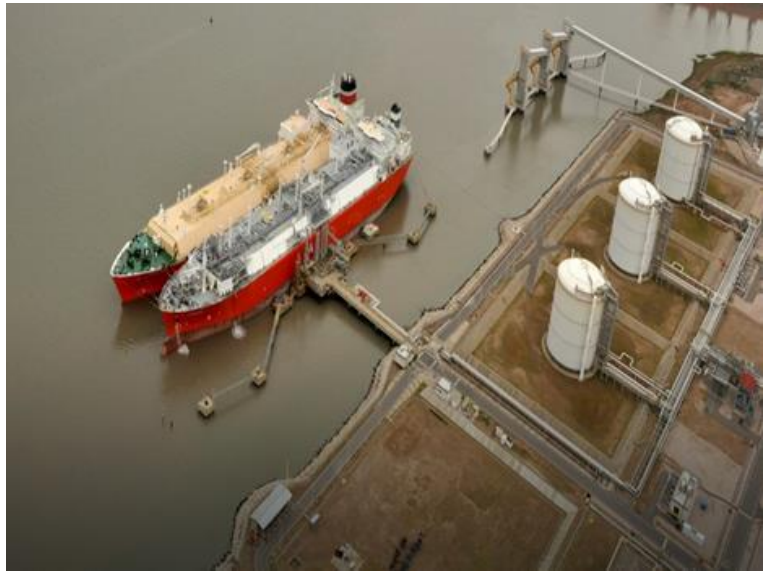
Note the small volumes in the blue boxes

West Java FSRU 400 mmscf/d
Kupang 5 mmscf/d



Source: SKK MIGAS

FSRU



Excelerate LNG, Bahia Blanca Argentina

PGN FSRU Lampung, Indonesia

25 floating terminals in operation

FSRU storage capacity ranges from 125,000 to 263,000 cu.m. but most about 170,000 cu.m.

These too big to support many of the emerging gas to power opportunities

Need some small/medium size FSRU's

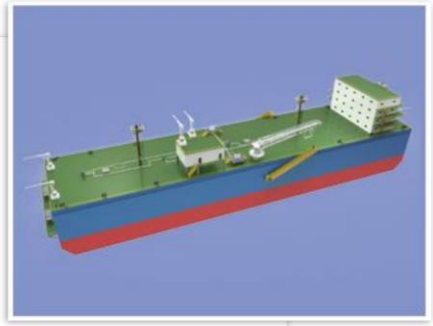
First small scale floating terminal

Bali 26K LNG FSU

"Floating Storage Unit for Bali Benoa Port to supply LNG to FRU"

- Year of Contract (Delivery): 2015 (2016)
- Client: JSK Shipping (Indonesia)
- Shipyard: *(TBD)*
- Classification: KR
- Scope of Work:
  - FEED & PMC
  - Shipbuilding Engineering & Design
  - Cargo Handling Equipment Supply
- Dimension of Vessel/ Barge
  - LOA : 119.1 m/ Breadth: 27.1 m/ Depth: 16.4 m
- Characteristics of LNG Storage Tank
  - Q'ty x Capacity: 2 x 13,000m³
  - CCS: MK-III Membrane type
- Cargo Handling Equipment
  - Main CP: 4sets (2sets/ tank), 200 m³/hr, 155 mlc
  - Stripping/Spray pump: 2sets (1set/ tank), 50 m3/hr, 155 mlc
  - Return gas compressor: 2 x 2,000 m³/hr
- Nitrogen Generator Plant
  - Capacity PSA plant: 2 x 40 m³/hr at 97 vol %

CCS: Cargo Containment System
CP: Cargo Pump
PMC: Project Management Consultancy
PSA: Pressure Swing Adsorption



Bali 50mmscfd LNG FRU

"The World's First Floating Regasification Unit for Bali Benoa Port to supply LNG to Power Plant"

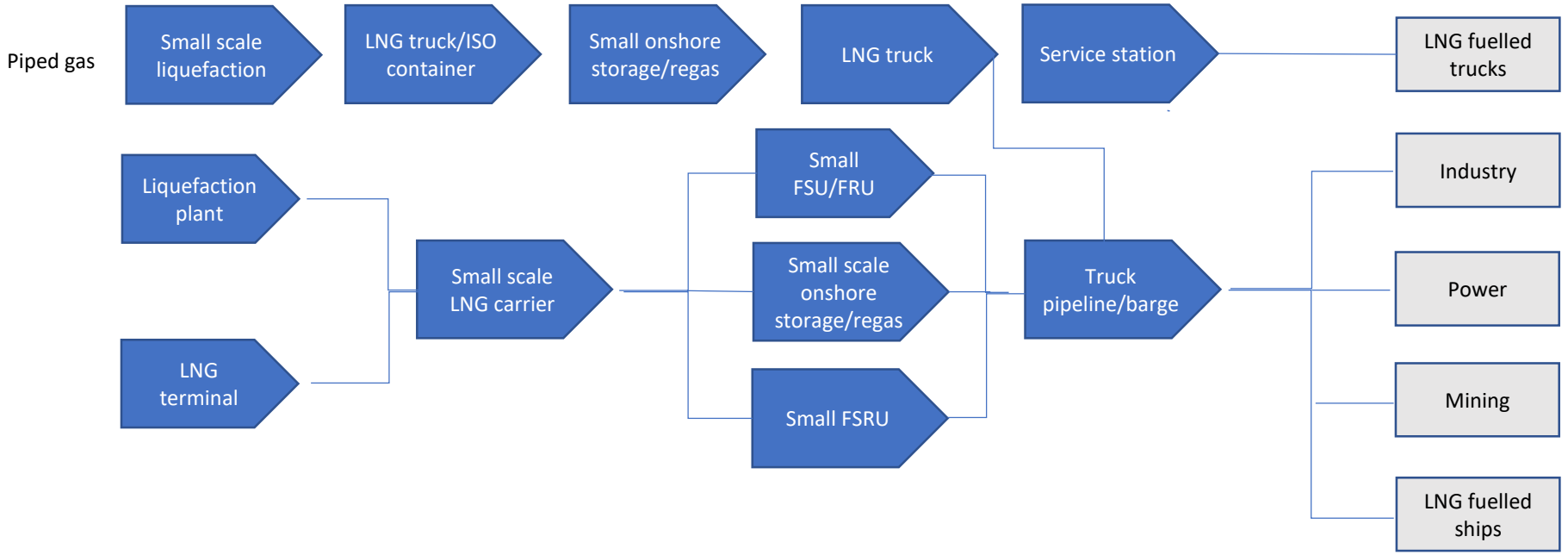
- Year of Contract (Delivery): 2015 (2016)
- Client: JSK Shipping (Indonesia)
- Shipyard: KangNam Corporation
- Classification: KR
- Scope of Work: EPC Contractor
- Dimension of Vessel/ Barge
  - LOA : 46.0 m / Breadth: 12.0 m / Depth: 4.7/ 5.2 m
- Characteristics of LNG Buffer Tank
  - Q'ty x Capacity: 1 x 400 m³
  - LNG feed pump: 2 x 100m³/h x 260 mlc, Electric motor driven, Barrel Type
- Regasification System
  - LNG flow to skid: 50 mmscfd
  - Inlet/ Outlet temp.: appr. -158 ℃/ min. 5 ℃
  - NG outlet pressure: 900 kPa.g

KR: Korea Register

Source Gas Entec

Separate Floating Storage Unit and Floating Regasification Unit (0.5 mtpa) Benoa, Bali

Small scale LNG value chain



More complex than large scale value chain – more options

Small scale can be relatively expensive

Small is relatively expensive:
Conventional 170,000 m3 LNG carrier – approx US$210 million
Mid scale 30,000 m3 LNG carrier (Type C) – approx US$105 million
Small scale 12,000 m3 LNG carrier (Type C) – approx us$50 million

How do costs compare with conventional LNG

Higher unit costs than for large scale LNG

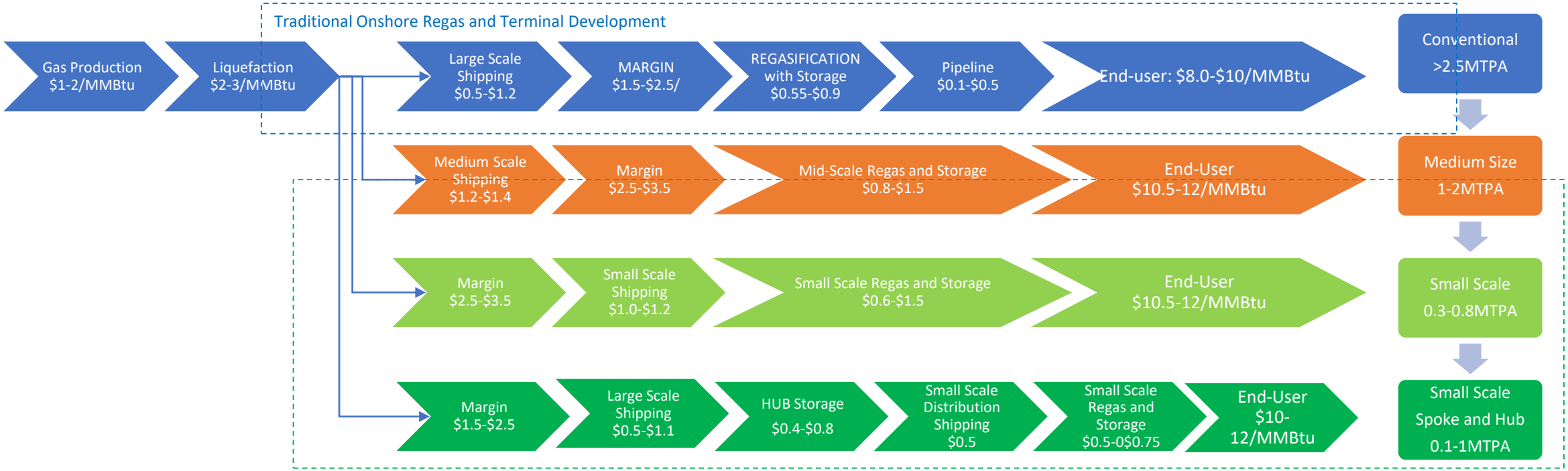
- Costs more to transport a cubic metre of gas in a small carrier compared with a large carrier
- Costs much more to store a cubic metre of LNG in a small bullet than a full size terminal tank

BUT

- Small or midscale does not need to be more expensive if concept is properly chosen around cost optimisation, considering logistics, technologies and if possible existing available infrastructure or natural shelter.

Small and mid scale v conventional

Small or midscale does not need to be more expensive if concept is properly chosen around cost optimisation, considering logistics, technologies and if possible existing available infrastructure or natural shelter.



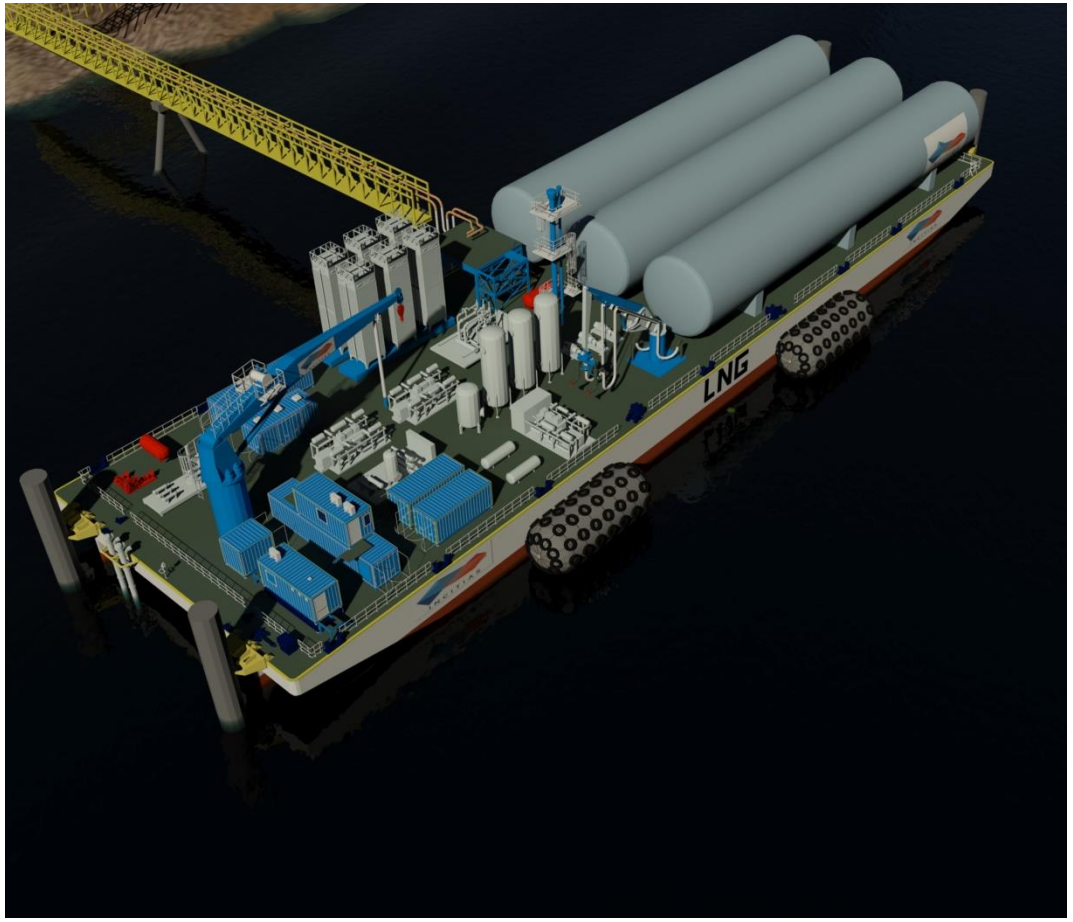
Optimised facility, minimising storage, maximising logistic chain, utilising existing infrastructure, choice between: regas on shore with storage onshore or FSU, FSRU (regas barge) or FSU and regas offshore.

Optimization

Optimization of logistic chain cost can bring advantage in the order of $0.5/MMBtu. This may include:

- Storage minimization
- Utilisation of existing key infrastructure such as berths.
- Slower steaming of LNG carriers – sailing at 10 knots rather than 14 knots can result in a 70% fuel saving.
- Maximisation of LNG carrier utilization – sharing with other projects
- LNG supply within a range of approximately 1,000 nautical miles for small scale and less than 2,500 nm for midscale.

SNG^{TM} Barge with 6000m3 Storage 20-30mmSCFD

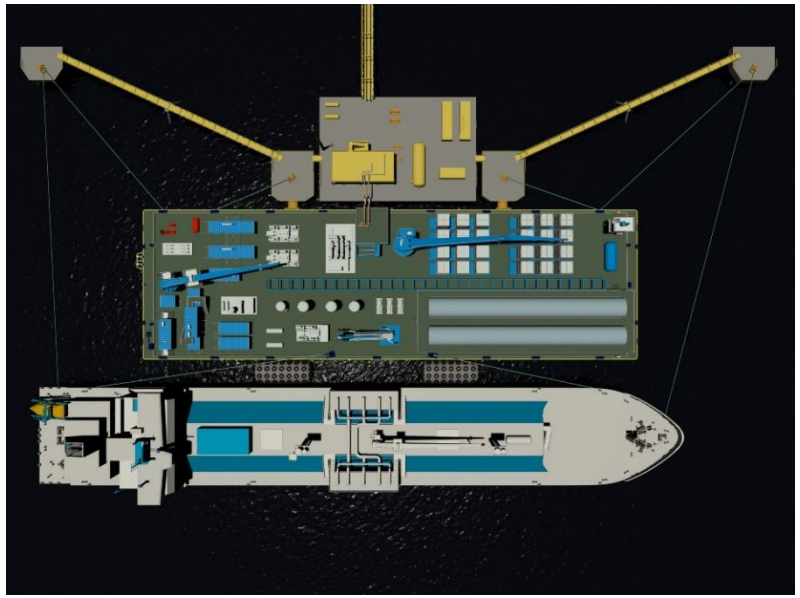


Draught<4m,
LOA=100m
B=33m,
Loading rate
800m^3/hour
IMO-IGC, SIGGTO, ISGOTT, ISO and ASME Standard compliant.

SNG^{TM} Barge with 3X 2270m^3 (100%) Storage Regas Capacity Modular : From 3-30mmSCFD Gas Engine for Power Generation on Board 8-52barg.

Source: INCITIAS

SNG Barge™ 30-110mmSCFD for use with FSU



Source: INCITIAS

SNG^{TM} Barge with 8X 2100m^3

Draught<4m,
LOA=120m
B=36m,
Loading rate
1200m^3/hour
IMO-IGC, SIGGTO,
ISGOTT, ISO and ASME
Standard compliant.

SNG^{TM} Barge with 8X 2100m^3 (100%) Storage Regas Capacity Modular : From 3-75mmSCFD Gas Engine for Power Generation on Board 8-52barg.

Source: INCITIAS

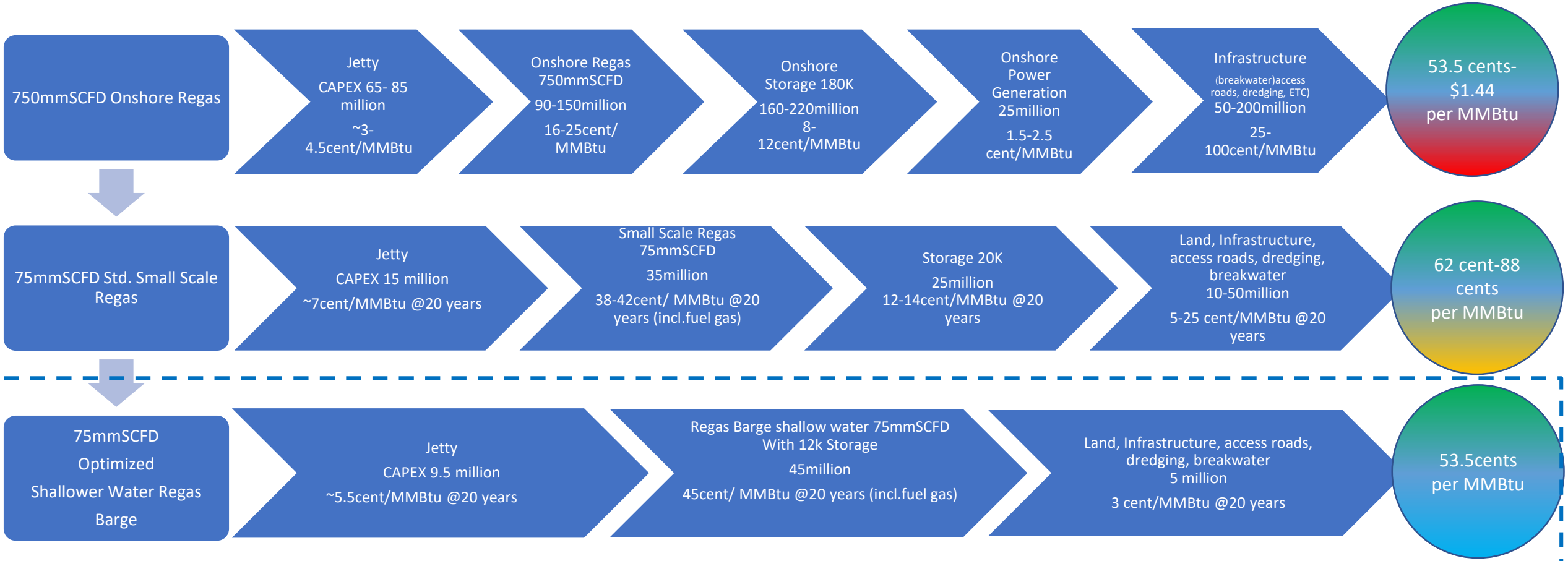
Shallow Water Multi Modal LNG distribution

Source: INCITIAS

- 3x 2270m3 LNG storage in C-type tank
- Transhipment on Barge to 20” and 40” ISO Container, to enable sub distribution
- Draught 3.4m
- L=95m
- B=30m
- Speed: 8kn-10kn
- Tug Push or Pull
- Can moor and offload to standard 6000DWT wharfs available in most south east Asian island ports
- Optional: Articulated Tug Barge solution.

Large Scale to Small Scale Regas Comparison

Assumption 20 year Design life, within Tropic of Capricorn



Based on a real project in Indonesia (with execution currently on hold) with local infrastructure provider based on turnkey pricing firm quotation and in country barge construction to meet local content with design done by reputable engineering house and reputable cryogenic equipment vendor and construction supervision accuracy +/-20% as BOOT contact.

Last word

- Small may be beautiful but it can also be high cost. First movers found it very difficult to find economically viable solutions
- Now, after much R&D, we have a good suite of economically viable solutions but challenges remain
- However, if one selects the right technology based on the site and local requirements and optimise around the logistic chain, minimise storage and avoid costly infrastructure developments (such as extensive capital dredging, construction of breakwaters) and by smart selection of site, technology and contracting strategy (say BOOT or EPCM, but also lease) then small scale LNG project economics can be low enough to enable gas to be supplied to even the smallest power plants
- Optimise the entire supply chain and scale equipment to the demand and unit costs can be comparable with large scale – 53 cents/MMBtu
- We now have economically viable solutions for the small scale market