

GE Global

LPG - *EXCEPTIONAL ENERGY* for
Power Generation

Bogota, August 20, 2019



LPG for Power Generation - more than talk...



- ① **LPG is a liquified gas like LNG – but better suited for smaller scale power...** up to 400MW LPG beats LNG on price
- ② **LPG to power is real – no longer a concept...** multiple reference plants across the world
- ③ **LPG logistics - key to success** ... logistics (transport & storage) must be easy and cost efficient ... advantage vs. LNG
- ④ **Clean fuel...** target diesel & HFO replacement ... lower cost, higher efficiency & lower emissions vs. HFO^{-a)} & diesel^{-b)}
- ⑤ **Hybrid solutions for Renewables** ... LPG complements solar and wind perfectly ... low emissions
- ⑥ **LPG supply** ... outlook for LPG supply favourable... forward pricing remains attractive

The timing is right!

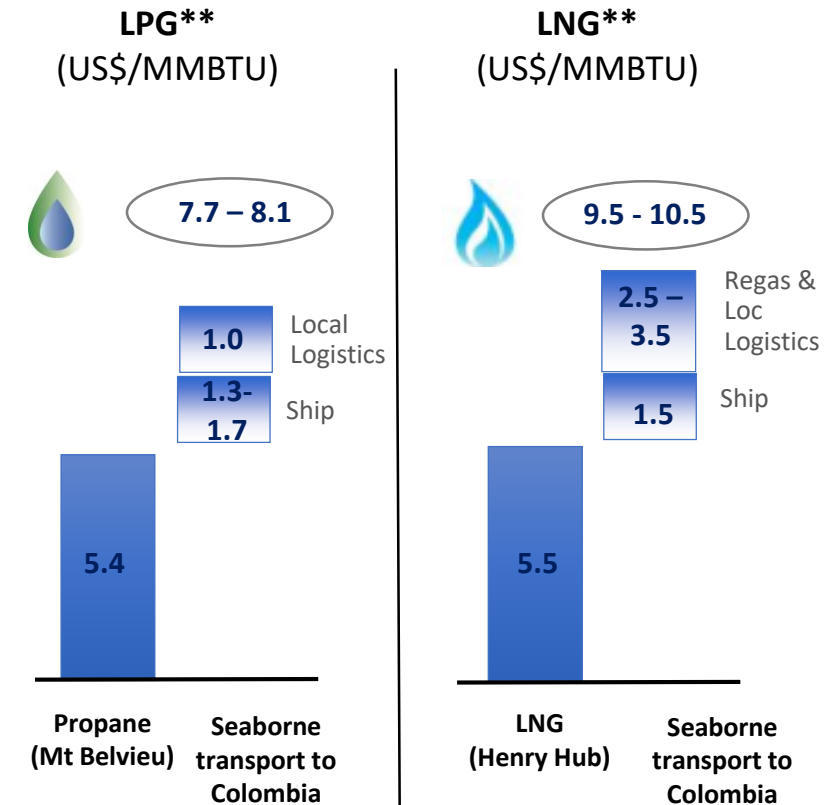
(a-Heavy Fuel Oil: Residual product of crude oil refining process with high viscosity. Boiling point ~600C
(b-Diesel: Blend of middle distillates, usually composed of light and heavy gas oil. Boiling point ~270C

Pricing more favourable...but scale differentiator*



- Many gas turbines can run on LPG ...but require a vaporisor
- Engines typically run on HD5 composition but experience slight derate

	LPG	LNG
Cost per MMBTU (delivered LATAM)	~US\$7.50-US\$8.50	US\$8.50-US\$9.50
Power generation sweet spot	< 300MW	> 400MW
Infra planning & permitting	Expand existing LPG terminal	Plan & permit new terminal or FSRU
Storage costs	US\$1,500-2,000/MT	+++
Time to operation	12-18 months	36+months
Environmental	Same environmental impact / cleanliness	



• Comparison based on a 100MW - 200MW power plant

** LPG & LNG prices spot at 15 July 2019

LNG incl. US\$3.00 / MMBTU liquifaction costs

LPG reference projects: it's real!



➤ Gas turbines

- Japan, Ibaraki Prefecture – IHI operated LM6000 (42MW)
- Ghana, Tarkwa – 33MW - 3x Caterpillar Solar Mars 100 GT
- Ghana, Dramang – 27.5MW - 5x Centrax CX501 KB7S GT
- Wichita Falls Electric, Texas – 75MW (3xTM2500) using LPG as back-up
- Ghana, Tema ... 5xTM2500 ... LPG as bridge fuel – 156MW – first fire October 2019
- Australia, Quarantine Bay – 120MW – conversion from NG to dual fuel incl. LPG

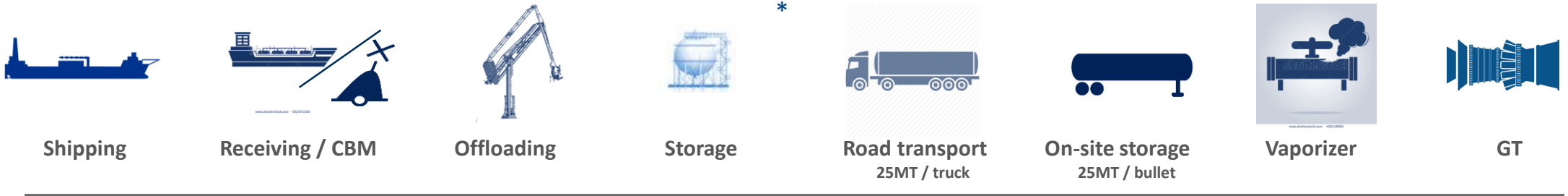
➤ Engines

- US Virgin Islands, St. Croix, – 20 MW – 20x Jenbacher engines J420
- Honduras, Roatan, – 28MW - 4x Wärtislä 34SG-LPG
- Puerto Rico; Jamaica; Hawaii 11 reciprocating engines– (Jenbacher – J420)



Growing pipeline for LPG to Power projects

LPG logistics more affordable than for LNG

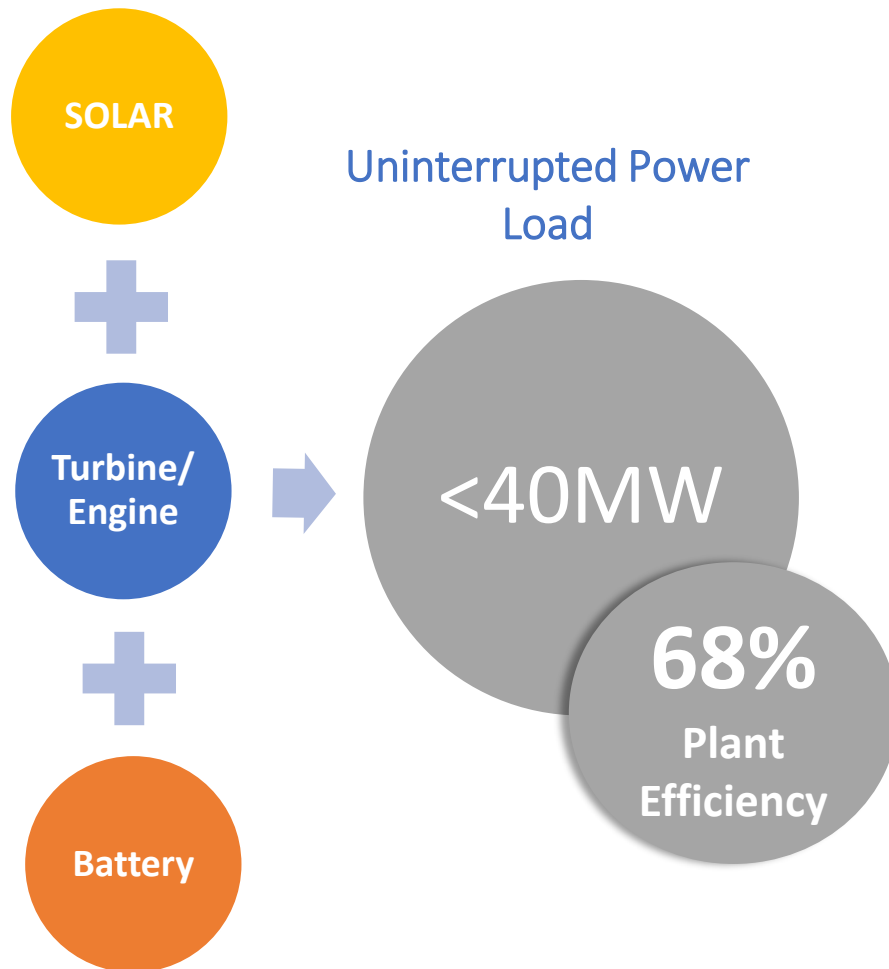


- **Shipping... LPG fleet more diverse in size and larger (3x) than LNG**
 - More than 95% of LNG fleet 82,000MT or larger
 - 100MW require approx. 100,000MTPA
- **Receiving / Offloading**
 - More than 130 countries have LPG receiving facilities vs. 40 for LNG
- **Storage**
 - LPG storage in bullets or spheres. No need for expensive cryogenic installation
- **Transport**
 - Road or rail transport easier and cheaper than LNG. Costs comparable to fuel



* Port storage not required if direct ship to truck offloading

LPG ideal for solar hybrid solutions



Advantages of (LPG) hybrid model

- **Ideal** for remote areas
- **Increased** dispatchable power
- **Scale** small scale <40MW - better LPG logistics
- **30% lower LCOE** vs. stand alone thermal
- **World class** 97ppm emissions level



Hybrid Solution ⇒ More Energy Sales ... LPG Power + Battery Storage = Perfect Complement for Solar

* Turbine refers to GE TM2500 in combined cycle

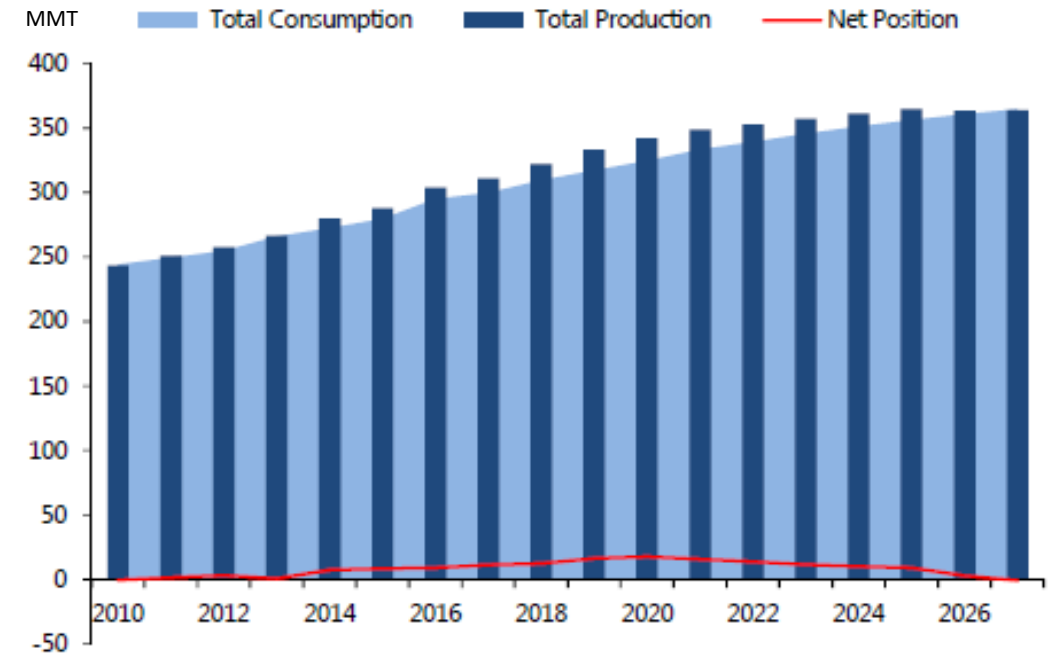
GTP – LPG to Power |

30 July 2019

LPG supply is there to stay



- LPG is a **GAS** – think household gas
- LPG infrastructure is everywhere
 - 130+ countries with LPG infrastructure vs. 40 for LNG
- LPG overhang for next decade – pricing pressure
- Production 300MMT p.a. – 100MMT waterborne – 5% = ~5GW
- LPG as interim fuel – before LNG / NG available



Source: Argus Media 2018

Supply growth over the next decade

Summary

Power Output up to 300 MW

- Fuel logistics for up to ~300K MTPA – by comparison 1MW engine ~1,500MTPA
- Lower capex/financing requirements than for LNG projects
- Greater ease of evacuation – less grid upgrading required
- Speed to first power – fast deployment of turbines / engines, storage bullets
- Rental solutions available

Things to Consider

- Fuel costs represent 70-80% of electricity costs
- Natural gas requires pipeline infrastructure ...LPG does not
- Use of existing LPG import infrastructure ... expansion where necessary
- Total project costs for power plants easier to finance ... LPG as feedstock acknowledged by World Bank / IFC

Focus on smaller, decentralized power projects

