PLANNING FOR LNG - A SUMMARY OF SYSTEM AND REGIONAL ISSUES IN PROVIDING GRID SUPPLY TO LNG

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May 15, 2014

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TOPICS

BC Hydro System and the Integrated Resource Planning (IRP) Process

LNG Loads and System requirements

Regional Issues

Potential Role of Gas Turbines

BC HYDRO SYSTEM

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- BC Hydro is one of Canada's largest electric utilities, serving 95 per cent of B.C.'s population ~ 1.9 million customers.
- BC Hydro operates 31 hydroelectric facilities and three thermal generating plants, totaling approximately 12,000 MW of installed generating capacity.
- Has electricity purchase agreements with ~ 130 Independent Power Producers including two gas generation facilities. The hydroelectric facilities and other renewable resources provide close to 95 per cent of the total electricity generated.
- Transmission and distribution network of over 75,000 kilometers of lines.
- The transmission network connects with transmission systems in AB and WA, which improves the overall reliability of the system and provides opportunities for trade.

ABOUT THE INTEGRATED RESOURCE PLAN

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The IRP is a long-term plan to meet future growth in electricity demand, including from LNG industry.

- Includes energy conservation, clean energy generation, and management of current energy supply.
- Addresses provincial objectives (e.g., achieving self-sufficiency, reducing GHGs, supporting economic development and job creation).

2013 INTEGRATED RESOURCE PLAN

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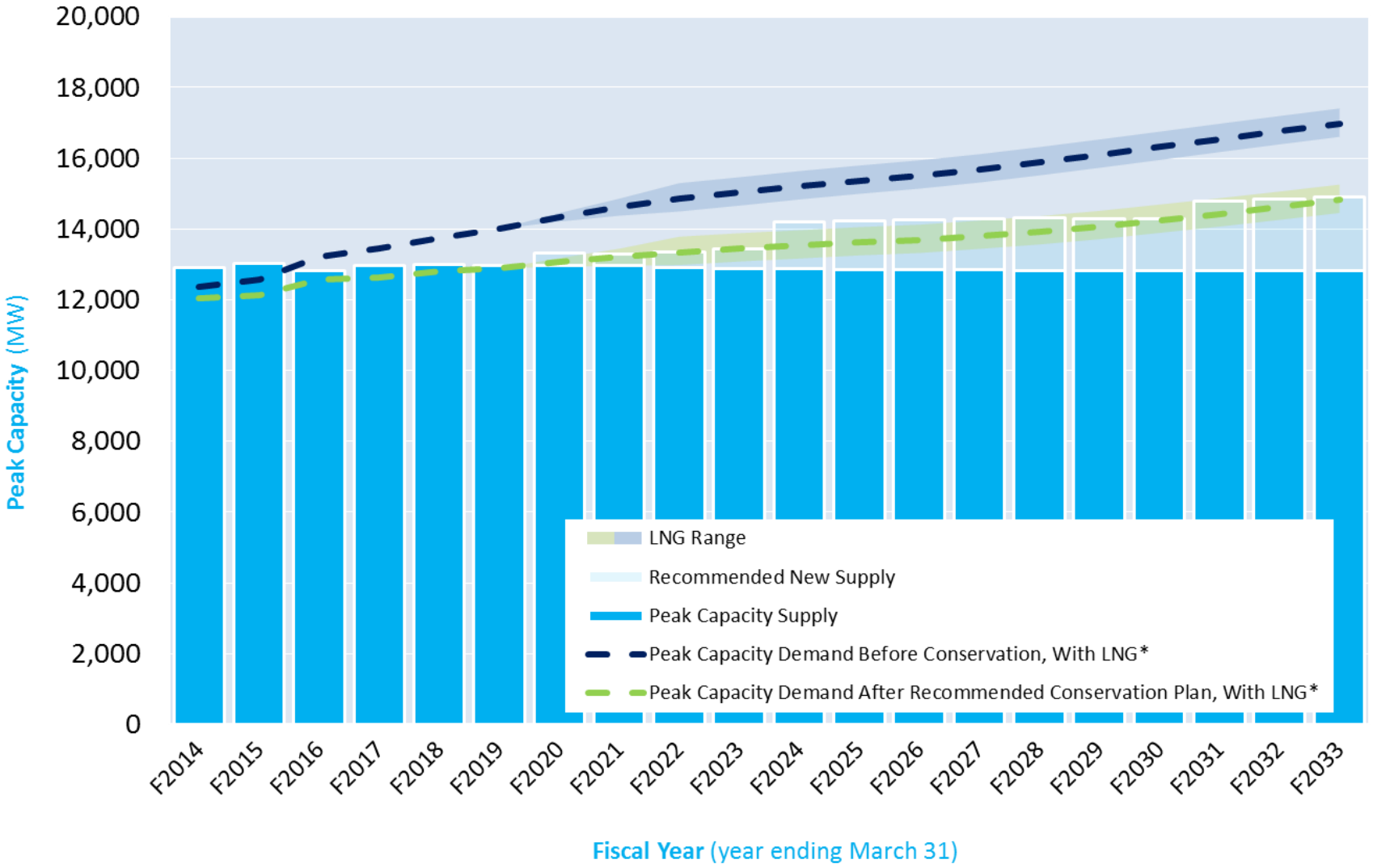
Approved by government on November 25, 2013

- The plan outlines how BC Hydro is conserving first, managing resources, meeting future electricity needs, meeting LNG supply needs and planning for the unexpected
- Demand in 20 years is forecast to be 23,000 GWh/year – increase of 40% before Demand Side Management (DSM) measures
- Taking into account potential DSM contributions projected total increase in load is about 23% in 20 years
- BC Hydro will review the IRP in the fall of 2015

CAPACITY LOAD RESOURCE BALANCE



* including planning reserve requirements

ENERGY LOAD-RESOURCE BALANCE (LRB)

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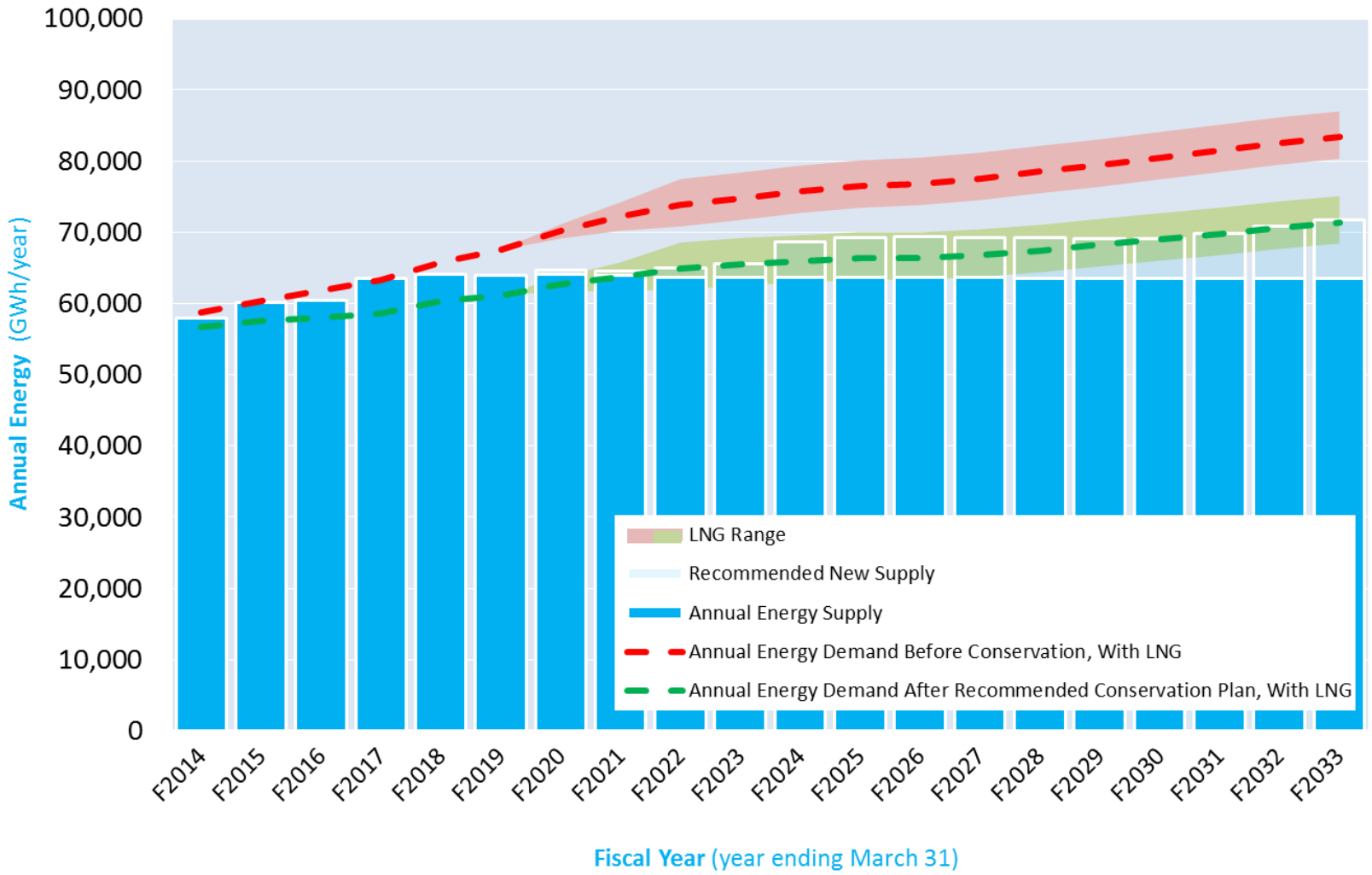

LNG POWER REQUIREMENTS

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- BC Hydro expects large LNG projects (with 5-7 mtpa trains) to use natural gas turbines to drive liquefaction compressors. May consider grid supply for ancillary needs
- Most small LNG projects (1-3 mtpa) are likely to be fully electric
- Rough rules of thumb:
  - LNG total energy requirements = 50 MW/mtpa (400 GWh/yr)
  - LNG non-compression (ancillary) power needs ~ 8 MW/mtpa (65 GWh/yr)

LNG IN THE INTEGRATED RESOURCE PLAN

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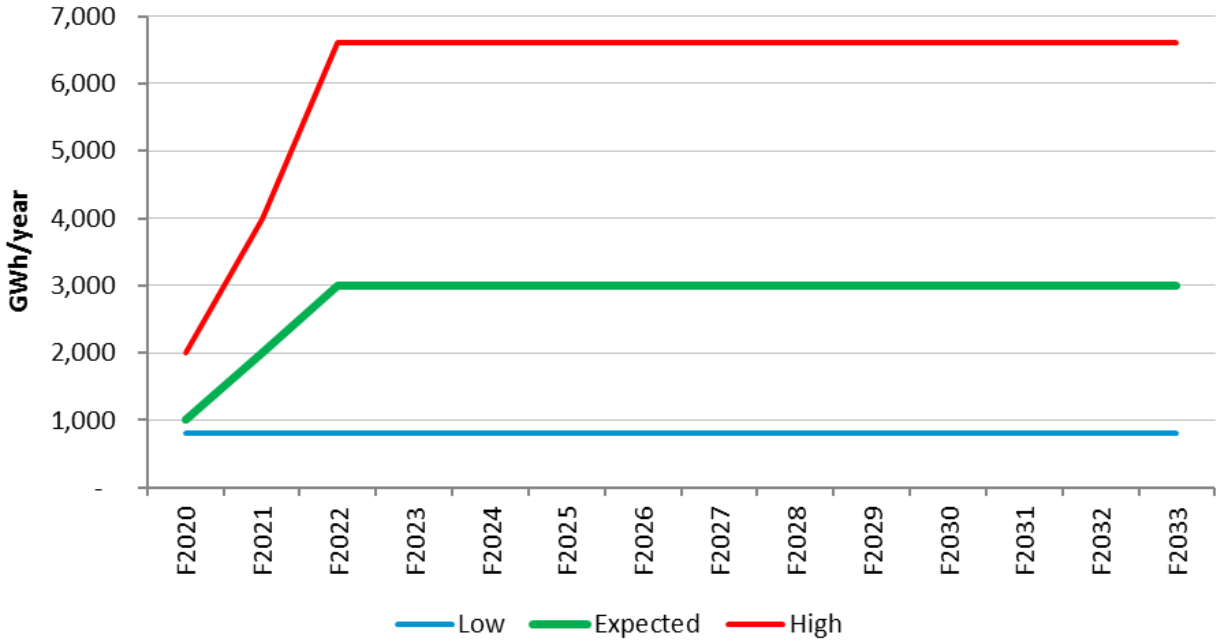
- Expected LNG load in the IRP:
  - 360 MW in 2019-2021 (3,000 GWh/yr)
  - Equivalent to 3 LNG plants, either small fully-electric plants or medium-large plants taking grid supply for ancillary requirements
  - LNG load does not trigger requirement for new energy resources
  - New capacity resources required: BC Hydro considering up to 400 MW of gas-fired generation for capacity, likely in north coast region
  - Transmission upgrades required in the North Coast region
- High and Low LNG load scenarios also considered

LNG LOADS



Beyond F2022:

- High LNG scenario: 6,600 GWh/year
- Expected LNG: 3,000 GWh/year
- Low LNG scenario: 800 GWh/year

THE NORTH COAST REGION

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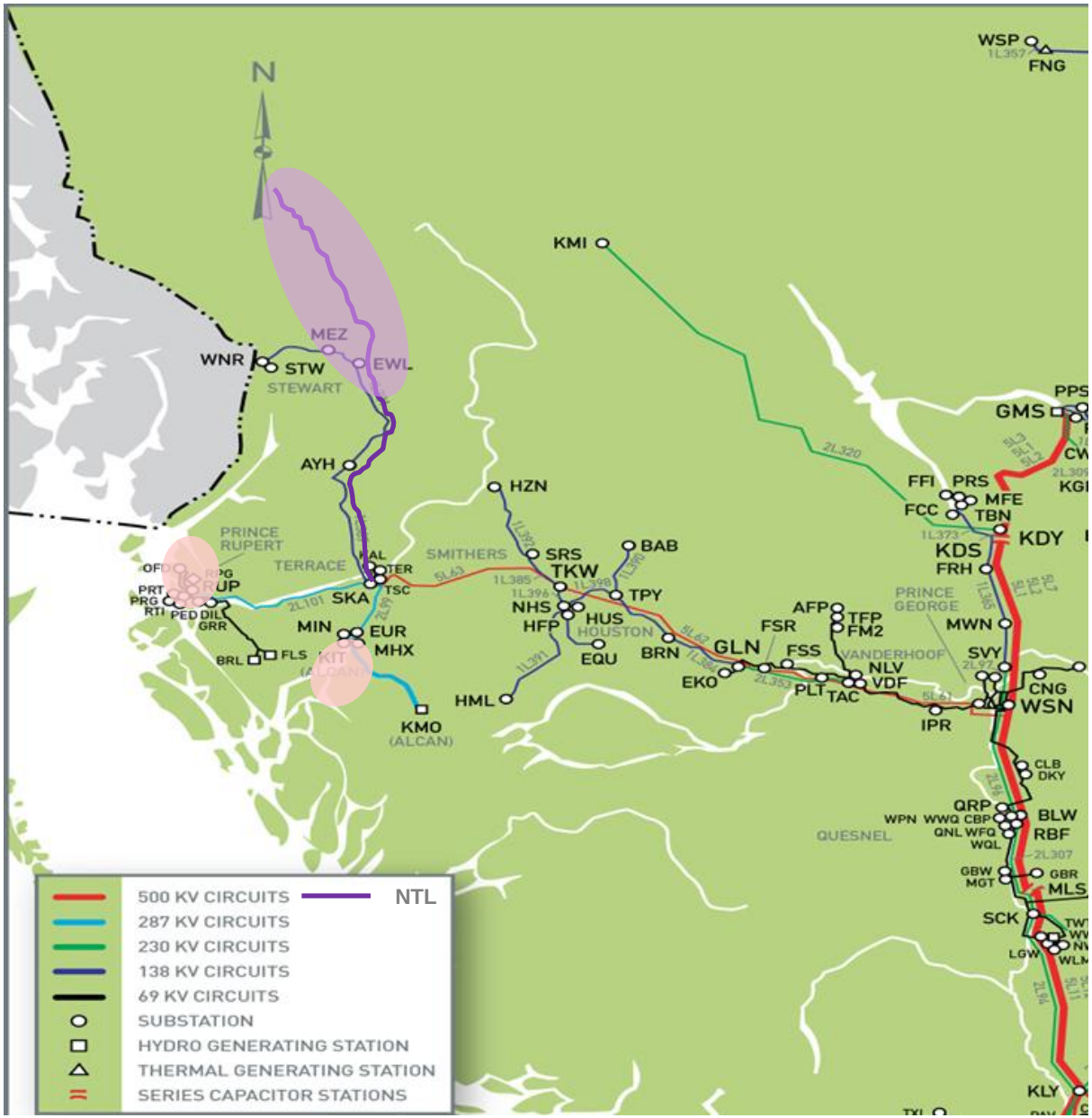

NORTH COAST PLANNING CONSIDERATIONS

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- Connected to the rest of the BC Hydro system by a 450 km single radial 500 kV transmission line from Prince George to Terrace. Beyond Terrace,
  - The area to the south is served by a single 287 kV transmission lines that extends to Kitimat,
  - The area to the west is served by a single 287 kV line that extends to Prince Rupert,
  - The area to the north (mainly metal mines) will be served by the North West transmission line that is currently under construction. Another single 287 kV line.
- Few local supply options with dependable capacity
- Transmission system has historically been very reliable, but challenges ahead if regional load growth is significant

NORTH COAST LOAD SCENARIOS & CAPABILITY OF 500 KV

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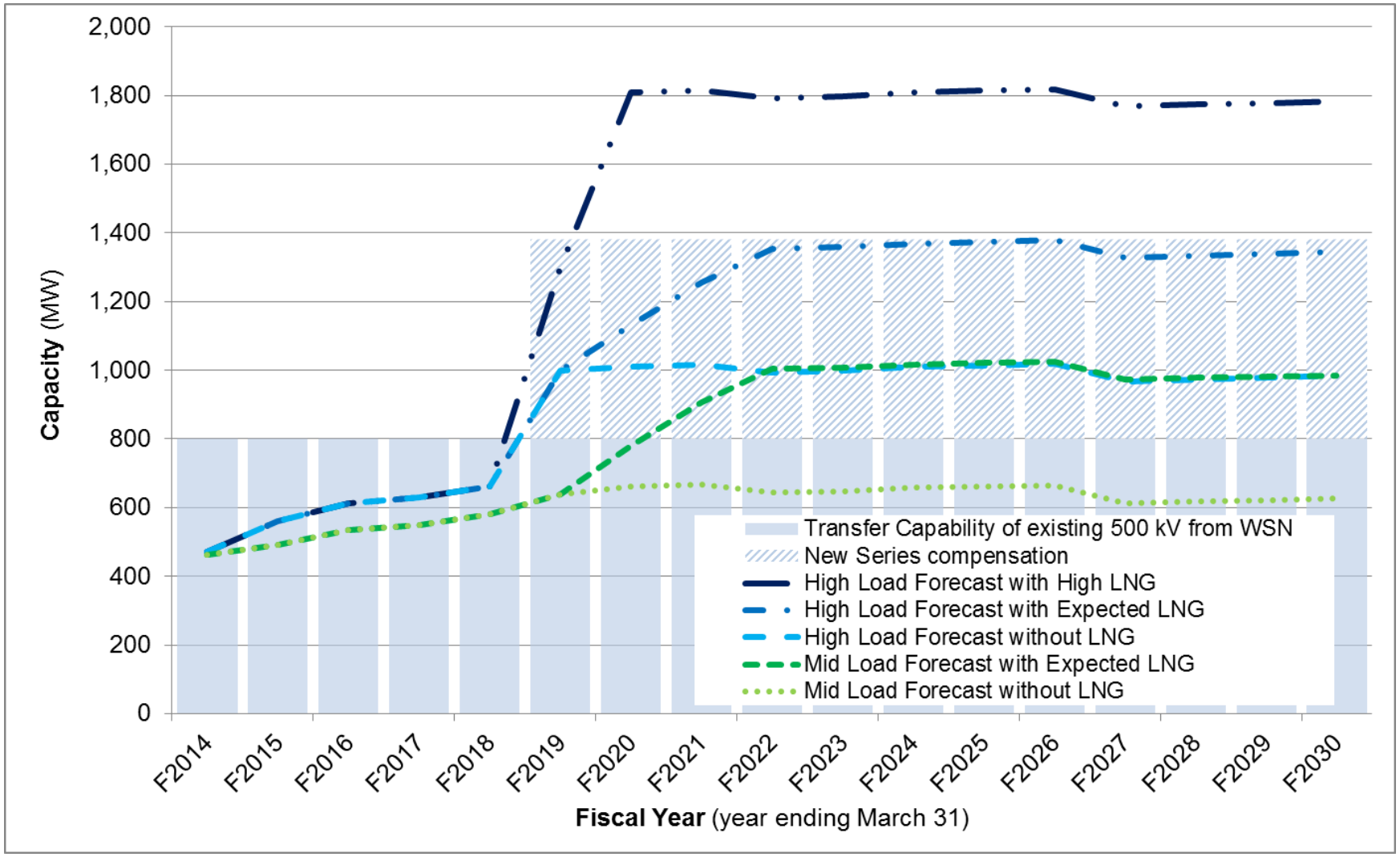

IRP RECOMMENDED ACTIONS

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	RECOMMENDED ACTIONS
Explore natural gas-fired generation for the north coast	Working with industry, explore natural gas supply options on the north coast to enhance transmission reliability and to meet the expected load.
Explore clean energy supply options, if LNG demand exceeds available resources	Explore clean or renewable energy supply options and be prepared to advance a procurement process to acquire energy from clean power projects, as required to meet LNG needs that exceed existing and committed supply.
Advance reinforcement of the transmission line to Terrace	Advance reinforcement of the existing 500 kV transmission line from Prince George to Terrace, which includes development of three new series capacitor stations and improvements in the existing BC Hydro substations to be available by F2020.
Horn River Basin and northeast gas industry	Continue discussions with B.C.'s northeast gas industry and undertake studies to keep open electricity supply options, including transmission connection to the integrated system and local gas-fired generation.

PRINCE GEORGE TO TERRACE CAPACITORS PROJECT

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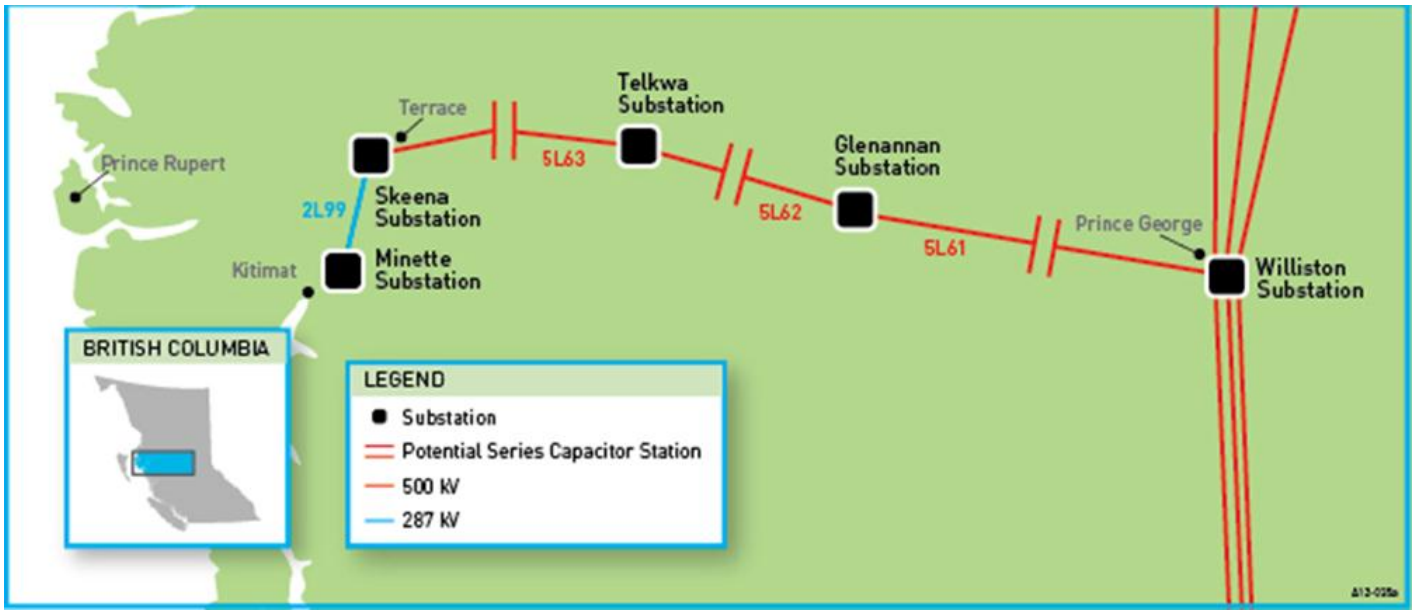

- Three 500kV series capacitor stations between Prince George and Terrace
- Expansion at GLN for shunt capacitors. Minor works at WSN, TKW, SKA and telecom stations
- Estimated In Service Date: Late 2019

TERRACE TO KITIMAT TRANSMISSION PROJECT

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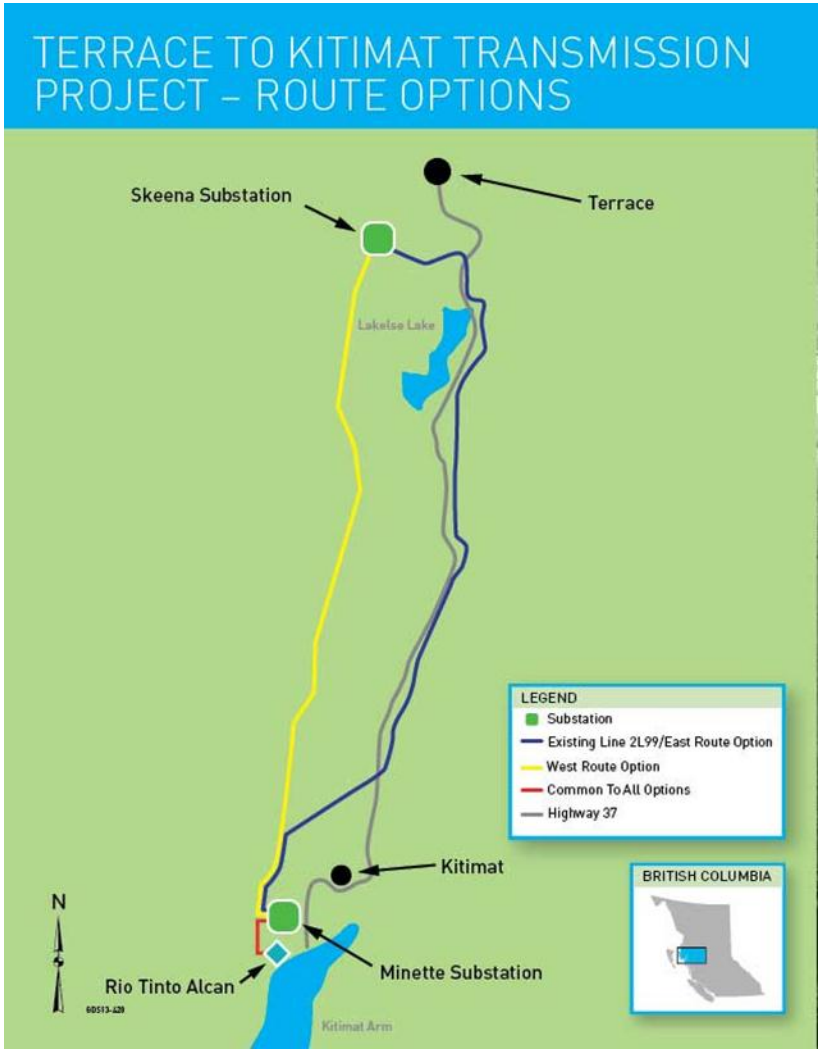
- Replace 287kV transmission line 2L99 with one or two new circuits between Terrace and Kitimat
- Replace 287kV transmission line 2L103 between Kitimat and Rio Tinto Alcan
- Both have reached the end of serviceable life and need to be replaced
- Estimated In Service Date: Late 2018/Early 2019



GAS-FIRED GENERATION IN THE NORTH COAST - CONSIDERATIONS

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- Need to provide backup for transmission
  - During forced outages – rare
  - During line maintenance
- Gas turbines may need to be online to provide uninterrupted service
  - Start up times of gas turbines
  - Service interruptions that can be tolerated
- Federal GHG Regulations for Gas Turbines
  - Environment Canada is currently developing GHG performance regulations
  - Could be function-based (peaker/non-peaker) or type specific (SCGT/CCGT)

GAS-FIRED GENERATION IN THE NORTH COAST - CONSIDERATIONS

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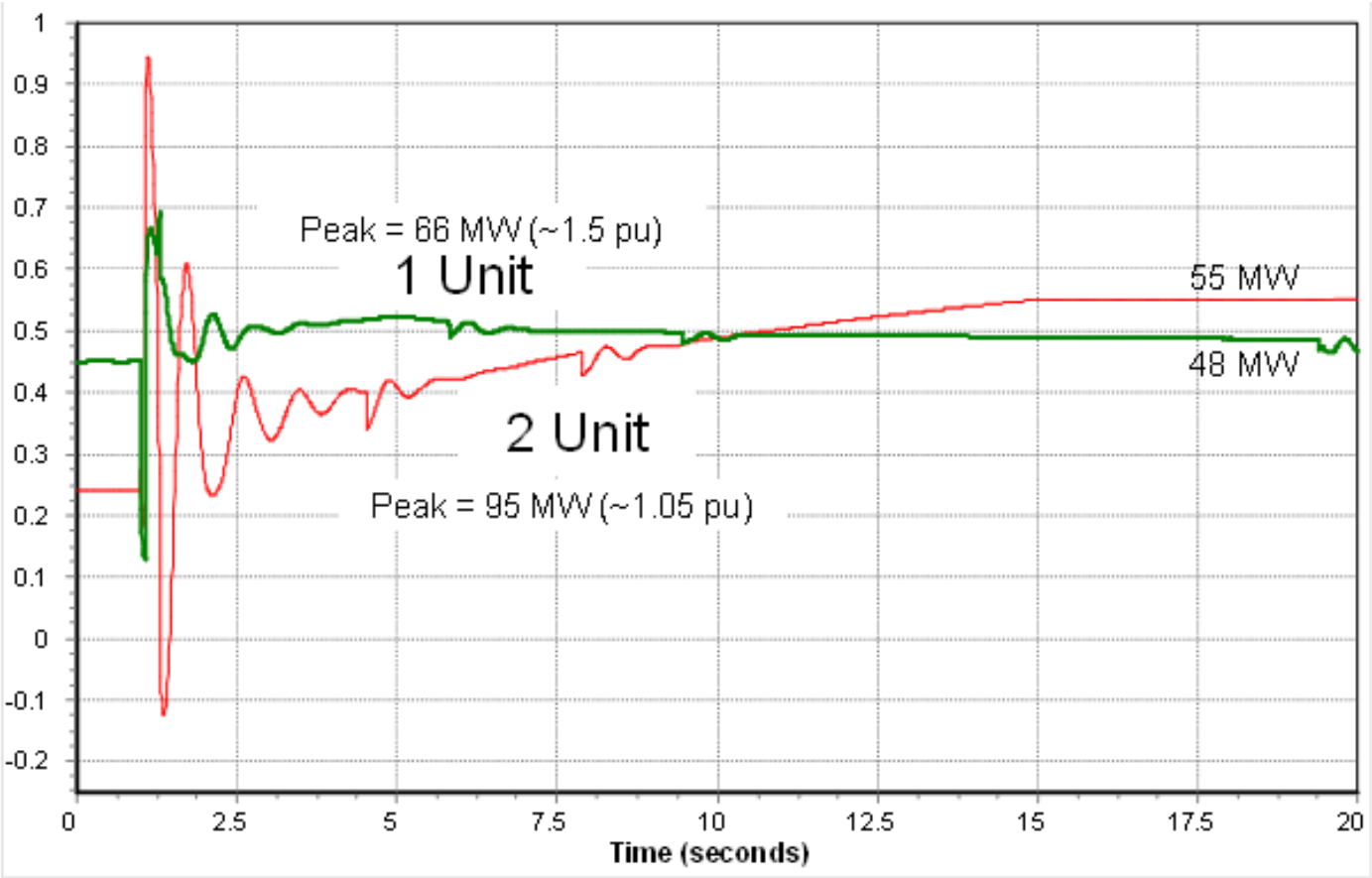
- Provincial Gas Turbine Emission Guidelines
  - Could require emission abatement equipment to be installed
- Conversion of Gas Turbines to Combined Cycle mode in the future depending on load growth
- Capability of providing voltage support
- Need for sub-synchronous resonance blocking filters

DYNAMIC STUDIES – GAS TURBINE OUTPUT



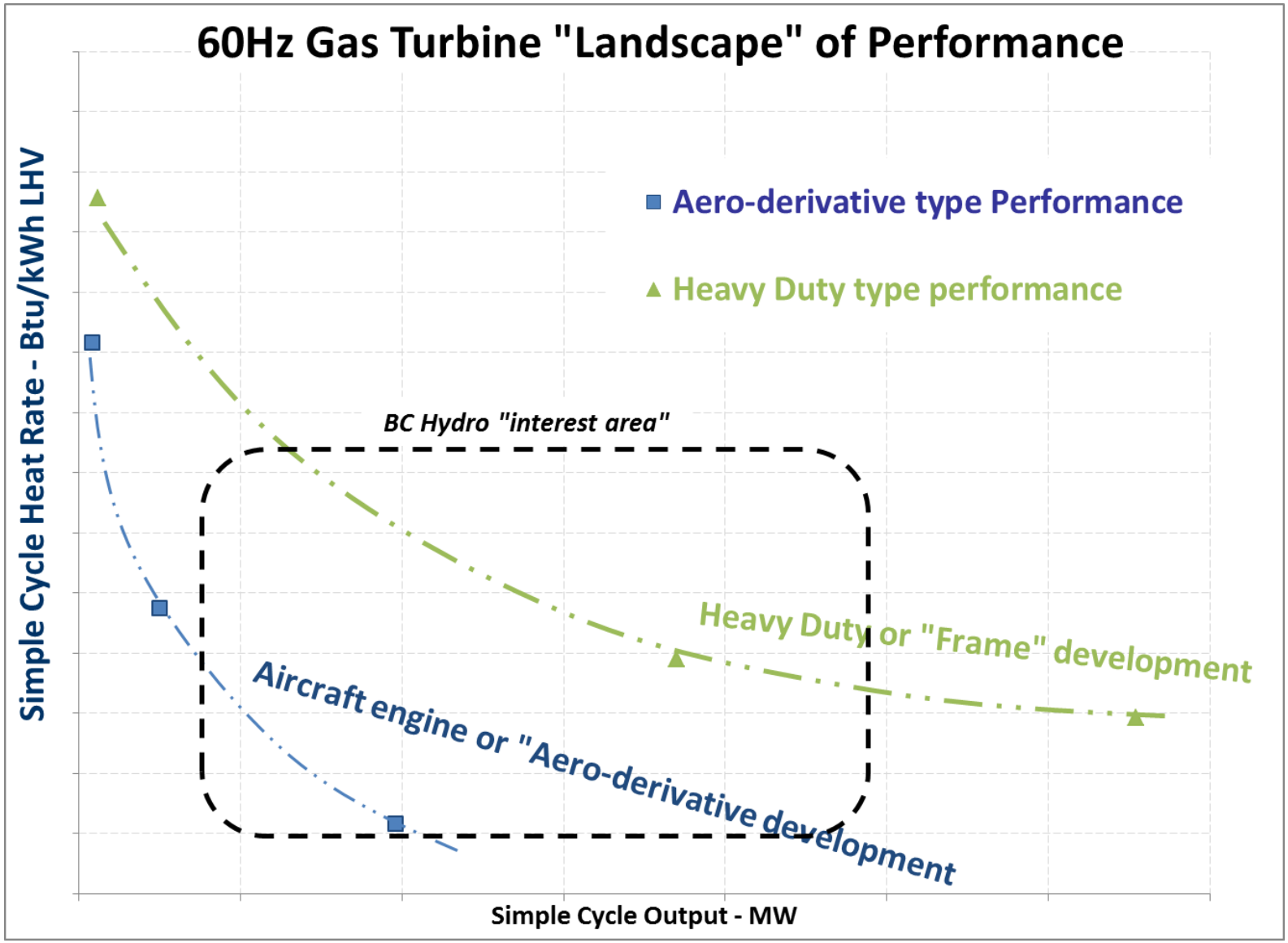
- Some gas turbines need to be online to ensure loads can be served without interruption.
- Transient output required can be high and may be a determining factor in how many GTs are required to be online.

STUDY ON GAS TURBINE TECHNOLOGIES

BC Hydro has asked a consultant to compile information on performance and cost data for commercially available, simple cycle gas turbine (SCGT) units that can meet several criteria. E.g.

- Fast start capability (i.e. from cold start to full load in less than ~ 20 minutes)
- Load following (i.e. ramp rates of at least 15 MW/minute)
- Low rates for both NOx and CO emissions (i.e. consistent with BACT)
- Capable of operation in synchronous condenser mode
- Single cycle thermal efficiency of at least 33% (LHV) (ISO conditions)
- Unit full load capacities in the range of 40 to 250 MW (ISO conditions)

AVAILABLE GAS TURBINES



FILTERED LIST OF GAS TURBINES

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Manufacturer	Model type info.	Output (full load capacity) ISO conditions (MW)
GE	LM2500+RC	36.3
GE	6B (Heavy Duty)	43
SIEMENS	SGT800 b (Heavy Duty)	50.5
GE	LM6000PH Sprint	51.7
MHI (P&W)	FT4000	60
ROLLS-R	Trent 60 DLE-ISI	61.8
GE	6FA+e	78
GE	7EA	90.6
GE	LMS100PB (DLE)	101.3
SIEMENS	SGT6-2000E	114
MHI	M501DA	115.4
ALSTOM	GT11N2	115.4
GE	107F.04	188.1
MHI	M501F3	192.4
ALSTOM	KA24-1 b	203.6
SIEMENS	SGT6-8000F5	227.7

NEXT STEPS

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- Identify specific SCGT installations (single or multi-unit) that could meet the North Coast capacity and reliability requirements.
- Evaluate conversion of SCGT installations to CCGT facilities in the future and compare against greenfield CCGT development
- Develop a procurement process – contingent upon load growth in the North Coast