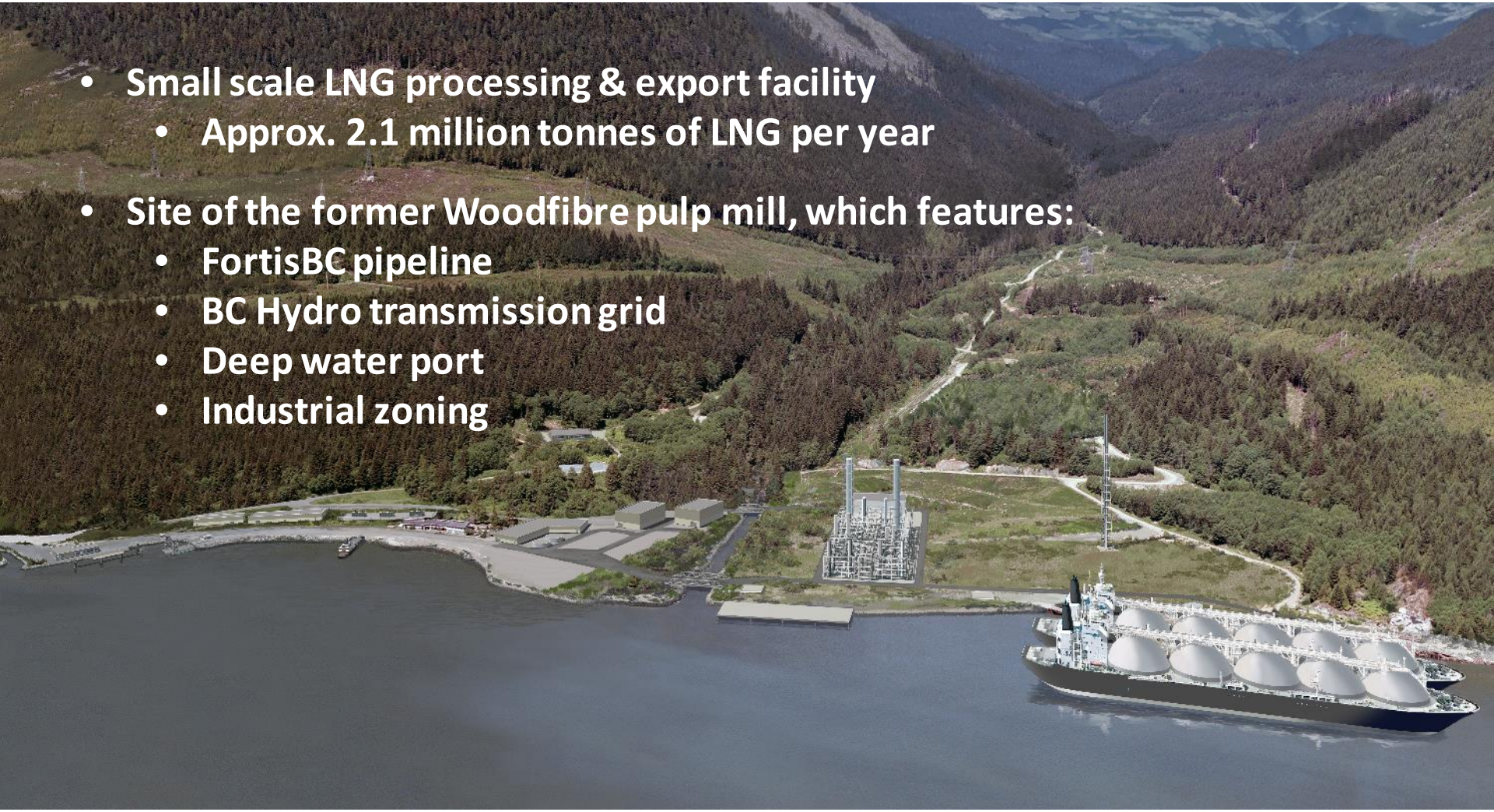
Woodfibre LNG

Electric drives & seawater cooling

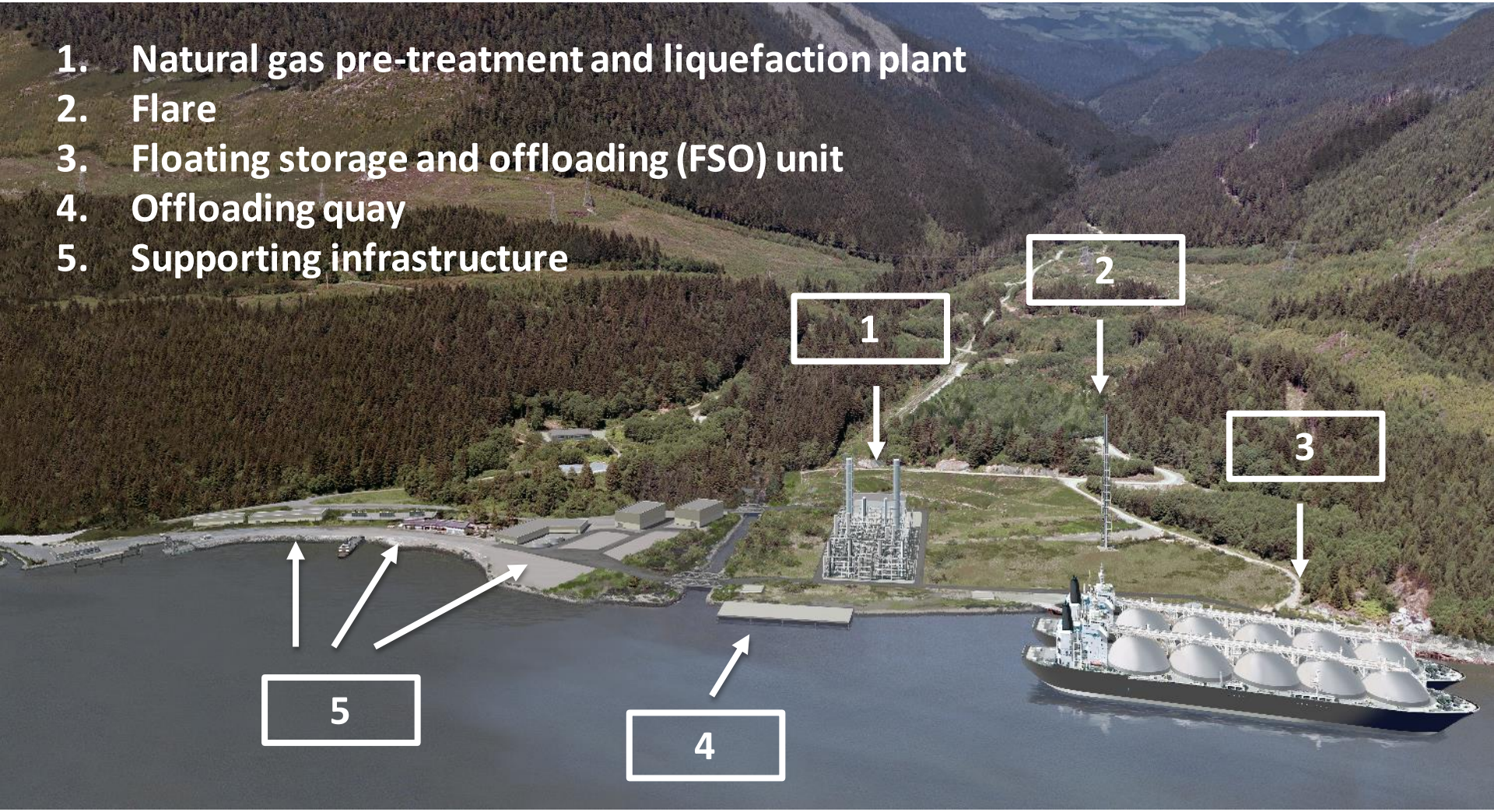
For discussion

- Project overview
- Project layout
- Electric drives
  - What is it?
  - Electric vs. gas
  - Potential project-related effects
- Seawater cooling
  - What is it?
  - Water cooling vs. air cooling
  - Potential project-related effects
- Next steps
- Discussion

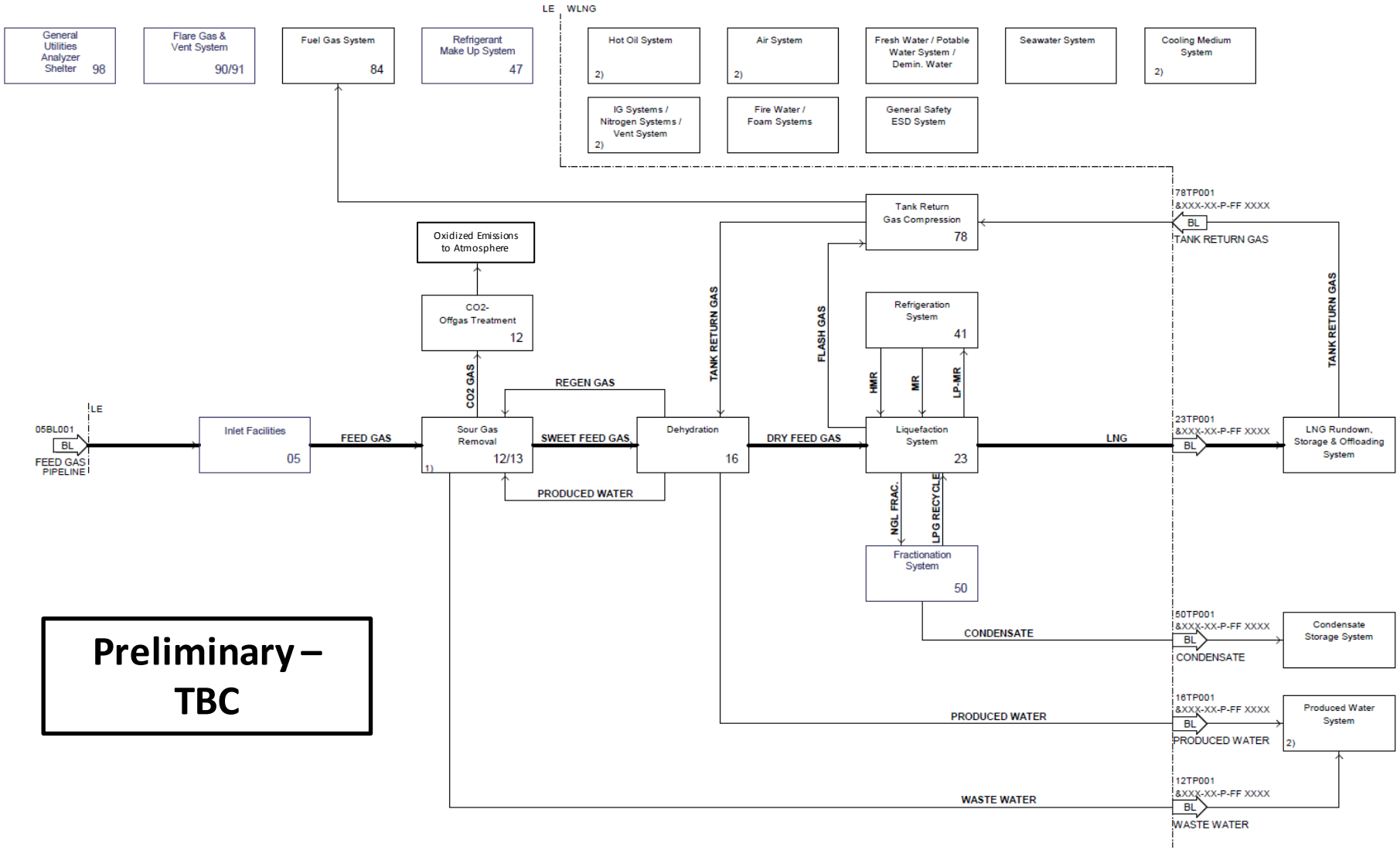
Project overview



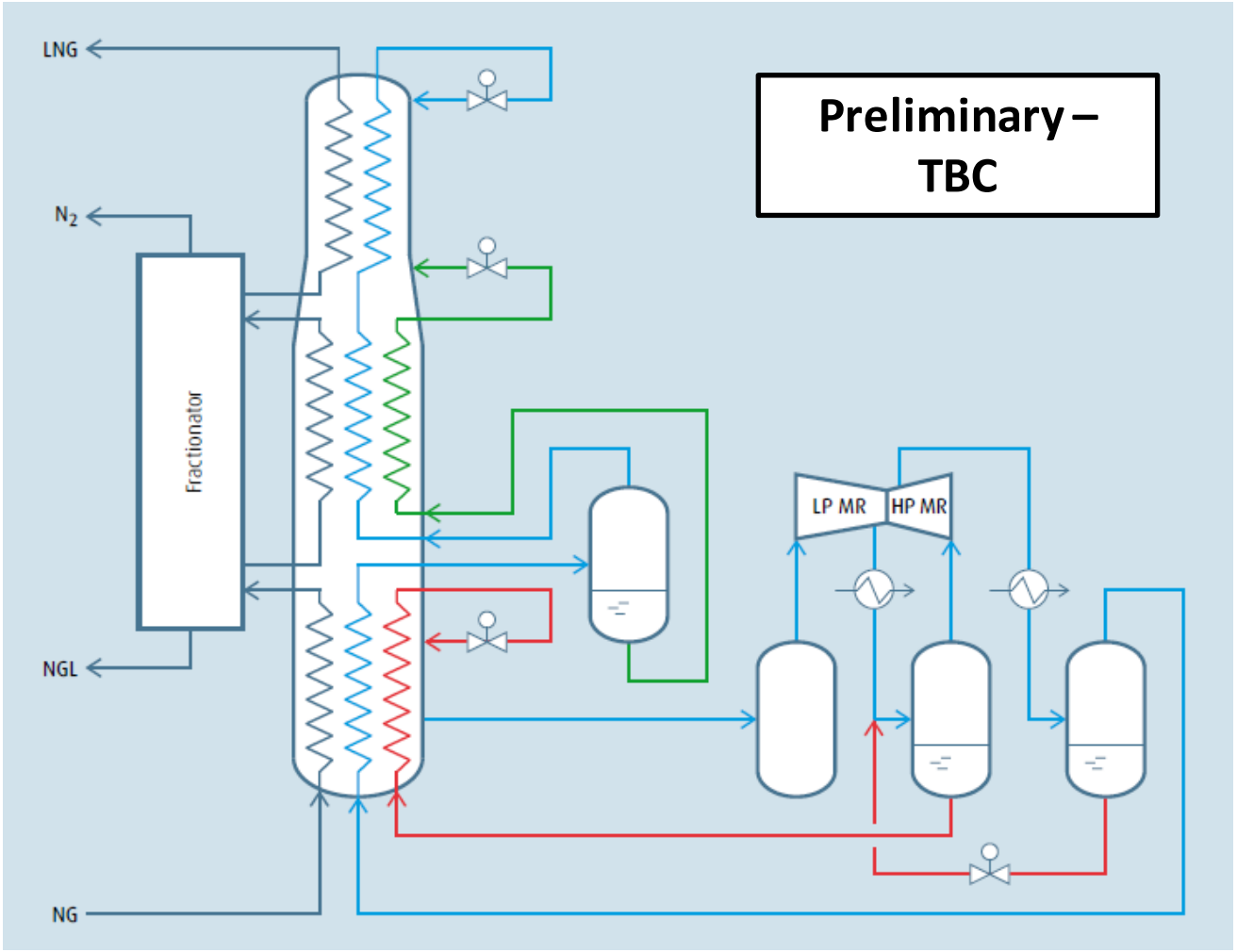
Project layout



Liquefaction process schematic



Liquefaction process – heat exchanger



Legend

- Light MR gas
- Medium MR Gas
- Heavy MR Gas
- Gas/LNG

MR: mixed refrigerants

Liquefaction process – compression drives

- Natural gas becomes a liquid when it is cooled at atmospheric pressure to -162ºC
    - Liquefaction shrinks the volume of the gas by 600 times, making it easy to safely store and transport around the world

- There are two main “drives” to power the liquefaction process refrigerant compressors:
    - Electric
    - Gas turbine

Electric vs. natural gas

Natural gas turbine drives used to power the liquefaction process refrigerant compressors

Advantages

- Proven technology
- Readily available fuel source
- Lower capital cost (CAPEX) than electric drives and required electric transmission line upgrades

Disadvantages

- Emissions: Approx. 80% more GHG, and 90% other air pollutants (smog)
- Higher down time

Electric vs. natural gas

Woodfibre LNG will use hydroelectric power (BC Hydro) to power the LNG plant

Advantages

- Cleaner with less air emissions
- Will be amongst the LNG facilities with lowest GHG emissions in the world
- Requires less down time for planned maintenance
- Reduces need for flaring

Disadvantages

- Higher facilities capital cost (CAPEX)

Electric drives – power demand

- BC Hydro existing generation capacity is sufficient to meet Woodfibre LNG's power needs
- Power distribution line upgrades are needed to deliver electricity to Woodfibre LNG facility
- Woodfibre LNG will not receive a preferred or subsidized rate on electricity from BC Hydro
- BC government Policy on electricity is clear:
    - All LNG proponents are required to bear all incremental costs of infrastructure required to provide their energy supply
    - Policy forbids any incremental costs be borne or subsidized by existing rate payers

Potential project-related effects

Estimated annual emissions in tonnes:

	Electric Drive	Gas Drive
• GHG	80,000	450,000
• NOx	20	310
• SOx	17	17

Air Quality, Climate and Greenhouse Gas Reductions

- Reduction in GHG and NOx
- Environmental Assessment Process requires licensed environmental consultants to conduct Baseline Studies
- Baseline Studies to identify all potential Project-related effects

Woodfibre LNG (WLNG) Best Practices Philosophy

- WLNG will meet and where possible beat all air quality standards

Emissions comparison – an example

Woodfibre LNG

2012 Greenhouse Gas Emissions Report Summary

BRITISH COLUMBIA | Ministry of Environment

Company	Howe Sound Pulp & Paper Corporation
Reporting Operation	Single Facility Operation
Facility Name	Howe Sound Pulp and Paper Mill
BC Facility ID	23221120006
Facility Address	3838 Port Mellon Highway, Port Mellon, British Columbia V0N2S0
Primary NAICS Code	322112 (Chemical Pulp Mills)
Geographic Coordinates	49.5237, -123.4837
Operation Representative	Khalid Jasim 604-884-2285 khalid.jasim@hspp.ca

Data as of	September 19, 2013
Report Status	Original Report
Report Date	March 27, 2013
Verification Status	See Excel Spreadsheet Summary Report

Category of Emissions	Greenhouse Gas Emissions (tonnes of CO_2e)								
	CO_2 * (fossil fuel)	CO_2 ** (included biomass)	CH_4	N_2O	SF_6	PFCs	HFCs	Total	CO_2 *** (excluded biomass)
Stationary Fuel Combustion	54,258		3,416	6,973				64,646	505,588
Industrial Process	1,979		627	6,063				8,669	921,320
Flaring									
Venting									
Fugitive									
On-site Transportation	2,183		2	97				2,282	
Waste	31,936		33					31,968	560
Wastewater									
Total	90,355		4,078	13,133				107,565	1,427,469

* carbon dioxide emissions from combustion of fossil fuel
** carbon dioxide emissions from combustion of biomass not listed in Schedule C of the Reporting Regulation
*** carbon dioxide emissions from combustion of biomass listed in Schedule C of the Reporting Regulation

NOTE: Totals may not reflect the sum of individual numbers due to rounding.

Air quality regulations & standards

Regulation

- Oil and Gas Activities Act, Environmental Management Act

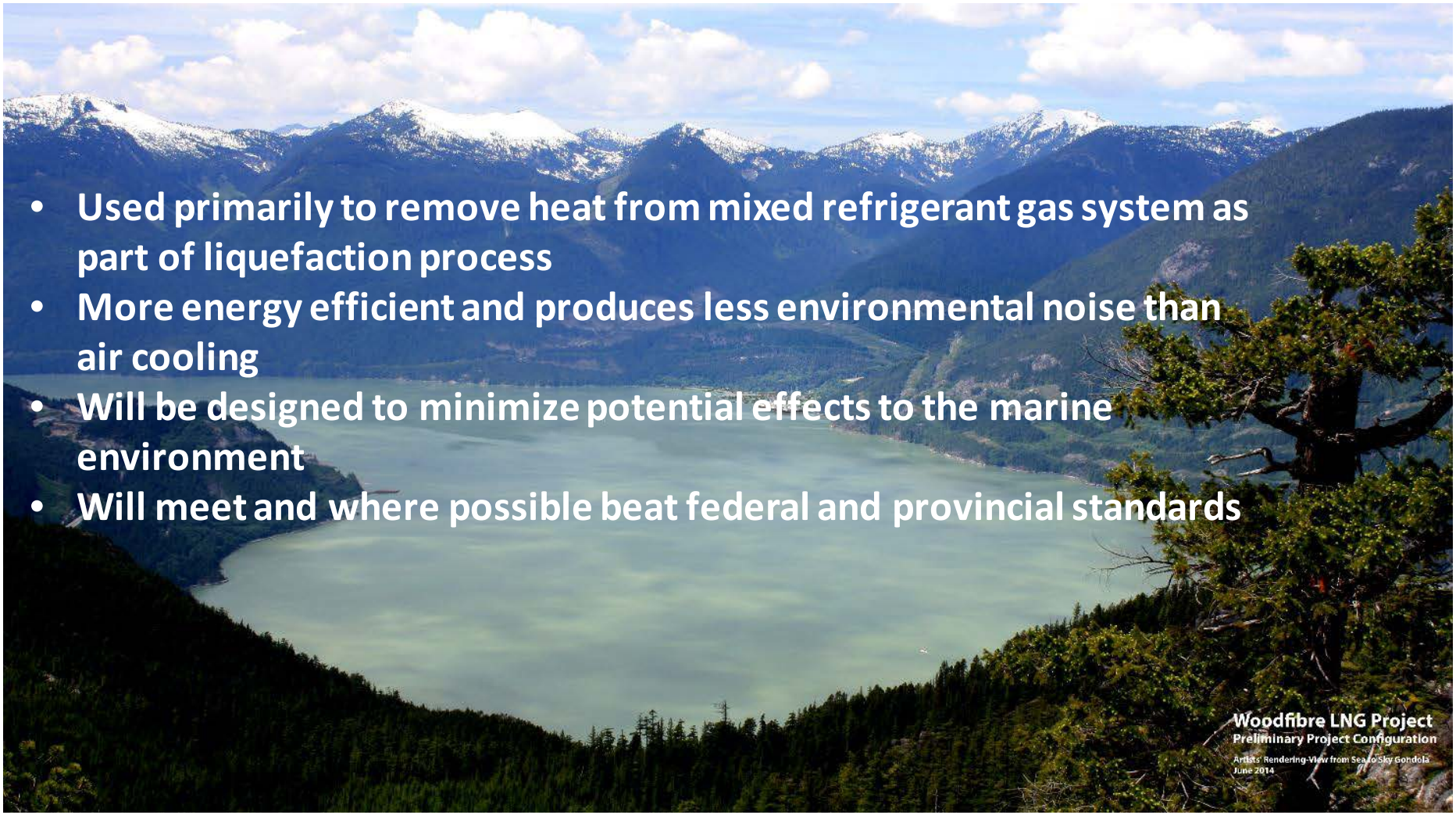
Standards

- Canadian Ambient Air Quality Standards, Environment Canada
- BC Ambient Air Quality Objectives, Ministry of Environment

Review

- Oil and Gas Commission (OGC)
- Ministry of Environment
- Health Canada
- BC Ministry of Health
- Vancouver Coastal Health

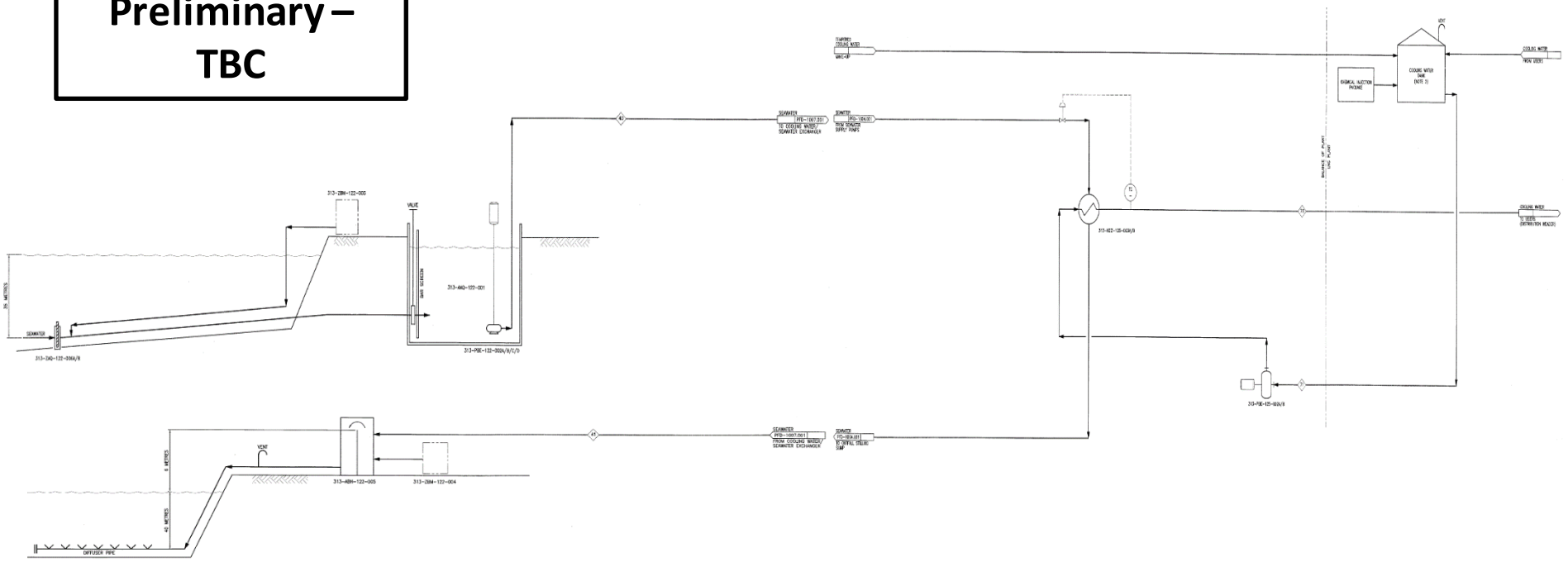
Seawater cooling



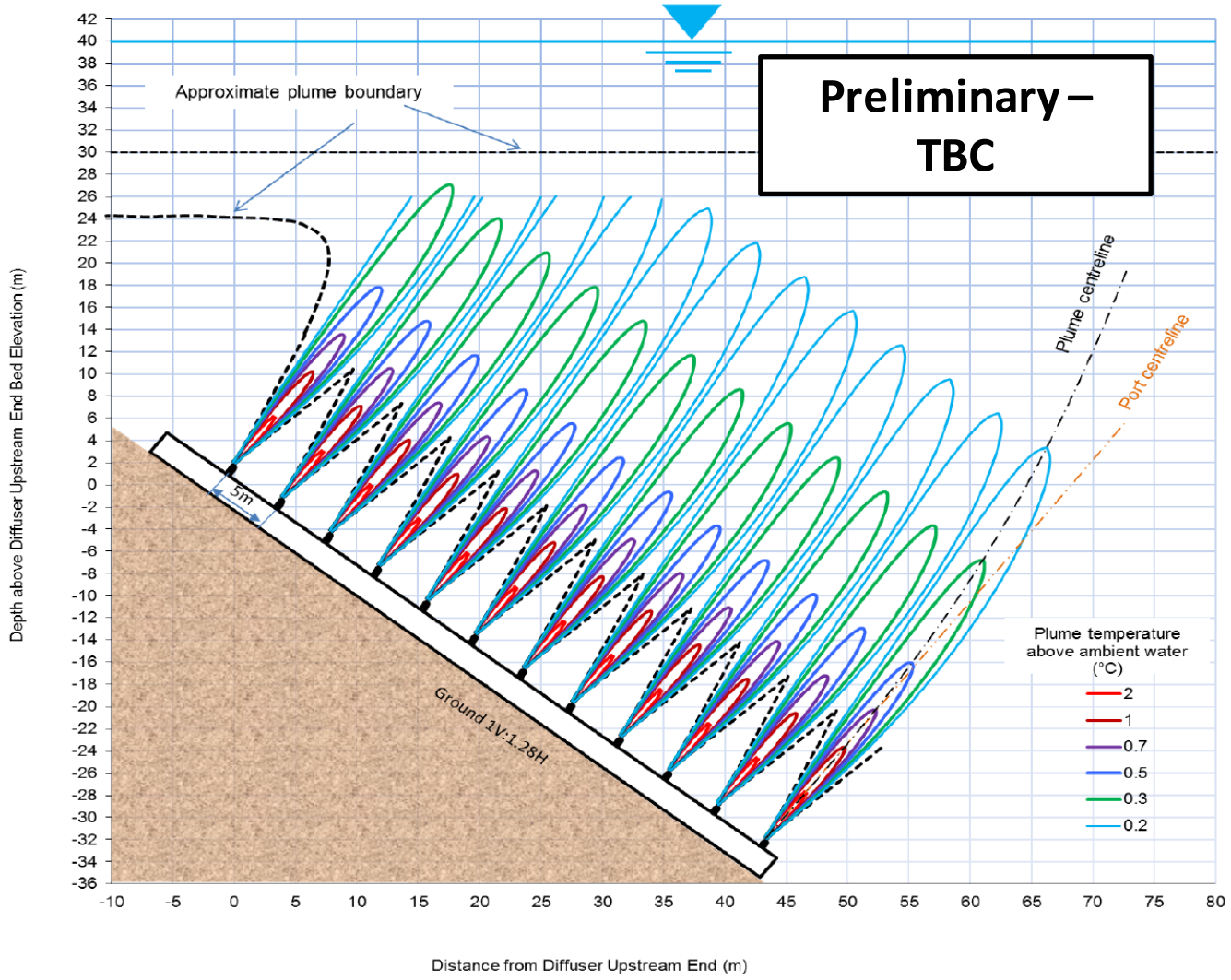
- Used primarily to remove heat from mixed refrigerant gas system as part of liquefaction process
- More energy efficient and produces less environmental noise than air cooling
- Will be designed to minimize potential effects to the marine environment
- Will meet and where possible beat federal and provincial standards

Seawater cooling schematic

Preliminary – TBC



Seawater cooling – return water diffuser



Seawater vs. air cooling

Woodfibre LNG has selected seawater cooling over air cooling

<u>Seawater cooling</u>

- More energy efficient than air cooling
- Produces less environmental noise than air cooling

Potential project-related effects

- Seawater cooling system will be designed to minimize potential effects to marine environment
  - Intake approx. 35 metres below sea level
  - Outlet begins 40 metres below sea level, reaches depth of 100 metres below sea level
  - Diffuser approx. 100 metres in length
  - Seawater temperature within plus one degree warmer than ambient temperature, less than 10 metres from diffuser ports

Potential project-related effects

- Seawater cooling system will be designed to minimize potential effects to marine environment
  - Seawater in seawater cooling system will be treated with sodium hypochlorite to keep system running efficiently
  - Sodium hypochlorite will be generated from the seawater using an electro-chlorination process
  - Regular low level dosing will be used to manage micro-fouling
  - Pulse dosing will be used seasonally to manage macro-fouling
  - Residual chlorine in discharged water will be continuously monitored and within the minimum regulatory requirement of 0.02 PPM

Water quality guidelines & standards

Regulation

- Oil and Gas Activities Act, Water Protection Act, Environmental Management Act, and Fisheries Act

Guidelines & standards

- Guidelines for Minimizing Entrainment and Impingement of Aquatic Organisms at Marine Intakes in British Columbia, Department of Fisheries and Oceans (DFO)
- Marine Water Quality Guidelines, Environment Canada
- Water Quality Guidelines, BC Ministry of Environment

Review & approval

- Oil and Gas Commission (OGC)
- Department of Fisheries and Oceans Canada

Next steps

- Community Committee, LNG Marine Transport (August 6)
- Environmental Assessment Process
- Project schedule
  - Construction (2015)
  - Operations (2017)

Discussion

Woodfibre LNG