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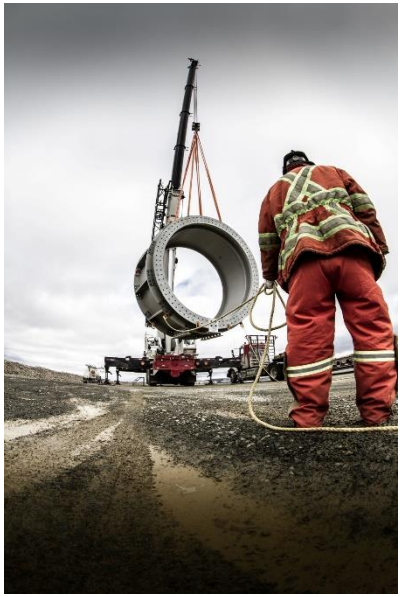
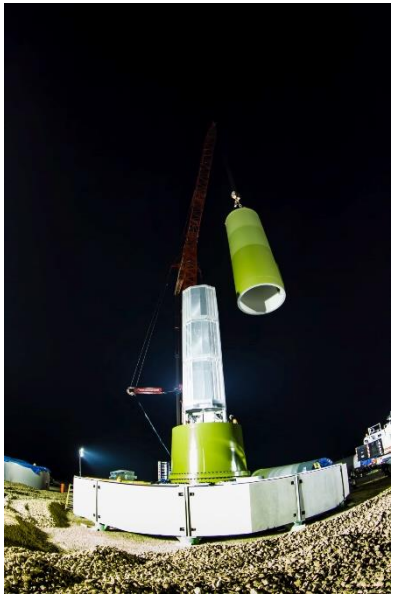
Proximity Next Energy

Transforming the Energy Supply in the Arctic: One Mine and One Community at the Time





NUNAVUT MINING SYMPOSIUM
APRIL 6th 2016

Diesel Consumption in the Nunavut: Growing and Unsustainable

	Yukon	NWT	Nunavut
Diesel-powered communities	5	23	25
Hydro-powered communities	16	9	0
Natural gas powered communities	0	2	0

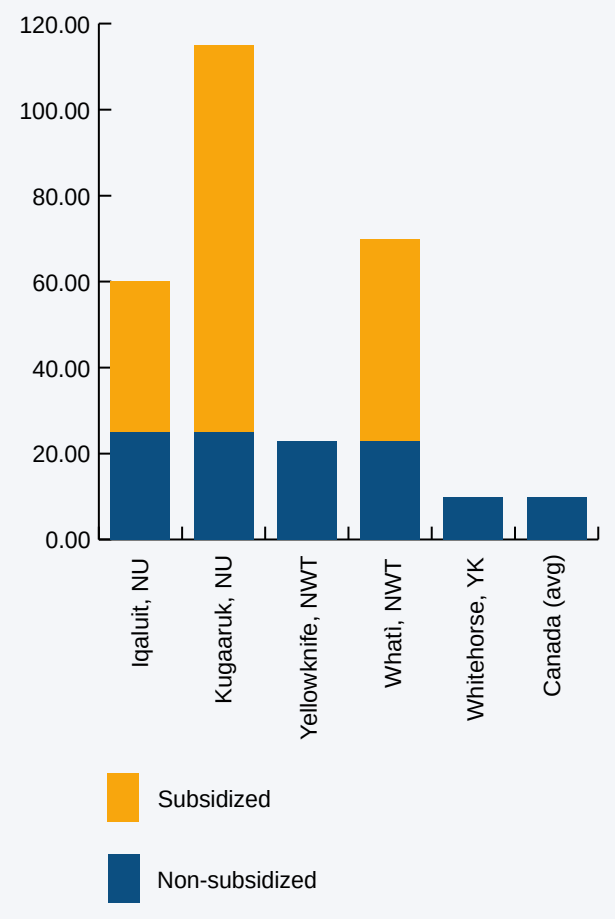
<u>TUGLIQ's objectives:</u>

1. Diversify away from diesel the power generation in the Arctic
2. Focus on distributed/local power generation
3. Create a new economic vector, job opportunities and revenue stream for the Inuit communities

Diesel Captivity Limits Economic Growth and Threatens the Environment

	Iqaluit	Kugaaruk
Between October 1 and March 31		
For the first 1,000 kWh	30.15¢ per kWh	30.15¢ per kWh
Above 1,000 kWh	60.29¢ per kWh	114.16¢ per kWh
Between April 1 and September 30		
For the first 700 kWh	30.15¢ per kWh	30.15¢ per kWh
Above 700 kWh	60.29 ¢ per kWh	114.16¢ per kWh

Source: Qulliq Energy Corporation, **Billings Centre**



- Cost of electricity is 5-10 times more expensive than grid connected supply
- Diesel power plants for mining projects are the largest GHG emitters
- Many diesel spills each year
- The largest micro-grids and key enablers for renewable energy projects are the Mining operations

Diesel Captivity Limits Economic Growth and Threatens the Environment

Deline, N.W.T. ice road

Inhibitors to Diesel Displacement

- Myths and pre-conceived ideas toward renewable energy
  - *'Hybrid applications cannot work. Wind is not always blowing. My power plant is not designed for this'*
  - *'It is not economical'*
  - *'We've looked at it internally and it doesn't make sense'*
- Large up front capital expenditures
  - e.g. $1.3M crane rental
  - e.g. $1.5M-5M$ civil and earthwork (access road, foundation)
  - High costs for energy storage – required for grid stability and extracting the full value from renewable energy assets (no curtailment)
  - It is not the mine's core business
- Market-entry barriers
  - Established fossil-fuel delivery arrangements
  - Electricity monopolies and regulations
- Lack of infrastructure
  - Distances
  - Lack of transmission/integration capacity
- Undercapitalization
  - Long, to impossible, break-even

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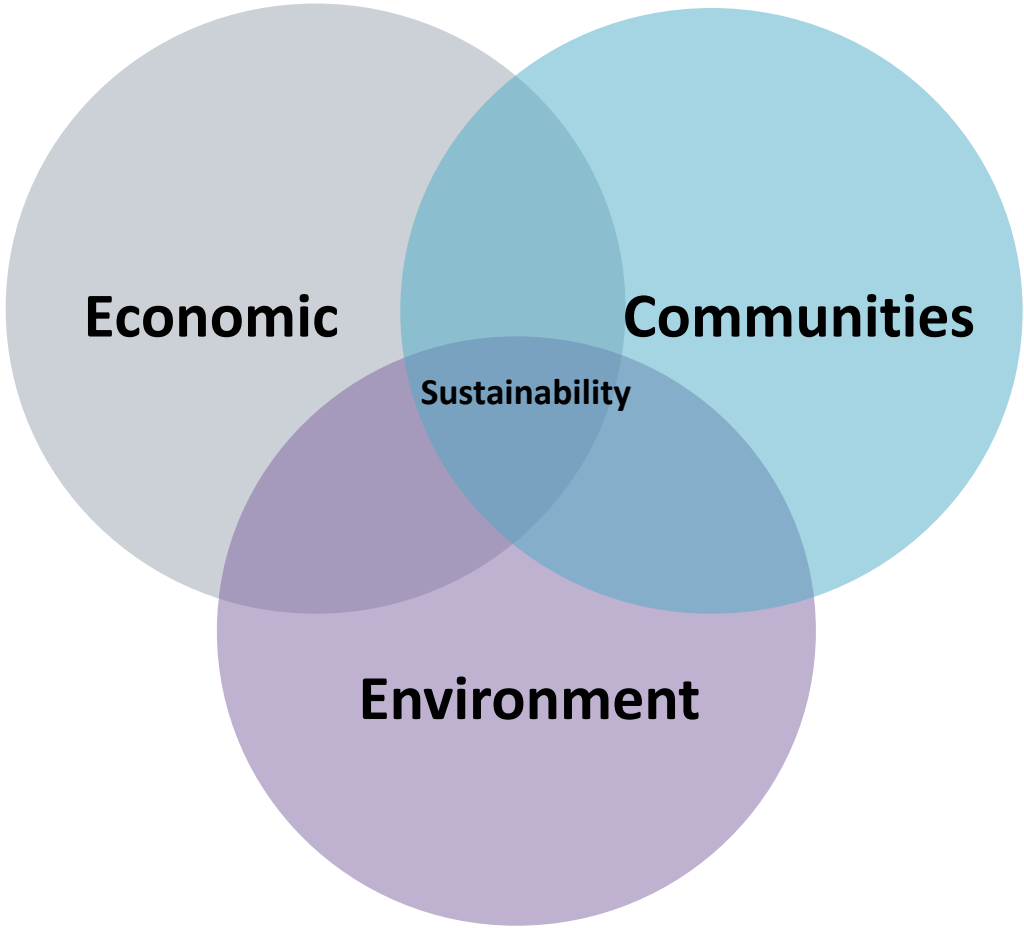
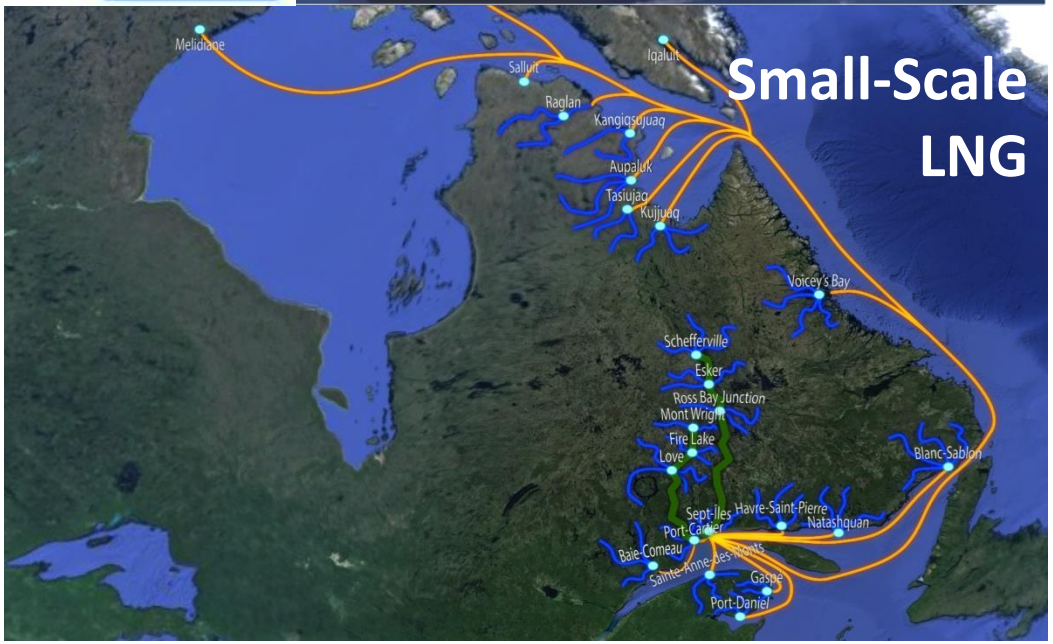
'In the middle of every difficulty lies opportunity'

– Albert Einstein

- Ensure the energy supply of the future will act on climate change and protect one of the most fragile ecosystem on the planet
- Use Inuit consultation and traditional knowledge as a building block to select the future sources of energy
- Avoid centralized power generation scheme and promote local sources of energy



A diversified energy portfolio: The northern Quebec example



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REALLY ?

Energy Portfolio to Diversify Away from Diesel

1. One stop shop in energy cost optimization

- Consulting / Studies
- Develop
- Finance & Build
- Own & Operate

2. Portfolio approach

- Renewable and clean energy focus
- Toolbox approach to adapt to customer's need
- Shared risk - shared rewards

3. Innovation for the mining industry and the communities

- Core business approach – we offload non-core activities from mining companies' balance sheet
- High penetration of renewable in micro grid environment
- Transition through cleaner fossil fuel (natural gas)
- Risk based approach contract structures

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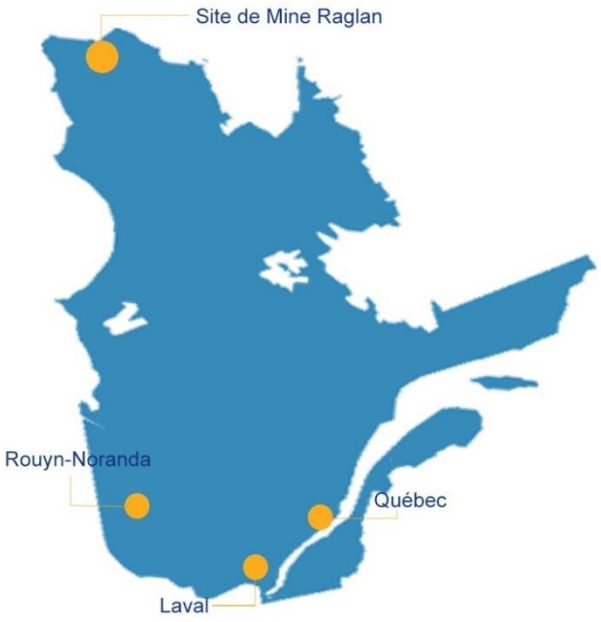
Case Study: The Raglan Mine



- Access by plane or by sea
- Autonomous Micro-Grid
- Power generation from diesel generators – Energy is the 2nd largest cost center at the mine
- Life of Mine: more than 20 years as of today.

Additional Challenges…

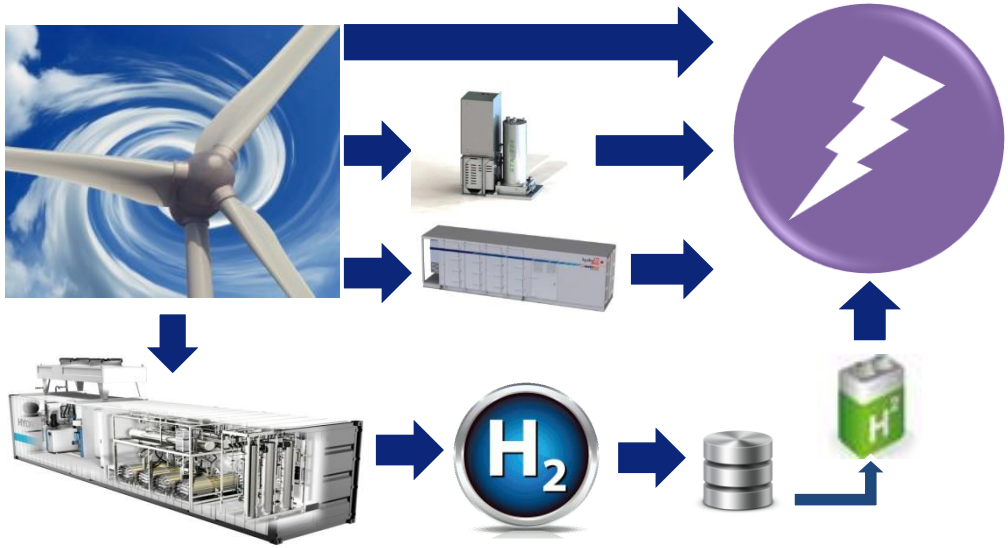
- **Nordic Climate**
  - Operation needed down to -40 °C
  - Severe Icing conditions, strong wind gusts and blizzards
  - Foundation on permafrost
  - Compensate for loss of heat recovery from diesel engine due to wind energy integration
- **Mining Operation**
  - Grid stability and genset operation constraints
  - Education and learning curve of the power plant operators
  - Short construction window (June to August)
- **Wind Power Variability**
- **Events stopping/Limiting wind turbine operation**
  - Major Icing events
  - Turbine untwist and blade daily maintenance
  - Cut-off due to wind speed, turbulent winds or cold temperature events
  - Miscellaneous wind turbine behavior

TUGLIQ's Wind-Storage-Diesel Project
Raglan Mine

The Pilot

» 3 MW Wind Turbine (Enercon E82) with cold weather package and fit-for-purpose foundation design (spider)

» 3 technologies of energy storage for a total of 650kW



Mission :

Demonstrate technical and economical viability of alternative energy for Glencore's RAGLAN Mine

» Reliability and robustness of the installations meeting the risk profile of mining companies

» Innovative solution leveraging top-of-the-art technologies (NRCan's EcoEII, Quebec MERN's TechnoClimat)

» Start small and grow → phased approach (pilot project) for TUGLIQ to become educated buyers/operators for the larger deployment phase in Nunavik and Nunavut

Energy Storage Components

Flywheel

- 200 kW – 1.4 kWh
- Smooth fast wind power transient over 25 seconds

Li-Ion Battery

- 200 kW – 250 kWh
- Smooth fast wind power transient or store energy over 75 minutes

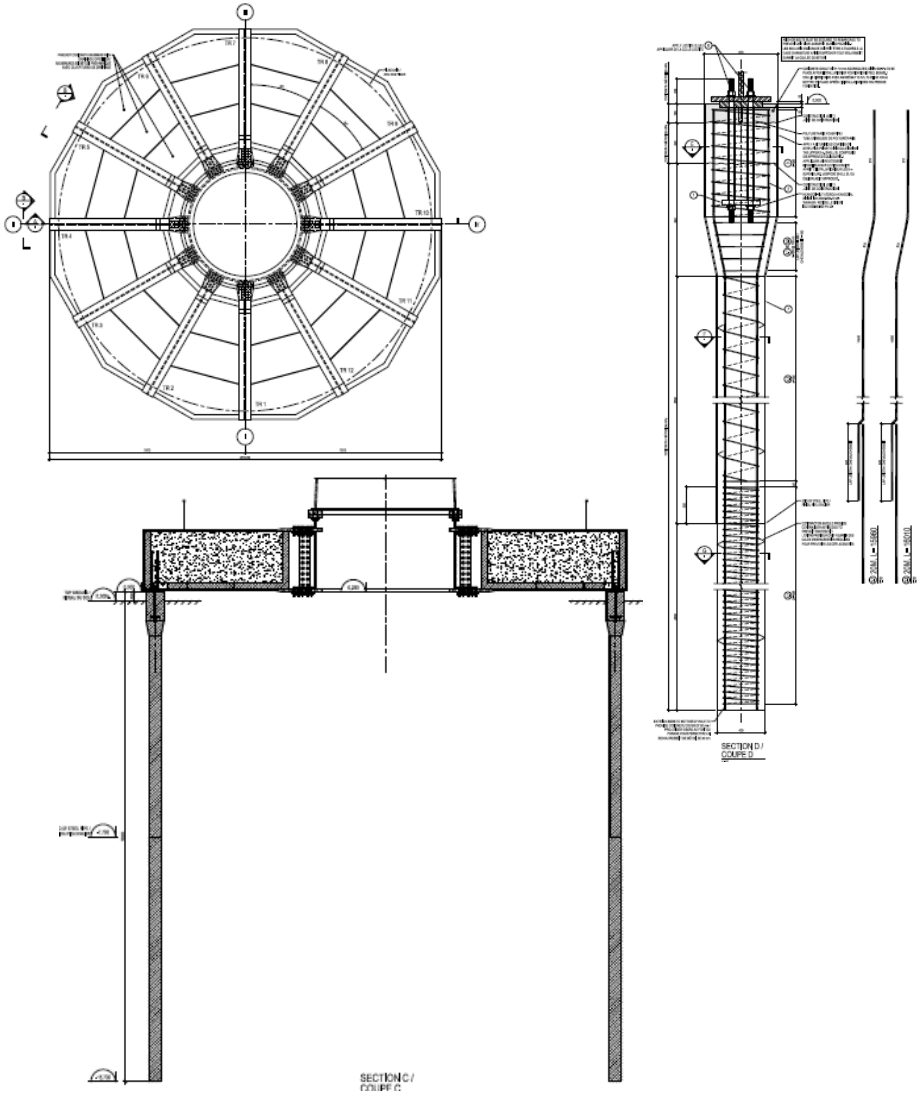
Hydrogen loop

- Electrolyser, 200 kW of fuel cells and 4 MWh of Hydrogen storage tanks
- Store excess wind energy for 20 hours

Micro controller - HμGRID

- High-Speed Controllers dispatching storage components to minimize wind power variation and store excess wind energy

The Only Turbine ‘Levitating’ in the Arctic



Quick facts on the Spider:

- 12 piles of 16’’ (406 mm) in diameter and 53 ft (16 m) deep, methodically surveyed to make sure required tolerance is met
- 130-tonne LEGO-like steel structure with 2m high H beams (legs of the spider) and a massive central ring
- More than 60 000 wires hand twisted for the assembly of the rebar cages
- ~ 90% less concrete required vs gravity based foundation
- Design suited for permafrost in remote location

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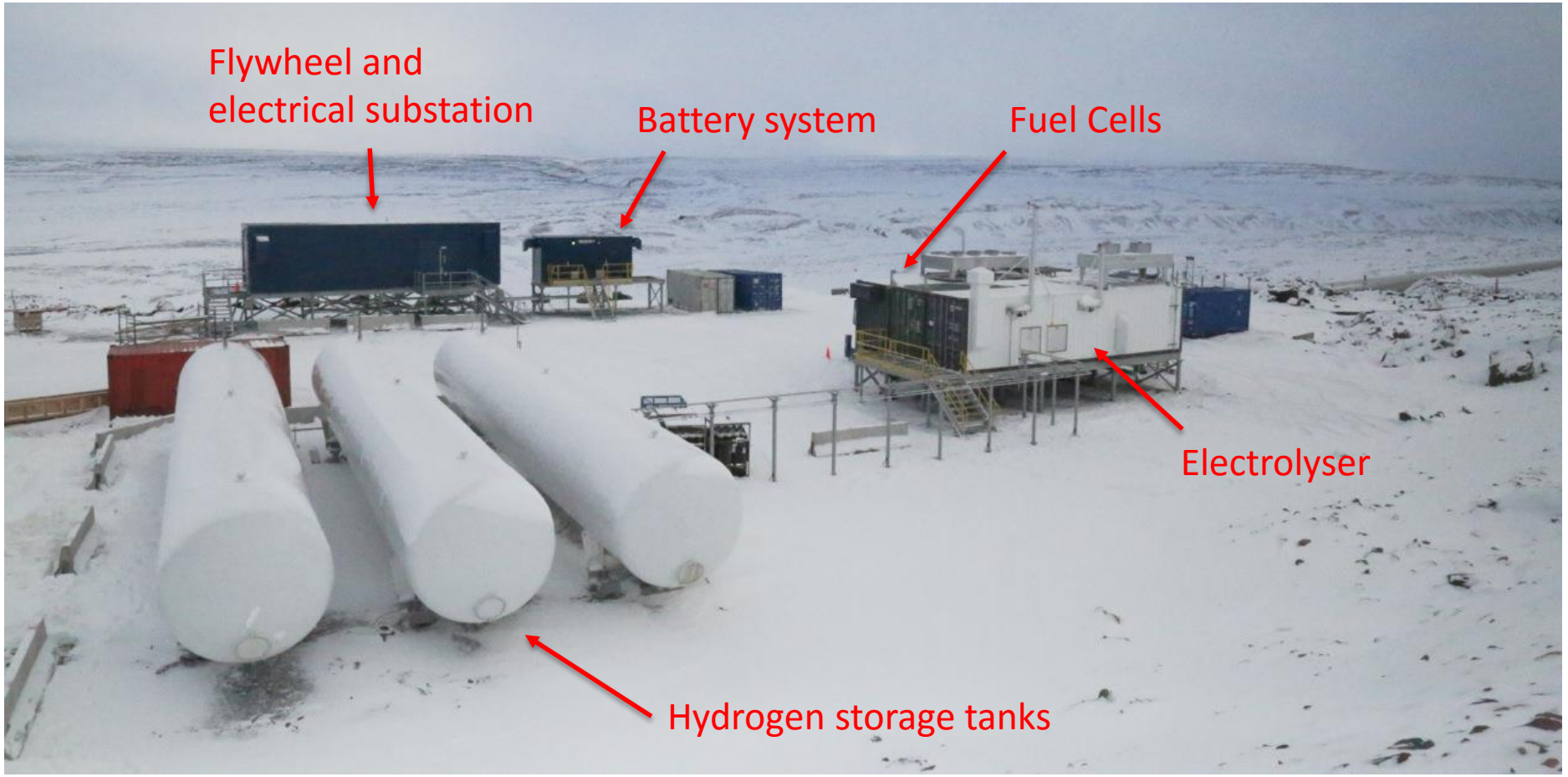
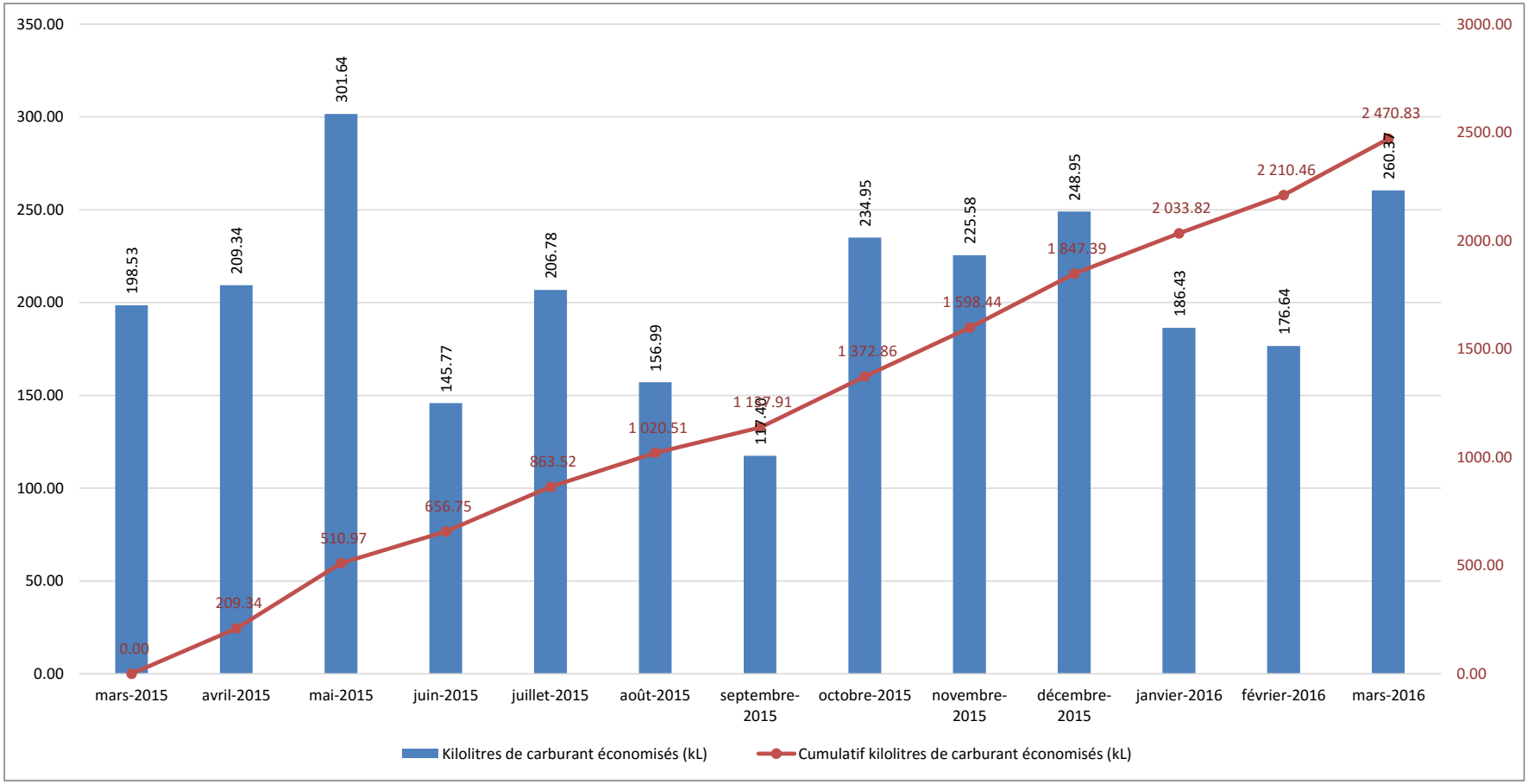
Energy Storage Plant



Results after 18 Months of Operation

- Energy Delivered: **13 849 MWh**
- Wind turbine availability: **97.18%**
- GHG Emission Reduction: **9 910 tons**
- Fuel displaced: **3.55 Millions of Litres**



Lessons Learned

Tools were developed and implemented to improve operability and predict wind power drops, such as:

- Automated daily email to power plant operators with 1 week look ahead wind forecast
- Hourly wind forecast
- Wind turbine icing accumulation estimation algorithm
- Sound alarm for major warning detected (eminent wind turbine stop for maintenance, icing, overheating, untwist, etc)
- Automated curtail wind if wind power drop is anticipated or automatic addition of spinning reserve
- TUGLIQ’s technician to control blade de-icing in critical conditions, preventing a sudden stop

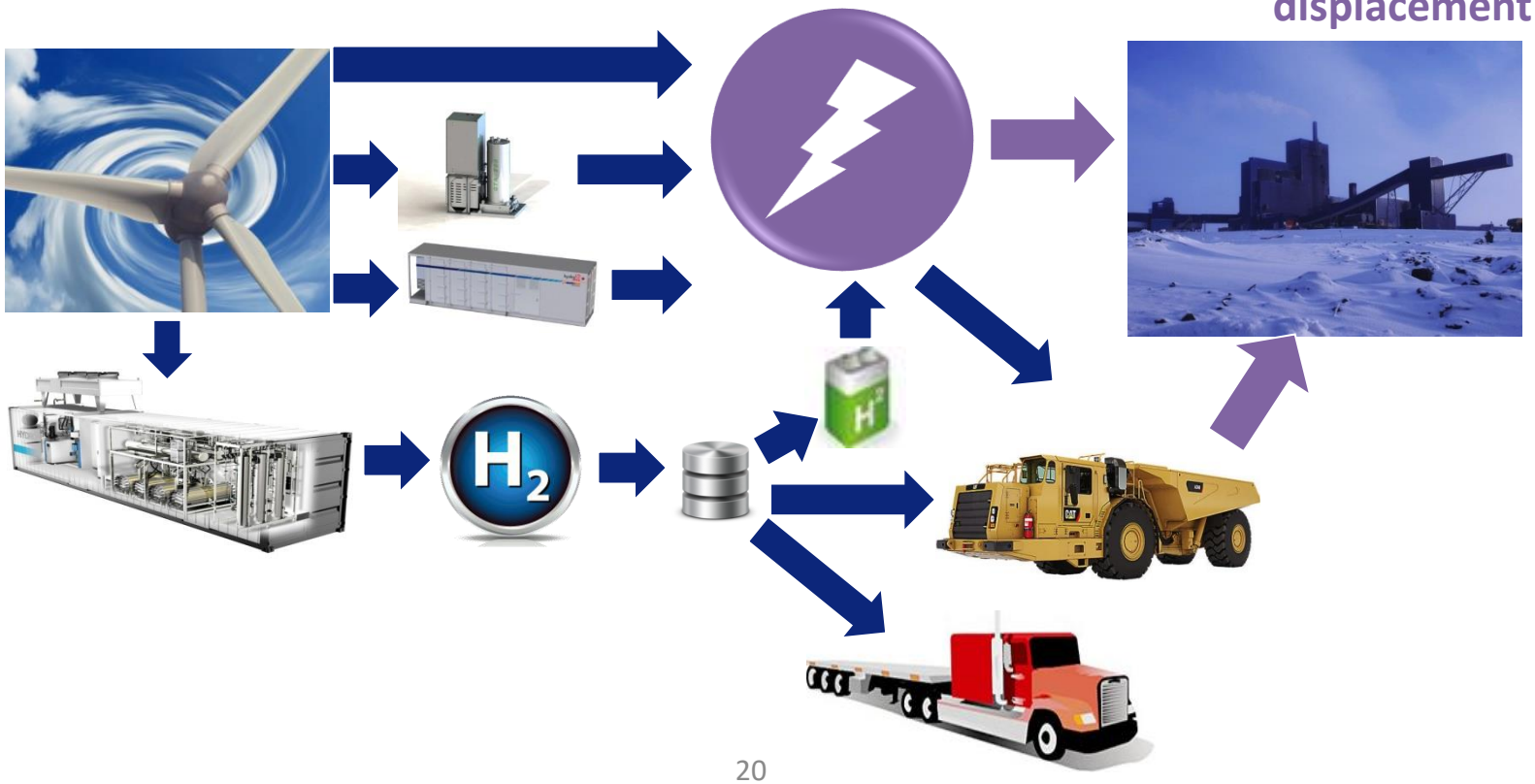

Looking at the Future
What’s next ?

Looking at the Future: Transport Electrification & Small-Scale LNG

To further increase fuel displacement and lower carbon emission

- Diesel mining trucks underground requires a lot of ventilation
- TUGLIQ has started to look at electric vehicles with mining partners
- Hydrogen can be used in other applications, mobility and heat

Maximum diesel displacement



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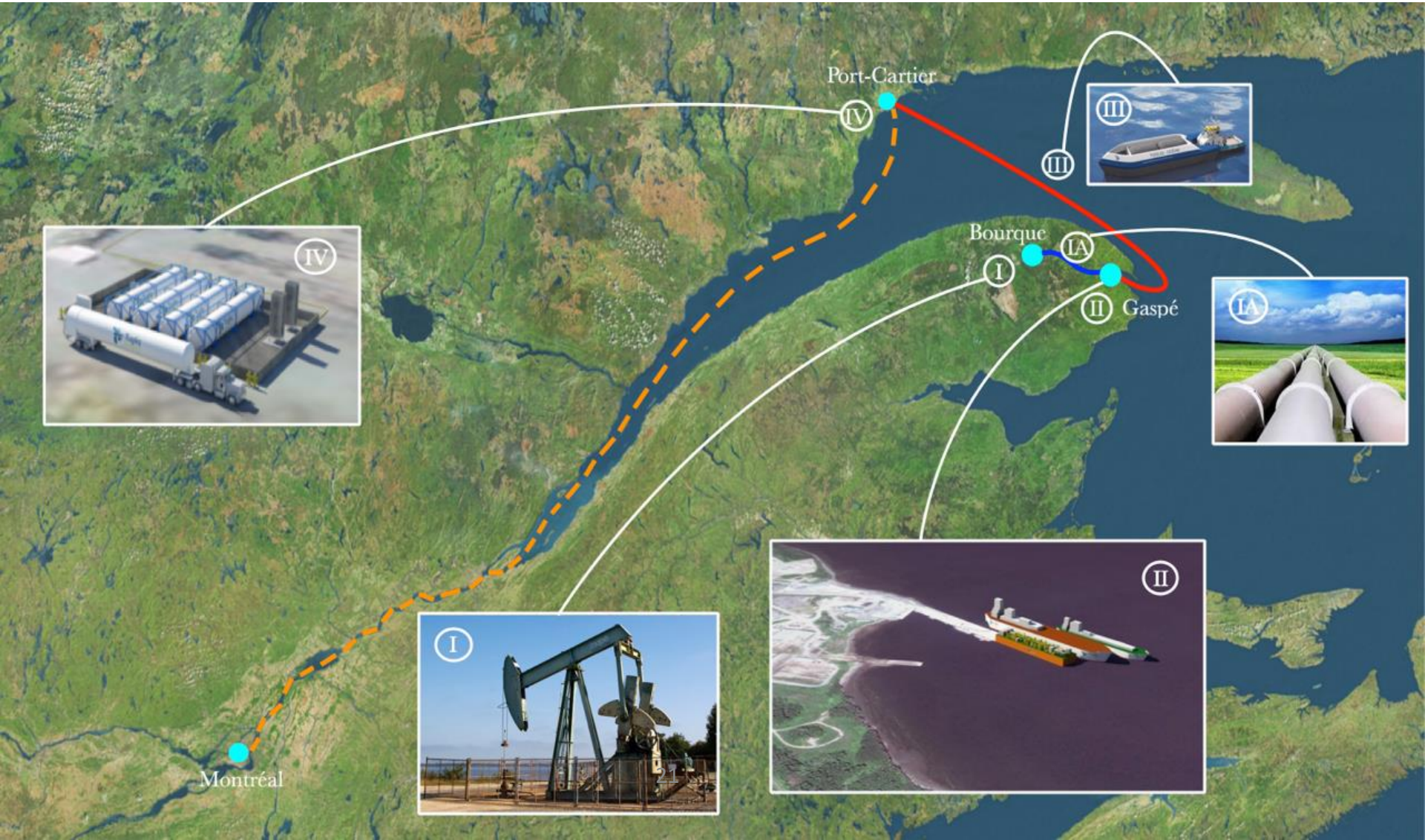
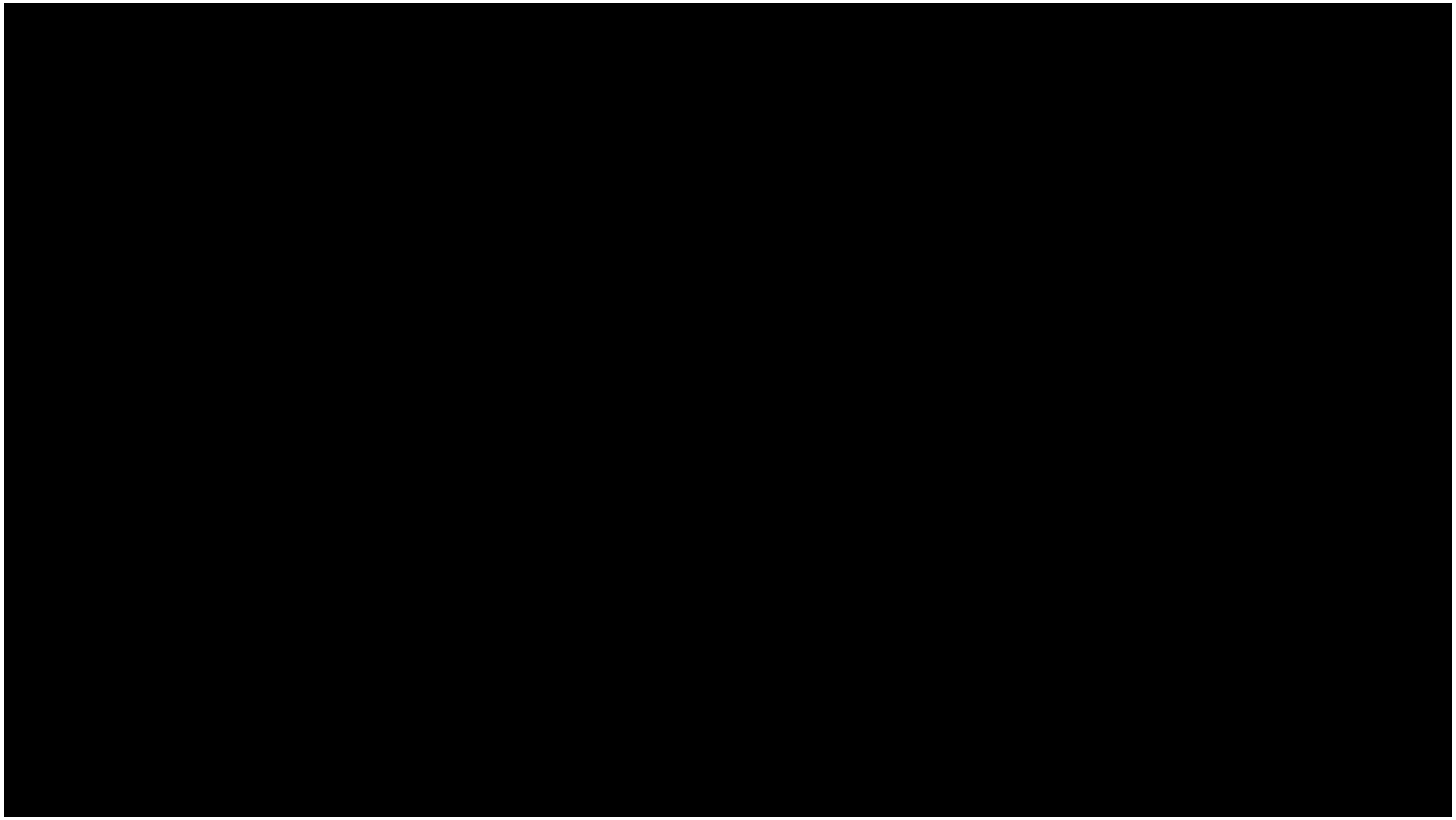
Natural Gas (Small Scale LNG) as a Transitional Tuel



TUGLIQ’s LNG Supply Chain



In Conclusion

- Renewable energy makes sense in the Arctic
- TUGLIQ has a defined plan to diversify the Northern communities and mines away from diesel (local renewable energy, electrification of transports, cleaner transitional fossil fuel, 100% renewable) and is delivering as per its established milestones
- To date, TUGLIQ has gained significant expertise and knowhow on integration of intermittent renewable power source and energy storage for off grid hybrid applications
  - Project development
    (financial modeling, FEED study, detailed engineering)
  - Project construction and commissioning
  - Operation and maintenance
  - Optimization
  - Legal framework, creative and adaptive PPA
- Benchmark project, replicable to other off-grid mining sites and communities


Nakurmiik!