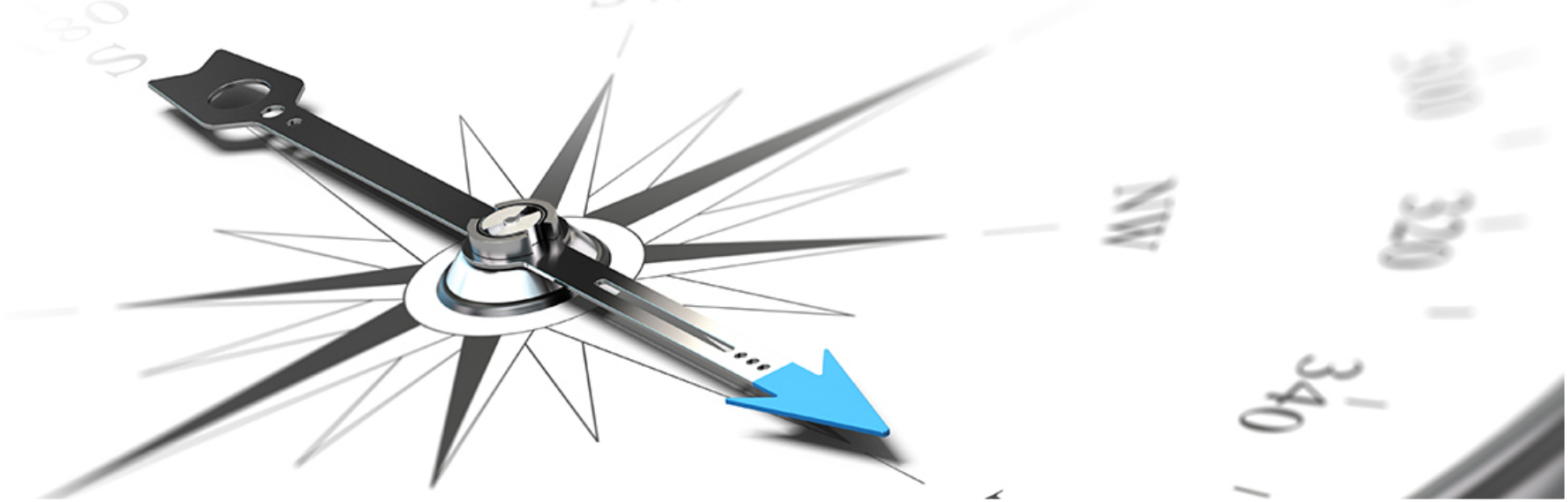

PÖYRY

ENERGY STORAGE IN A MINE

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INTRODUCTION TO PYHÄSALMI ENERGY STORAGE

First large scale energy storage facility in Finland

Description and key metrics

- **Situation**
  - Orebody of Pyhäsalmi mine, deepest base metal mine in Europe, is expected to be depleted by 2019
  - Pyhjärven Kehitys Oy is developing business opportunities to the existing mine infrastructure
- **Developer**
  - Main developer is Pyhäjärven Kehitys Oy, a development company which finances and oversees local development projects
- **Key metrics**
  - 75 MW capacity and 7 hours storage size
  - Possibility for capacity and storage size expansion in the future (+75 MW)
- **Revenue streams**
  - Day-ahead market arbitrage
  - Participation in ancillary services markets & balancing market
  - Offering wind producers balancing capacity

Location of the plant

Pyhäsalmi mine is located about 150 km south of city of Oulu and about 40 km distance from planned (in 2023) 400 kV transmission line*

*Fingrid: Kantaverkon kehittämissuunnitelma 2015 – 2025

KEY HIGHLIGHTS

Well positioned for electricity market development

- Increasing intermittent generation in the future and retiring thermal capacity increases the demand for flexibility and decreases the supply of flexibility*

Suitable existing infrastructure

- The existing infrastructure is well suited for an energy storage plant
  - Mine depth enables having head of 1400 m
  - Good location, close to the Finnish transmission grid
  - Available backfill quarry on surface that can be used as an upper reservoir
- Good and well-known rock conditions

Reliable and green technology

- Pumped hydro energy storage technology is widely used and based on proven and robust technology with technical lifetimes of over 40 years
- Pumped storage operates in closed water circulation

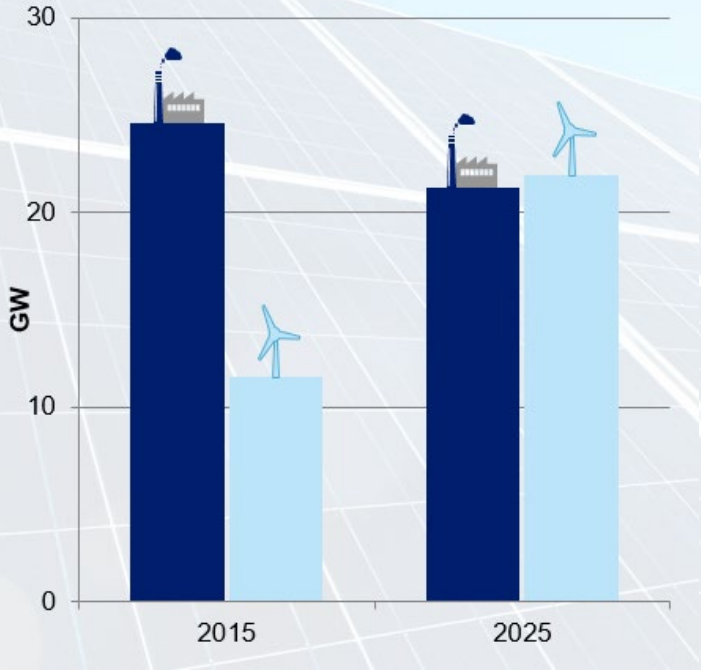
Local economic benefits

- Continuation of activity in the mine will boost the local economy by being part of the business development and creating jobs during construction. Local skilled labor and expertise can be utilized.

Source: *Pöyry analysis and Fingrid

EXPECTED MARKET DEVELOPMENT

Expected capacity development in Nordic countries



- Intermittent generation, both wind and solar power, is expected to increase in the Nordic power system over the next years
- Flexible thermal generation has and is likely to continue to decrease in the future because of low profitability resulting in less capacity that is capable of balancing the intermittent generation
- New investments are not taking place to replace the retiring capacity
- This challenging situation is high on Nordic TSO's agenda and has been brought up by Fingrid in recent discussion paper*

Source: *Fingrid, Electricity market needs fixing – What can we do

BENEFITS OF PUMPED HYDRO ENERGY STORAGE

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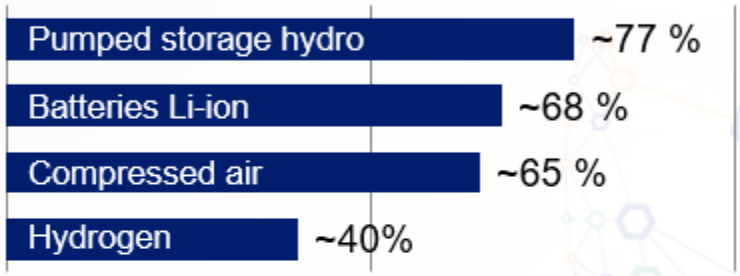
Longer technical lifetime

Pumped hydro vs. **Battery solutions**

Over **50** years | **11 – 15** years

Higher round-trip efficiency

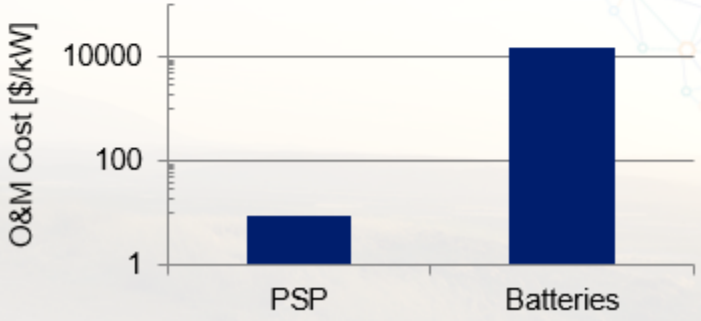


Higher storage volume

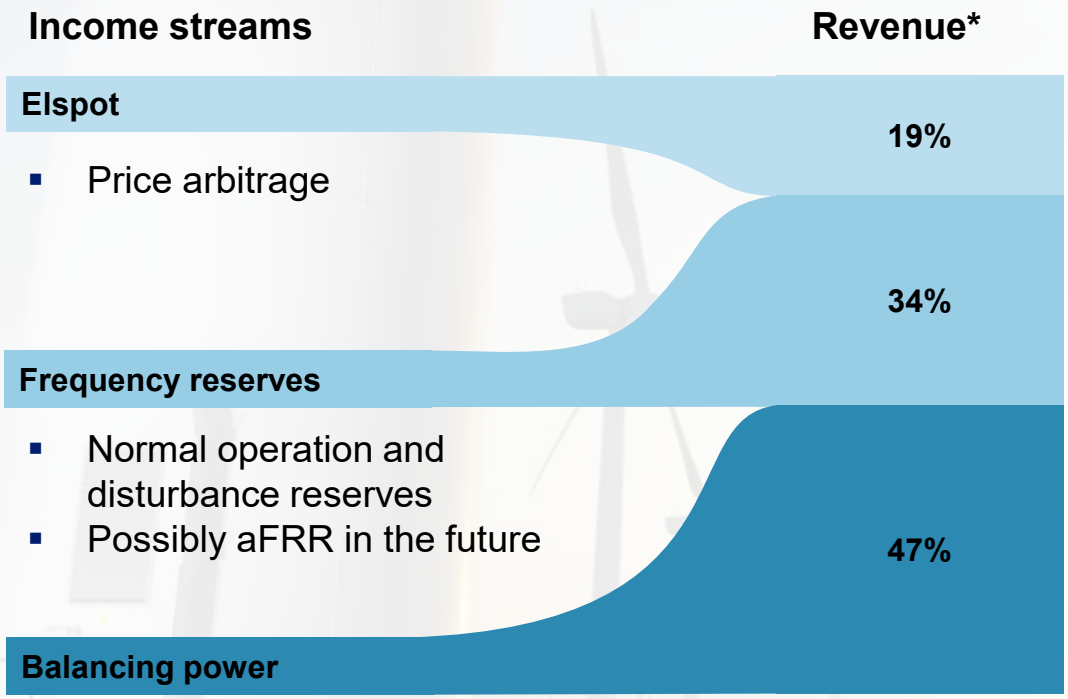
Pyhäsalmi PHES vs. **Helen Suvilahti battery**

7 hours storage | **0.5** hours storage

Lower Opex



REVENUE SOURCES



- Pyhäsalmi energy storage revenue sources were estimated using Pöyry's independent analysis and BID3 electricity market modelling tool
- The energy storage generates revenue from three distinct sources
- Frequency reserve and balancing power have higher revenue generation because of their higher price level
- Balancing power is expected to play a more important role in the future because of increasing intermittent generation in the market

* Estimate based on Pöyry analysis. Revenue split develops over time, with increasing emphasis on balancing power. Example split is from 2025.

PROJECT FACT SHEET

Technical Data	
Plant capacity	75 MW (+75 MW)
Number of Units	1 (ternary set)
Flexible operation range	±75 MW (Charge/discharge)
Operation time turbine / pump	7/9 h
Storage size	530 MWh (1054 MWh)
Reservoir volume	162.000 m³
Cycle efficiency	77 %
Head	1400 m

- Plant capacity was chosen based on financial analysis with the 75 MW option being most profitable
- Plant has the option of increasing capacity in the future, thus minimizing the current investment risk

Preliminary timetable

2017/2018	2019/2020	2023
▪ Completion of feasibility study ▪ Look for partners and financiers ▪ Project planning, permitting and tender process	▪ Beginning of construction ▪ Construction time: 3 years	▪ Plant operational

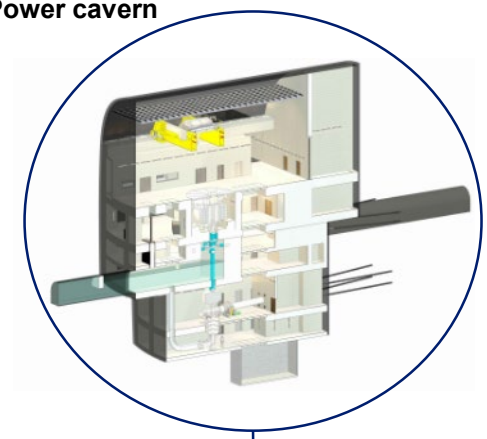
- Project timetable is set to match the closure of operations in Pyhäsalmi Mine

Total Capex: 102.9 MEUR

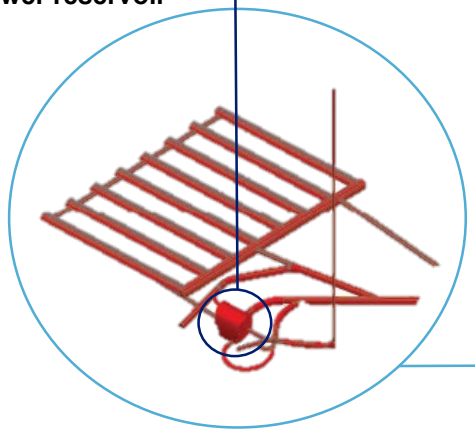
- Capex is expected to be split 20%, 40% and 40% during three construction years
- Maintenance and revision Capex need is minimal until year 40 of operations
- Total Capex for two 75 MW units is 174.2 MEUR

3D MODEL OF THE MINE AND THE PLANT

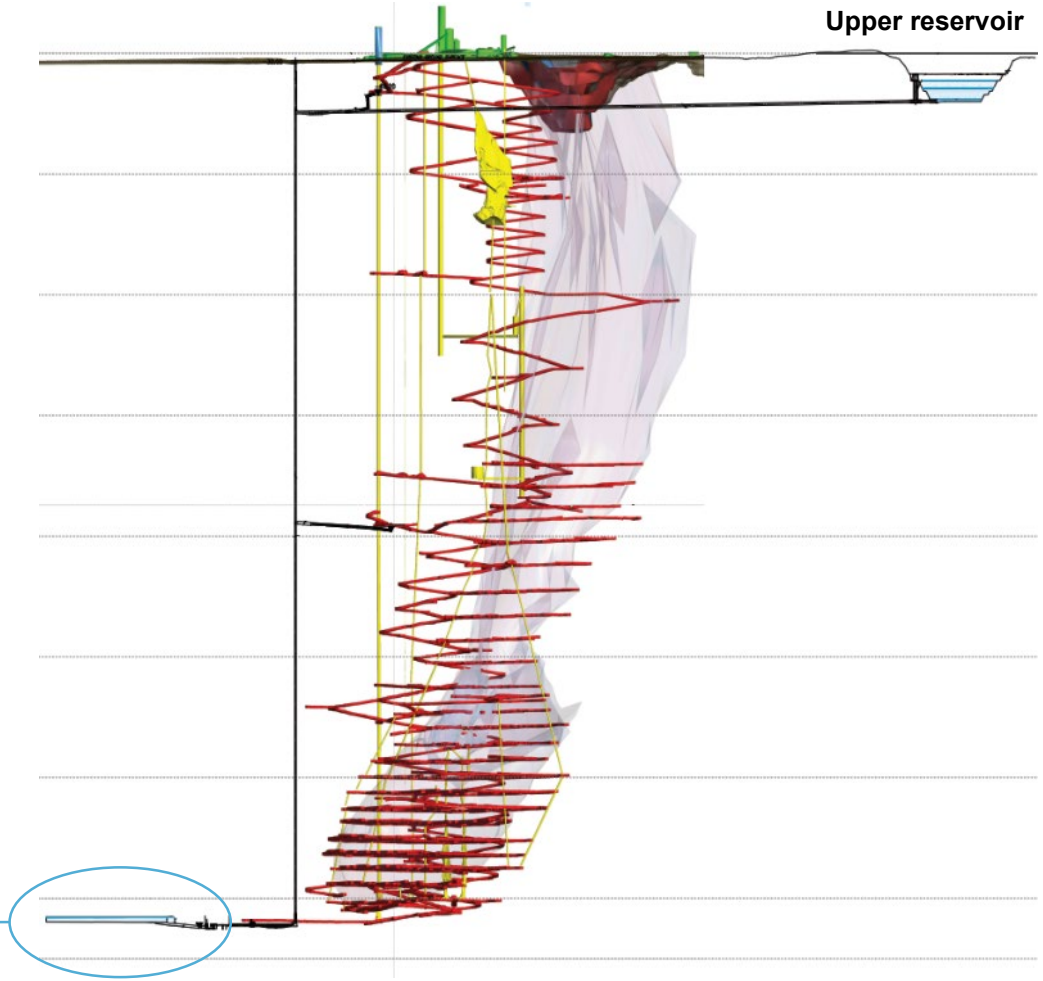
Power cavern



Lower reservoir



Upper reservoir



PROCESS AND NEXT STEPS

Process information

- Feasibility study completed 1/2017 by Pöyry Energy GmbH and Pöyry Management Consulting
  - All critical parameters are set
  - Technical design completed
- Additional commercial studies by VTT & ÅF Consulting 2/2018 and SKM Market Predictor AS 2/2020
- Currently looking for potential partners, investors and financiers

- Next Steps (2019/2020):
  - Planning of project implementation
  - Approval and tender design
  - Approval and permitting process
  - Tender process

- Project Implementation (2020 – 2023):
  - Construction phase (3 years)
  - Plant in operation (beginning of 2024)

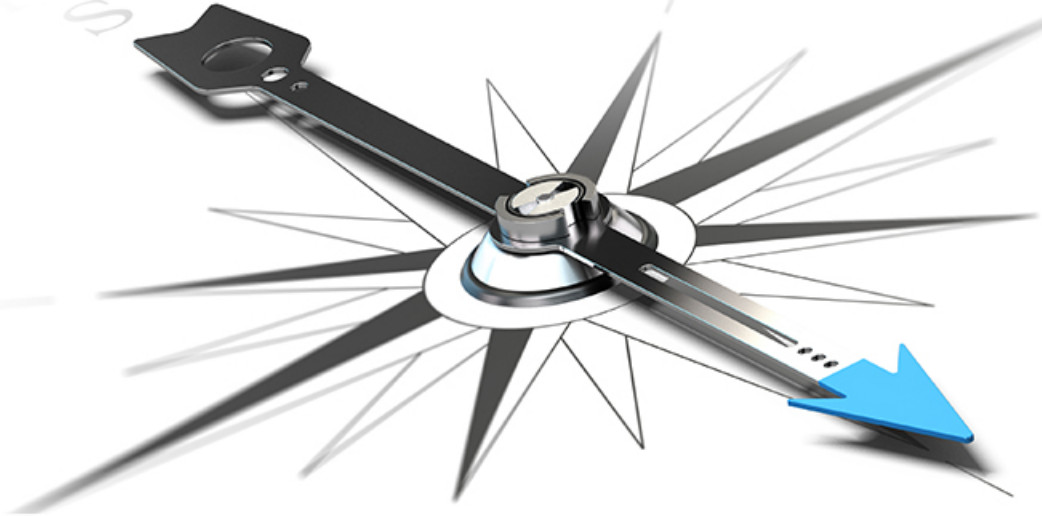
CONTACT INFORMATION

Contact information

Sakari Nokela
Program Director

Callio Pyhäjärvi – Mine for business
Ollintie 26
FI-86800 Pyhäsalmi
p. +358 40 1809511
sakari.nokela@pyhajarvi.fi
www.callio.info

MINE FOR BUSINESS
CALLIO
PYHÄJÄRVI, FINLAND



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