



Introduction to Innovation Management

Assessment: Presentation

Course : MSc Industry 4.0 Advanced
Manufacturing

Module Code : ACPA7005

Supervisor : Alan Mumby

"A breakthrough innovation - Sand Batteries"

Prepared by

Gareth Gooding (2125561)

Rahul Bhosale (2116970)

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POLAR NIGHT ENERGY

- Polar Night Energy is a company based in Tampere, Finland.
- Founded in 2018 by Tommi Eronen and Markku Ylonen



TOMMI ERONEN
CEO

Passionate and tireless innovator, who is not afraid to shout his bright ideas out loud. Expert in heat transfer and storage modeling. M.Sc in Power Plant Engineering.

tommi.eronen@pne.fi | +358 45 7831 5988



MARKKU YLÖNEN
CTO

Grasps the inner world of machines and solves most problems before they even occur. D.Sc in Applied Mechanics.

markku.ylonen@pne.fi | +358 45 7832 8399

Introduction & Company

POLAR NIGHT ENERGY

- Name - Polar Night Energy - refers to the Seasonal effects on Energy generation
- Polar Night Energy hold a Patent for A system and a method for storing and transferring heat - “Sand battery”

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Sand battery

is a high temperature thermal energy storage that uses sand or sand-like materials as its storage medium. It stores energy in sand as heat.



Problem Statement

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1. Renewable Energy Sources such as Solar relies on Sunlight to work.
 - Finland is a country that has limited Sunlight during the Winter season, reducing the effectiveness of Solar power as an energy source
 - Finland is reliant on Combustion Powered Sources for heat during this winter period - Negative Carbon Impact.
2. Renewable Energy often produces excess electricity, often sold or treated as surplus
3. Cities across the world, including New York rely on District Heating, often provided by Combustion Powered Sources - Negative Carbon Impact.
4. Finland is facing an energy crisis, with Russia threatening combustible fuel limitations

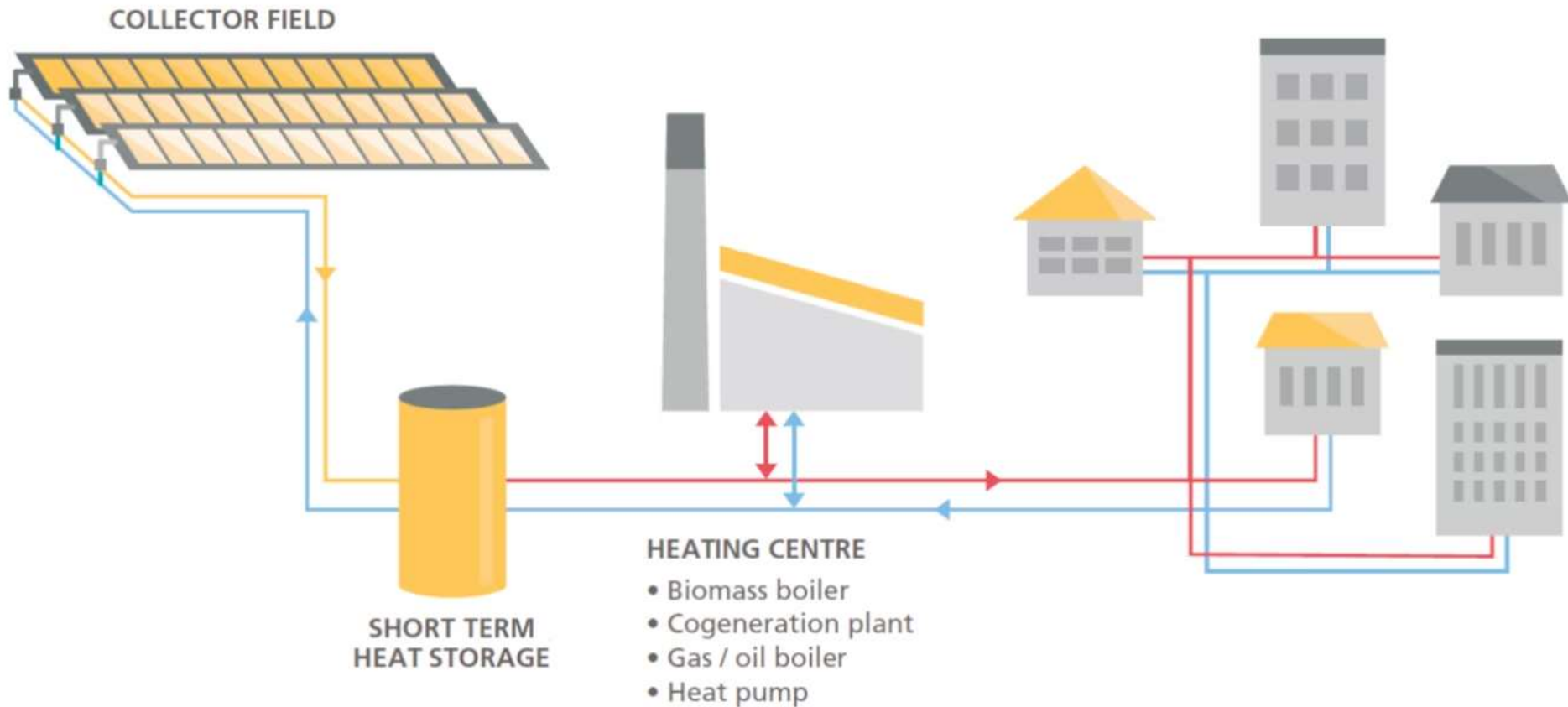
District Heating

District Heating is a Heat Network that takes heat from a central source and distributes it to domestic or non-domestic buildings via insulated pipes. The central source of heat could be a power plant, heat recovery from local industry, or energy from waste plants. *(gov.uk, 2022)*

Examples of locations that utilise District Heating:

- New York City - uses 105 miles of steam pipes to provide heating, hot water, and in some cases powers steam chillers to cool. The fuel for the central Steam generating plants is 97% Natural Gas, so cleaner than oil and coal.
- London Underground -unwanted heat from the Northern Line network is being used to heat 1350 homes and community buildings in Islington. *(Ramboll, 2022)*
- Finland - Finland's most popular heating solution is District Heating. More than 66% of new building select district heating. Approximately 70% if Finland's municipalities produce district heating with renewable energy sources such as Solar Collector technology. *(FINDHC, 2022)*

Example of Solar District Heating with Short term storage



(IEA, 2021)

Solution - Sand Battery

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- Polar Night Energy have developed the 'Sand Battery' to ensure that the risk in fluctuations from Solar Powered Energy is mitigated.
- The 'Sand Battery' is referred to in this instance is a high temperature Thermal Energy Storage solution. (Not to be confused with the Electricity Storage sand battery solutions being developed in other areas of research)
- There are a number of different types of Thermal Energy Storage Solutions, such as water tanks or borehole technology, which are both expensive, and limited by water medium temperatures. To contain high temperature water can be difficult due the boiling point of water. Both of these are solutions in current use for Seasonal Thermal Energy Storage Solutions, such as this application.
- Polar Night Energy have used Sand for the following reasons
 - Low cost, and abundant
 - Sand can be heated to 1000 degrees centigrade
 - Sand heat retention can be up for months
 - Sand tanks are simpler in design compared to water tanks/boreholes

Sand Battery - How it works

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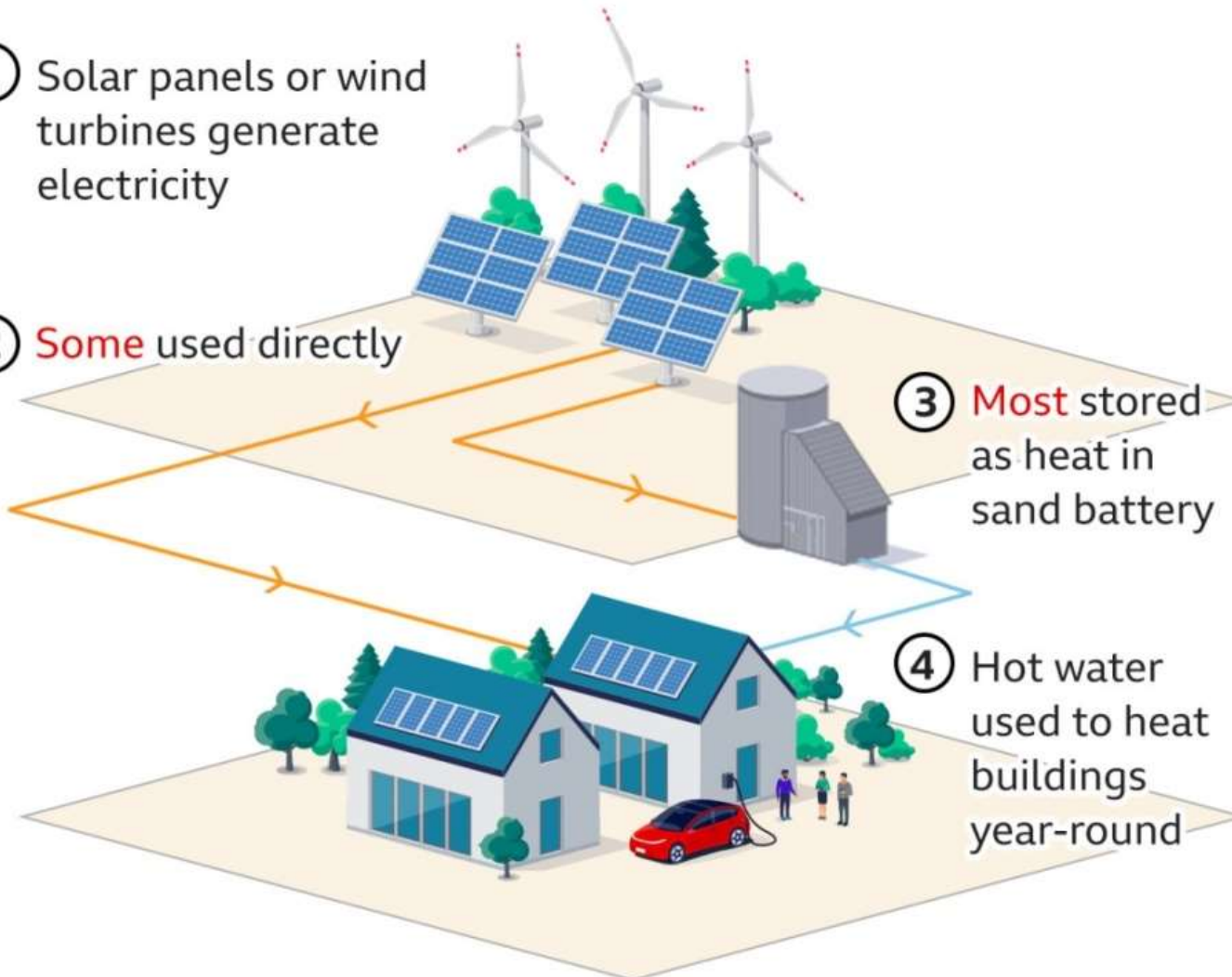
How sand batteries work

- ① Solar panels or wind turbines generate electricity

- ② **Some** used directly

- ③ **Most** stored as heat in sand battery

- ④ Hot water used to heat buildings year-round



Sand Battery - How it works

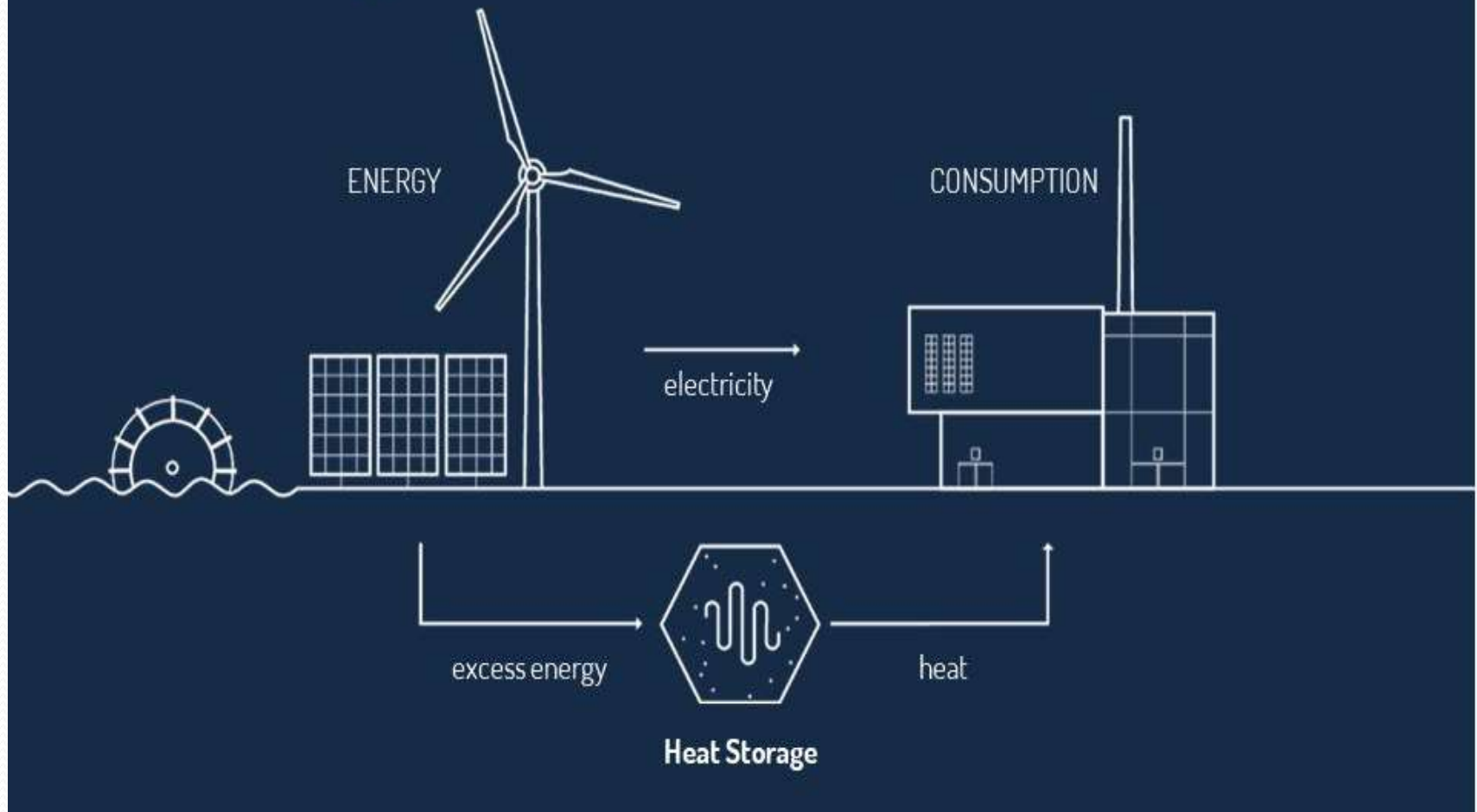
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- Polar Night Energy use a tank of Sand to store heat produced from electrical resistors, powered by the excess electricity from Solar or wind energy. Heat can reach up to 1000 °C
- The Sand Battery heats up air which is passed through pipes in the Sand Battery. This air can be direct heating, used to water into process steam, or heat water.
- The Sand Battery storage size can vary from tens to thousands of cubic metres, depending on the size of operation, and can be stored underground.
- The Sand Battery can be made from steel and insulated with standard heat resistant insulating materials.

Sand Battery - How it works

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Store Energy in Hot Sand



- Thermal Energy Storage is fundamental in operating a Renewable Energy Heating Networks, such as District heating, with various technologies available.
- Molten Salt Thermal Energy Storage systems have been used since the 1980s, and currently in use at the Gemasolar Concentrated Solar Power plant in Seville, Spain, since 2011. Masdar, who collaborated to build the Gemasolar have been researching Sand as a solution since 2013 - ‘Project Sandstock’, with an announcement of success in January 2022. (*Masterson, 2022*)

Sand has been a material of interest for Heat Storage previously, due to the thermal properties of sand :

- In 2013 the Institute for Energy Systems and Thermodynamics, Technical University of Vienna wrote a paper on “sandTES - An active thermal energy storage system based on fluidization of powders”, critically analysing Sand as a suitable material for Thermal Storage. (*K.Schwaiger, 2013*)
- In 2015 D.Schlipf wrote a paper on “*Using sand and other small grained materials as heat storage medium in a packed bed HTTESS*” analysing the use of sand as a cheaper alternative to Molten-salt Thermal Energy Storage Systems. (*D.Schlipf, 2015*)

Innovation - “Is never a single event”

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- “Innovation is never a single event” (*Satell, 2017*) - The Sand Battery is following on from similar technologies, to provide a different solution for Thermal Energy Storage.
- Previous solutions use a tank transfer system - passing the Thermal storage medium from a ‘cold tank’, through a concentrated heat source (solar) to a ‘hot tank’
 - Polar Night Energy (PNE) use a single tank.
- Molten Salt is in use for this similar applications, with a thermal capacity of 600 ° C.
 - Polar Night Energy are using Sand with a thermal capacity of 1000 ° C
- Other solutions include water and borehole - which are more expensive, and lower lifecycle due to corrosive issues.
 - Polar Night Energy Sand Battery has a non corrosive medium, with a lifespan of tens of years

- “Innovation is never a single event” (*Satell, 2017*) - The Sand Battery is following on from similar technologies, to provide a different solution for Thermal Energy Storage.
- “Innovations are novel solutions to important problems” (*Satell, 2017*) - With the heat storage lasting months, and to be considered as a true Seasonal Thermal Energy Storage solution, the risk to solar from the lack of sun in the winter can be mitigated with Polar Night Energy’s Sand Battery.
- A cheaper more accessible solution has been achieved by Polar Night Energy.
- Leveraging Platforms - Polar Night Energy has used the power of Media and Social media to promote themselves and the Sand Battery. Innovation requires Customer Development, which PNE has utilised across different platforms:
 - YouTube ‘NowKouknow’ channel - interview 14th May 2021 - 270,833 views (*NowYouKnow, 2021*)
 - BBC News - Climate change: 'Sand battery' could solve green energy's big problem - 5th July 2022 (*McGrath, 2022*)
 - International Media coverage for the Vatajankoski Project.
 - Intuitive Website to communicate the technology, and Case Studies to offer examples

Minimum Viable Product - Vatajankoski partnership

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“The Minimum Viable Product” (*Satell, 2017*)- not a prototype, but a working solution to engage customers by proving the solution is a sustainable business model.

Polar Night Energy designed and built the first commercial sand-based heat storage with Vatajankoski, an energy utility based in Western Finland. It will provide heat for Vatajankoski’s district heating network in Kankaanpää, Finland. The storage has 100 kW heating power and 8 MWh capacity. Full operation - July 2022

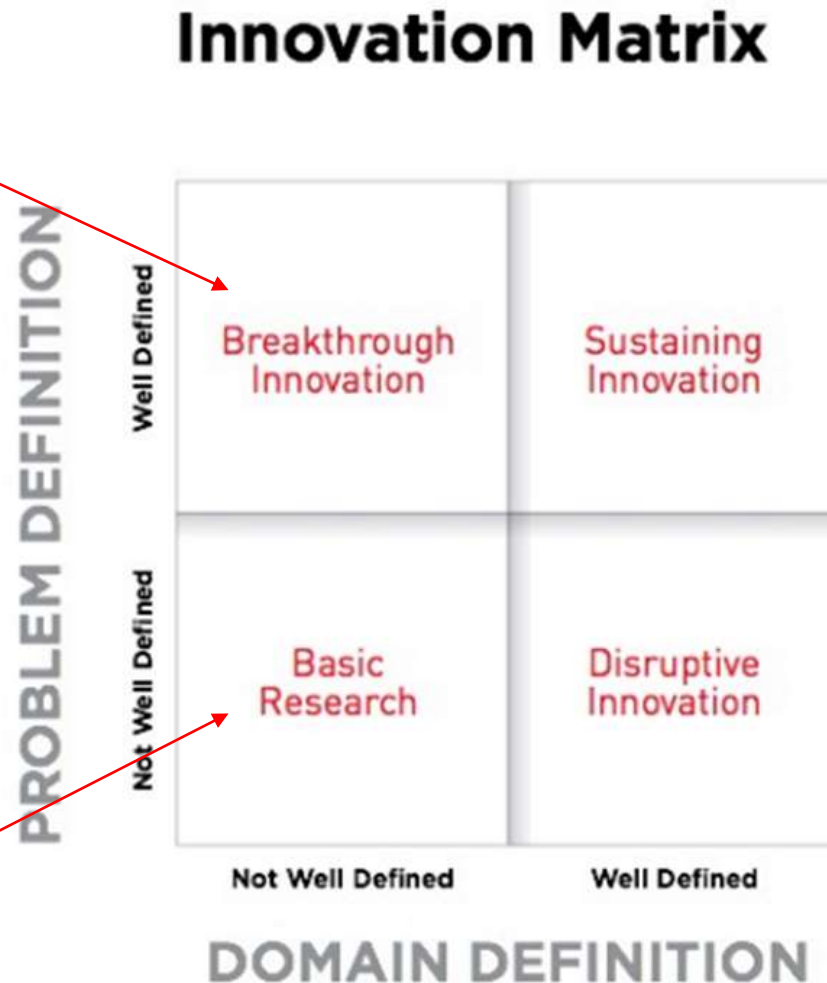
The local council provided funding.



Innovation Matrix

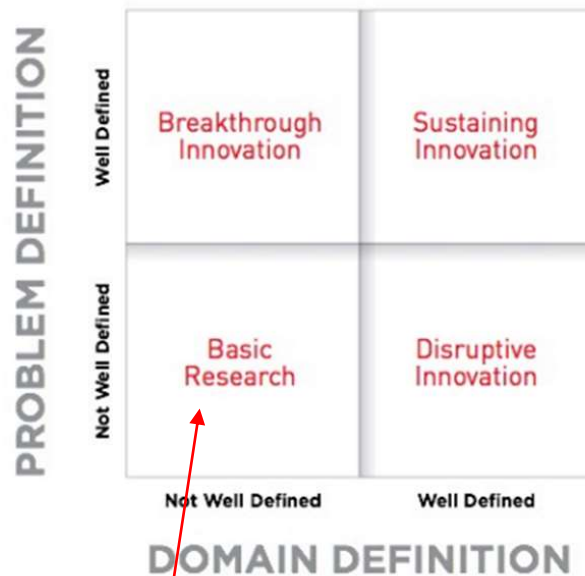
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Partnership
Launched with
Vatajankoski to
showcase the
Minimum Viable
Product



Tommi Eronen and
Markku Ylonen
developed the
Sand Battery as
part of a Study
Thesis

Innovation Matrix



It was during Basic Research into a Masters Degree thesis about energy storage solutions that Tommi and Markku discussed, researched and developed this Innovation

Tommi Eronen and Markku Ylonen developed the Sand Battery as part of a Study Thesis

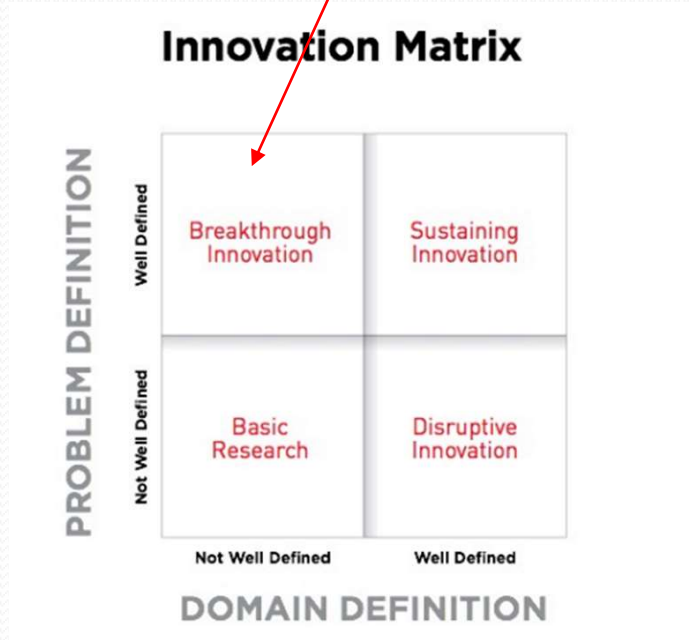
Breakthrough Innovation

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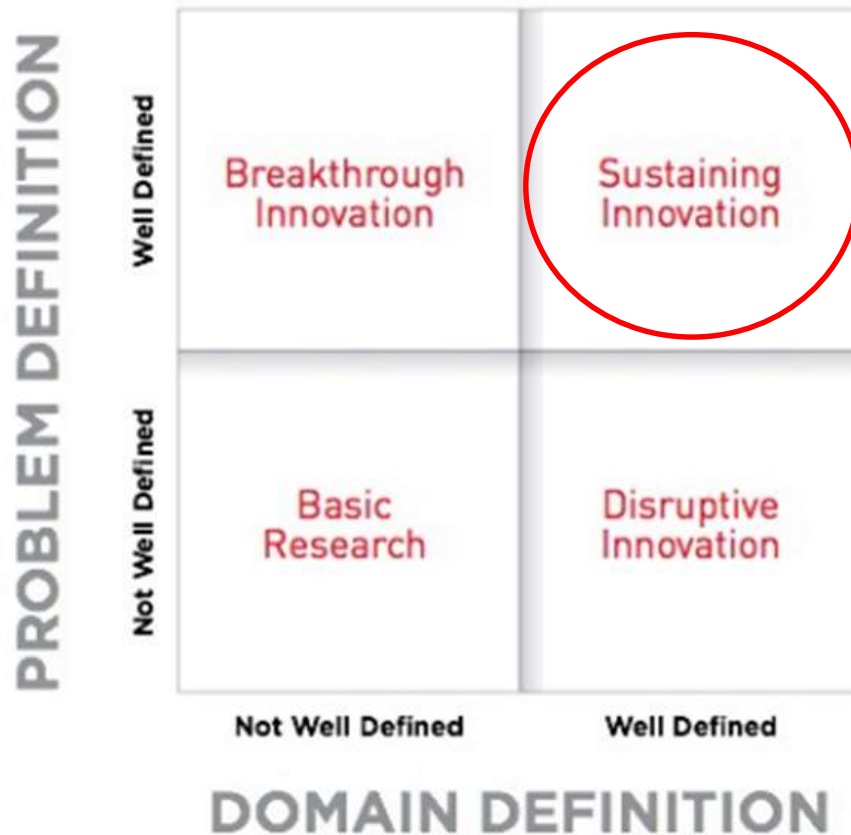
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The energy problem was clear for Finland, with a threat to its Energy source (Russia), and Seasonal affects.

This Innovation is a solution to these problems.



Innovation Matrix



The Sand Battery is a relatively new Innovation, and the technology has been openly discussed. This may allow competitors to adopt, or innovate further solutions.

To ensure a stable future Polar Night Energy will need to adopt Sustaining Innovation - road mapping the next innovation of the Sand Battery, to keep the product improving.

1. Polar Night Energy Market Position

Polar night Energy is a new company, so has not a trading market position. Through Customer Development via a wide range of Media, social media and International news reporting the company has gained recognition in what the Innovation is, and does. With recent political escalations in Russia, Finland is in an energy crisis, so the original problem definition has grown. The timing of this new situation has the media suggesting the Sand Battery is a solution Finland can use. This has the potential for more investment and customers, to give Polar Night Energy a good market position.

The Sand Battery does have a lower cost per stored energy unit compared to competitors. *(CBInsights, 2022)*

2. The company's internal structures and management processes

Polar Night Energy started off with just Tommi Eronen and Markku Ylonen. As the Innovation has developed, including a test pilot system being proven the company has expanded to include experts in Product development, Project Management, Communications and Business Relations. With Tommi and Markku focussing on the product they needed to engage people with other talents.

3. Technology Dependency

Polar Night Energy has innovated a solution to be less technological than what has been used before. Moving from a Tank transfer system to a single tank has made the product simpler. The equipment design uses standard parts, which can be provided by other partners. Solar and Renewable energy sources are widespread, which this supports.

4. Outcome of the innovation

The innovation development, test pilot, and Customer engagement via media platforms being leveraged has led to the first commercial system commissioned in July 2022. Media attention, Worldwide Environmental focus, and recent political pressures between Russia and Finland has promoted the Sand Battery exceptionally.

Risks to this Innovation include a larger company innovating this product further - out of the parameters of Polar Night Energy's patent

Current technologies, such as Molten Salt Thermal Energy Storage already proven have Market Position in Energy Storage. Companies involved with Molten Salt may look to further innovate their products to reduce the requirement for the Sand battery

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