Energy Island.

Opportunities and Social Feasibility

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We@Sea, 2 December 2009

Agenda.

1. The Energy Island, from an old visionary plan in the 1980s to a innovative concept in the 21st century
2. Opportunities (first results):
   a. Energy Island is technically feasible
   b. one can make a business case of it
3. Social feasibility: patience and perseverance required to realize this project

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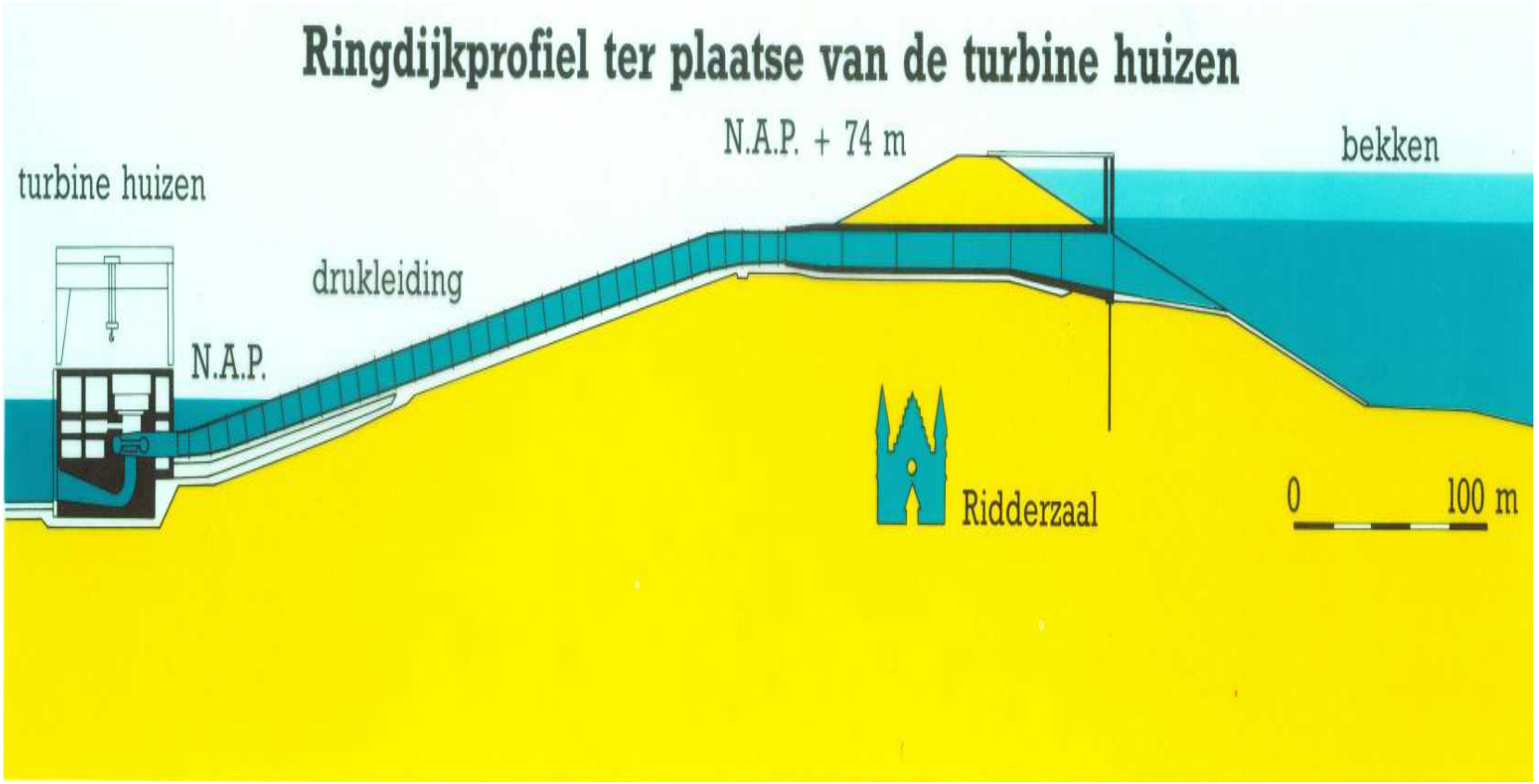
1. From old idea to new concept.

- History of the Energy Island, back to the 1980s
- Combine electricity storage and wind energy

The ‘old’ design: Plan Lievense.



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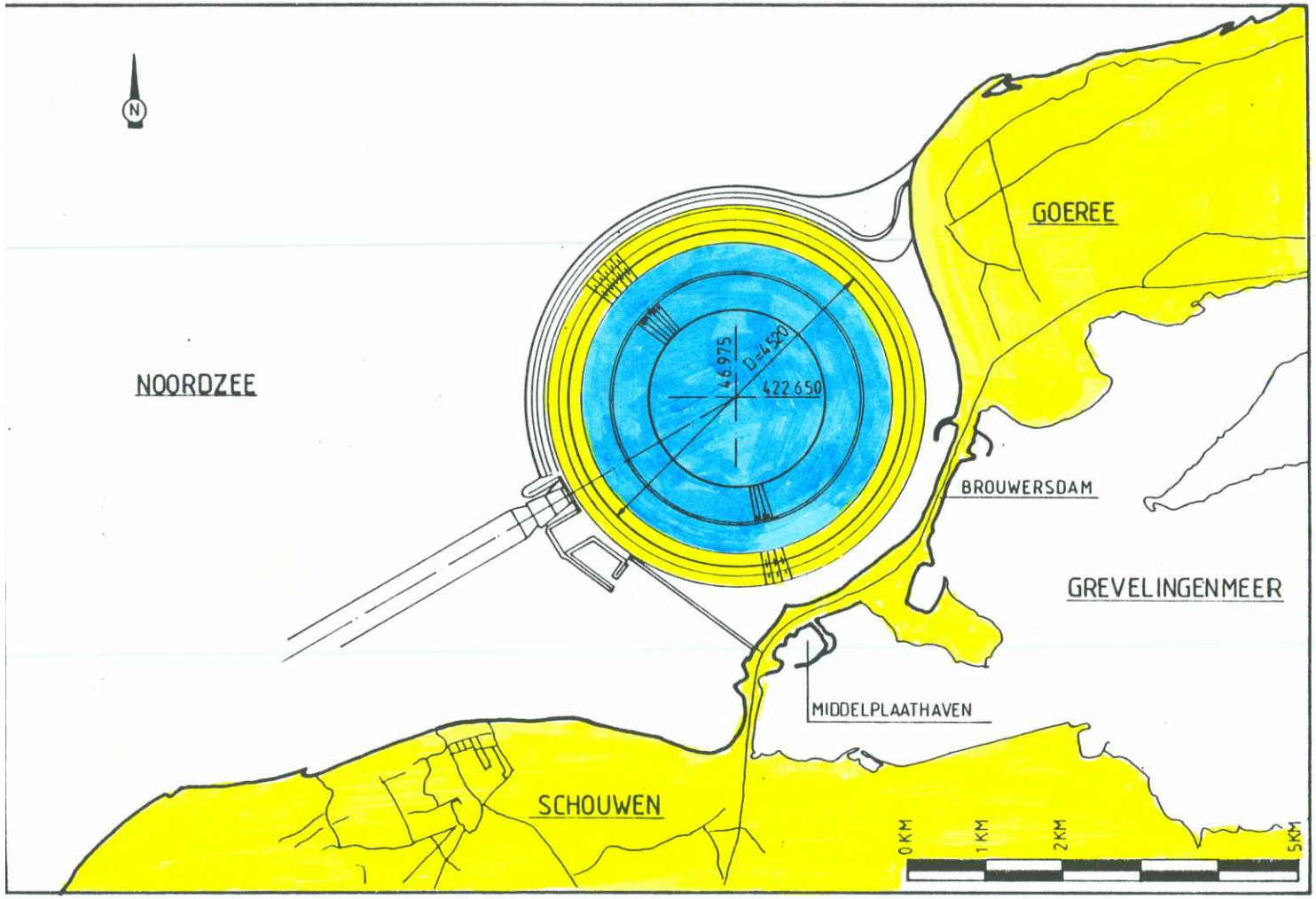
The ‘old’ design at Brouwersdam.



Figuur 5.4.22 VOORKEURSLOKATIE

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Artist impression of the ‘old’ design near the Brouwersdam.

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Transfer to an innovative concept.

Energy Island
an artificial island in the North Sea

- A 40 meters deep dredged open pit enclosed by a ring of dikes containing ~ 1.500 MW / 20 GWh for Energy Storage
- Island can be made with the sand of the pit
- Room for 300-500 MW of wind turbines on the island …
- … and other renewable energy sources, e.g. aquatic biomass
- Location for industrial activities, e.g. harbor facilities

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Our first thoughts on ‘the island’.

- Governments aim at large volumes of renewables
  - Climate change
  - Security of supply
  - Reduction of fossil reserves

A new idea was born:
the Energy Island

- Offshore wind energy is key element in RES policy …
  - Offshore wind energy has largest potential in The Netherlands (as in other North-western European countries)
  - Our country is well-known for its offshore industry
- … which requires smart measures for integration
  - Flexibility of power generation mix, demand side management, improved cross-border cooperation, or …
  - … Electricity storage

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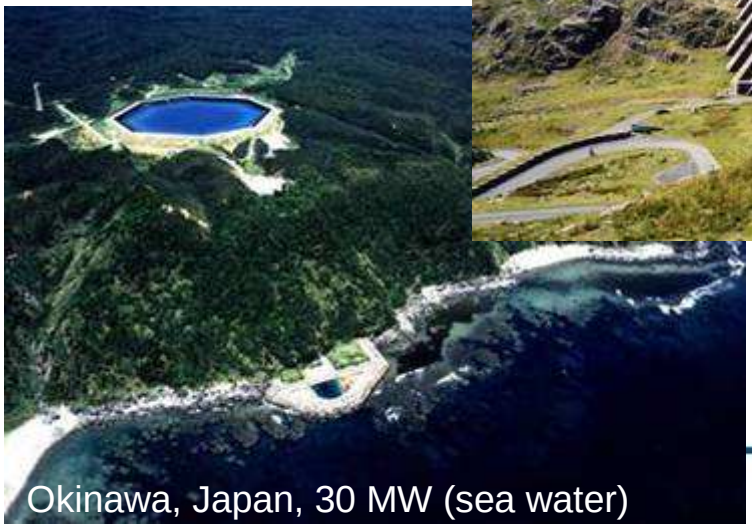
Combination of electricity storage and wind energy seems logical …

- Electricity storage is well-established practice
  - In 1999 the EU had 32 GW capacity of pumped storage out of a total of 188 GW of hydropower and representing 5.5% of total electrical capacity in the EU (90 GW worldwide)
  - Wide variety of (mainly small-scale) storage applications


Okinawa, Japan, 30 MW (sea water)

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… besides storage adds value to the energy sector.

- Decouples supply from demand
- Increases technical reliability of power supply
- Reduces loads on conventional power plants due to less frequent adjustments → less maintenance
- Absorbs unpredicted variations in wind power
- Balances wind during windless or stormy periods
- Provides more flexibility in utilization of conventional power plants
- Stabilizes costs of electricity (peak shaving) and decreases imbalance costs

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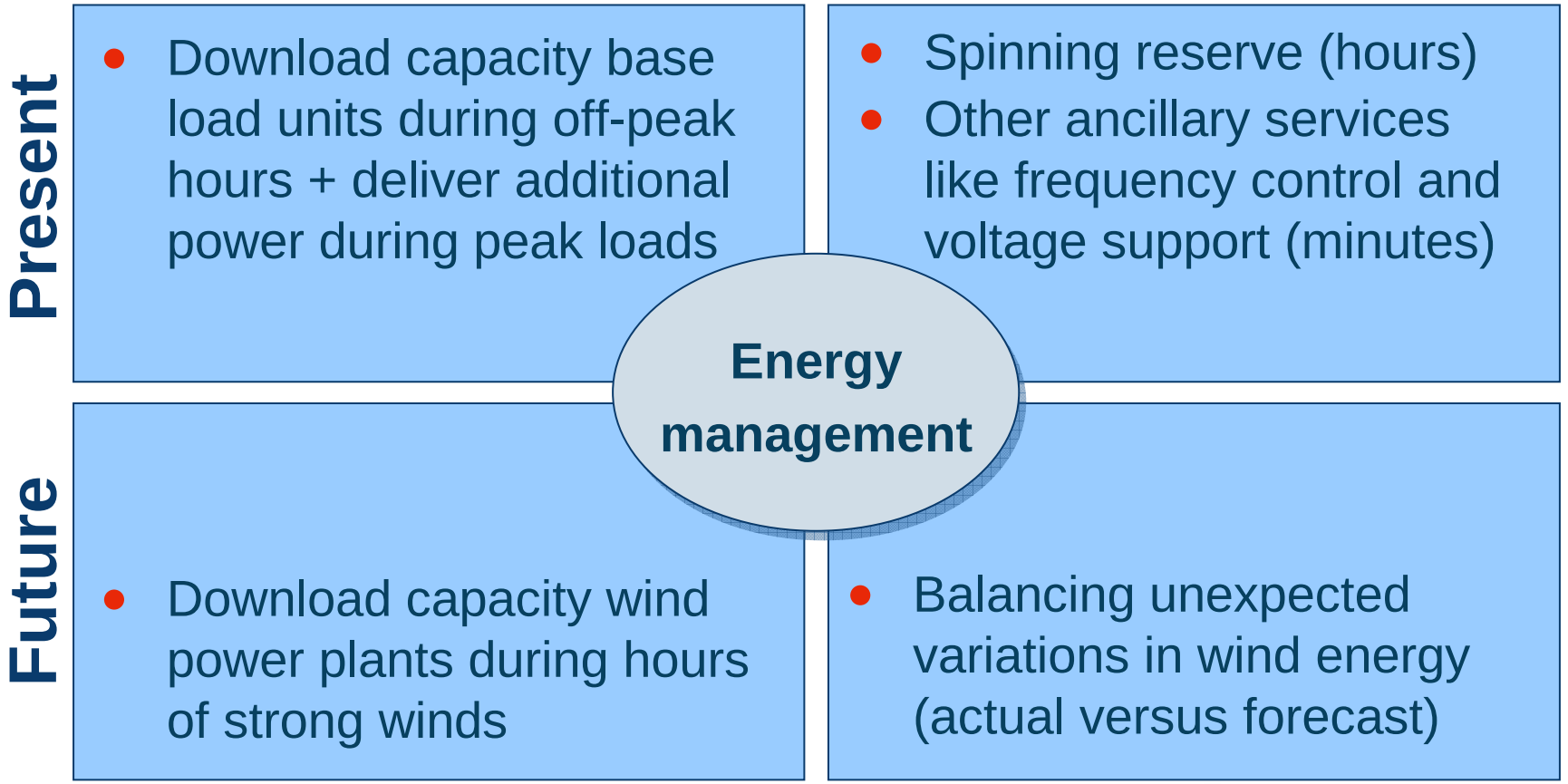
2. Opportunities – first results.

- Optimal size of storage system determined
- Technical feasibility of Energy Island investigated
- Economics large-scale electricity storage analyzed
- Final result: Energy Island is feasible

First study: check technical feasibility and business case of our idea.

- KEMA and Lievense performed study sponsored by
  - Utilities: Delta, Eneco, E.On Benelux, EPZ, Essent, Nuon
  - TSO: TenneT
  - Additional funding: We@Sea
- Goals of this study
  - Determine optimal size of storage system (MW / GWh)
  - Calculate costs of large-scale electricity storage
  - Value system with respect to costs and emission reductions

Optimal size of large-scale electricity storage based on main applications.



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Result for NL

1.500 MW, 20 GWh

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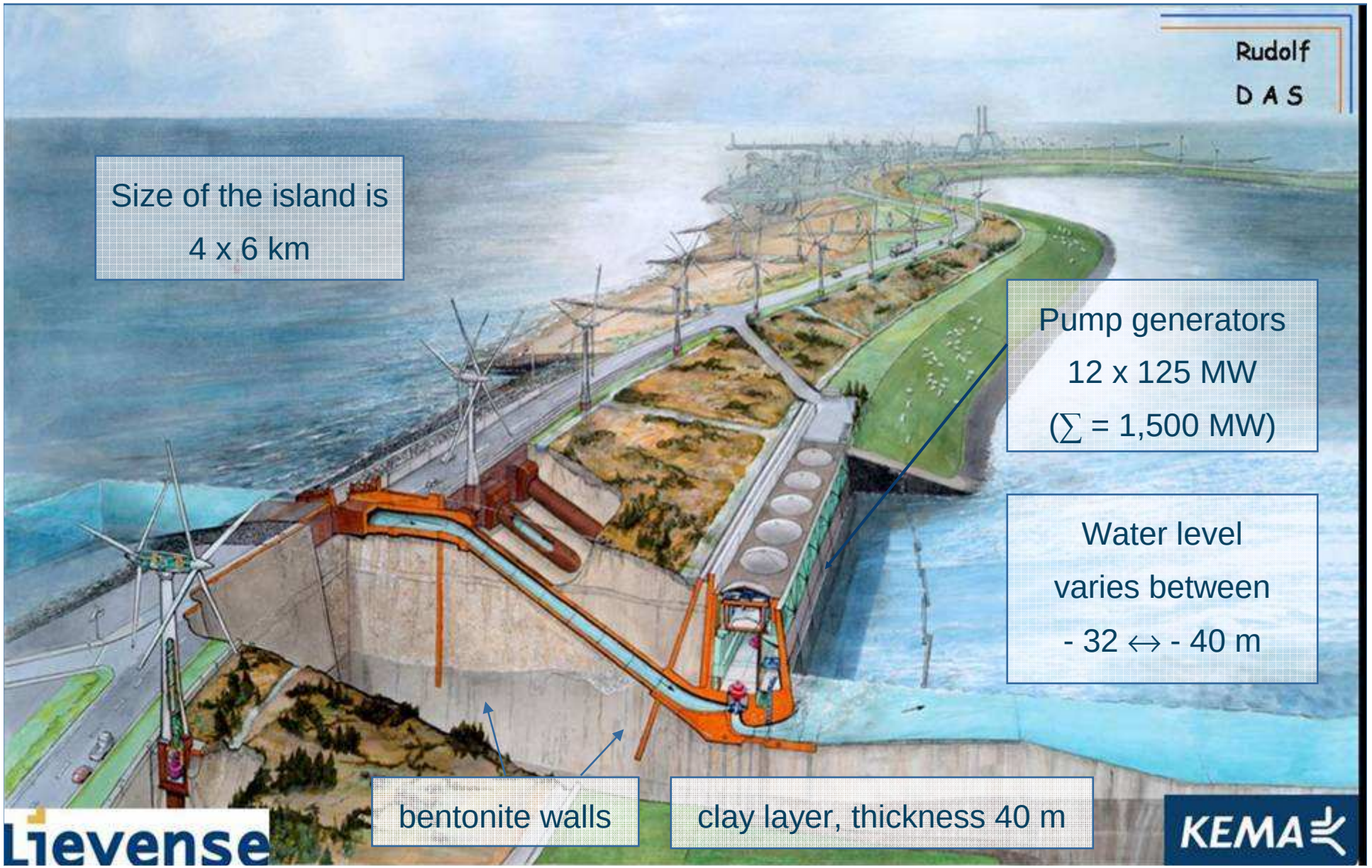
Inverse pump accumulation.



Technical data.

Capacity	20,000 MWh
Power (12 units x 125 MW)	1,500 MW (about 12 hours)
Number of cycles	Max. 1 per day
Efficiency	about 80% (full cycle)
Availability	98% (2% O&M time)
Response time	Sec (normal) to min (cycle change)
Size of the Energy Island	about 8 x 4 km
Distance to shore	25 to 30 km
Water levels	-32 to -40 m
Building time	6 years

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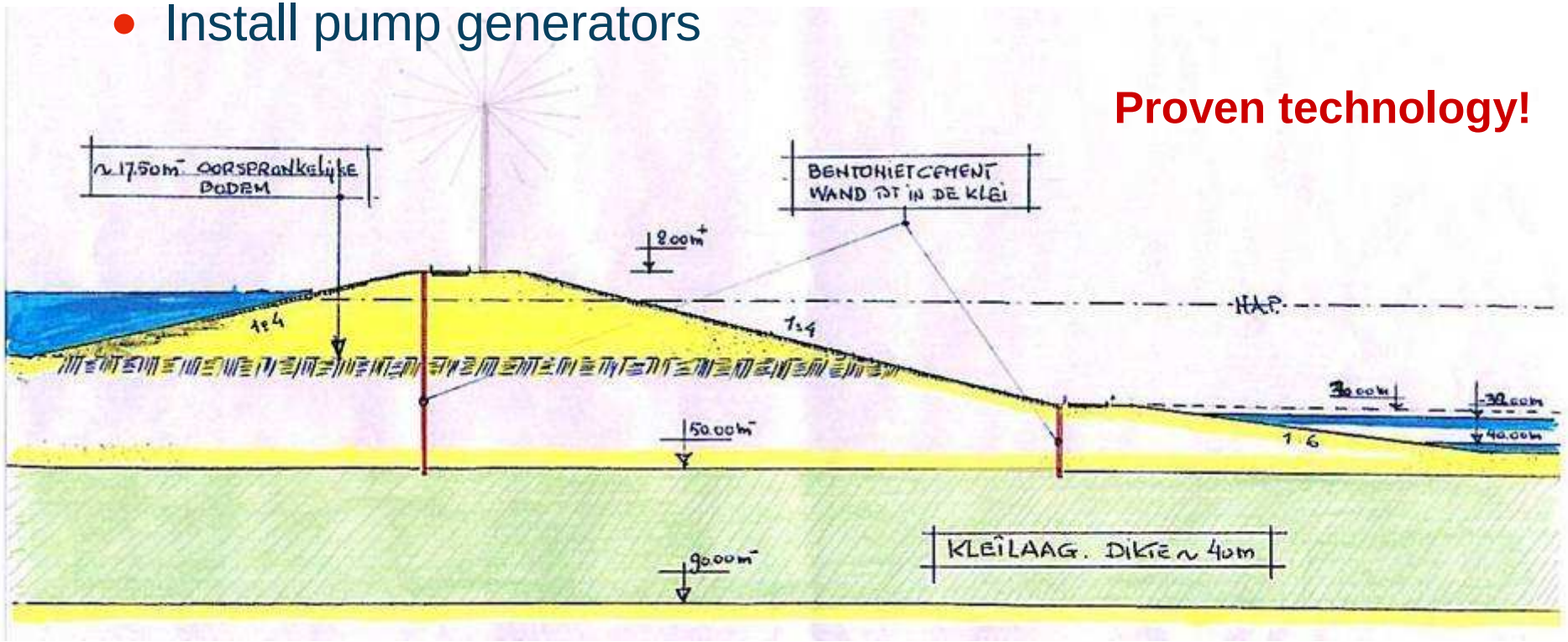
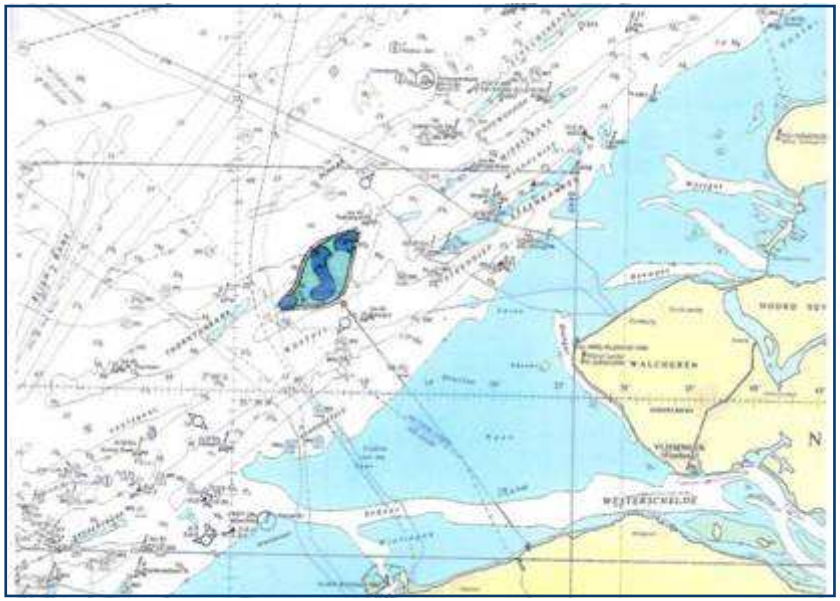
Building an artificial island at the North Sea, a piece of a cake.

- Dredge an open pit an enclose it by a ring of dikes
- Make the island using the sand of the pit
- Prevent water coming into the inner subsurface lake
- Use the surrounding sea as pumped hydro facility
- Install pump generators

Proven technology!



Planned location fulfils requirements.



- ~ 20-30 km from coast line, enough room for the island, acceptable impact on ecology and morphology
- A location with heavy clay at -50 to -90m beneath NAP, able to resist water pressure from aside and underneath
- Fits in governmental policy, and is not too far from HV station to connect to the grid

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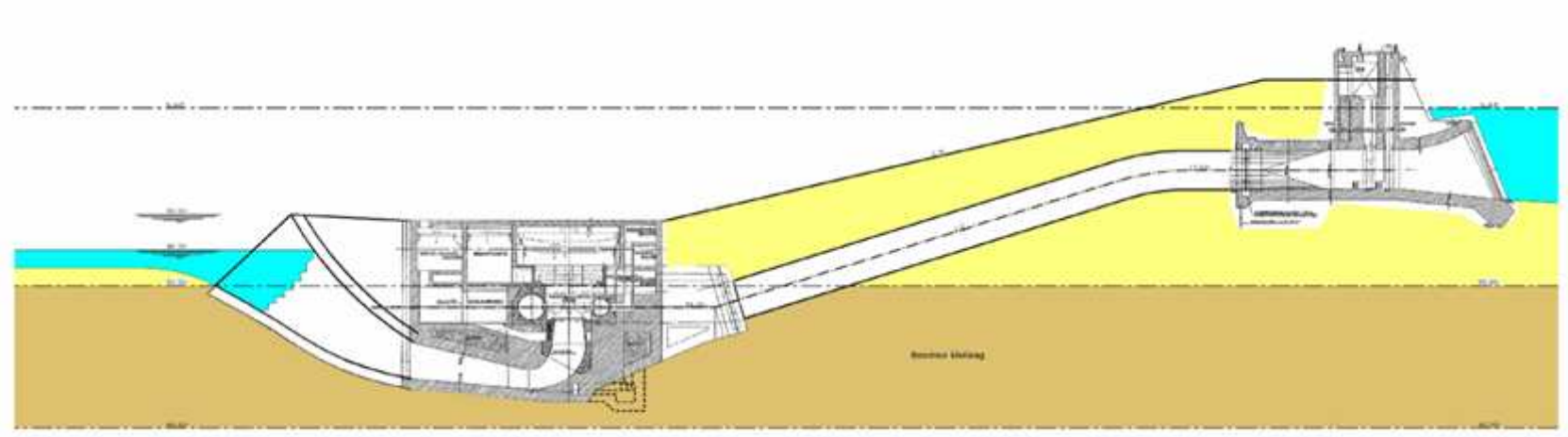
Energy Island is technical feasible.

- Thick clay layer available near the coast of NL
- Offshore industry experienced in creating such islands
- Bentonite walls has been applied in other projects
- Suitable pump generators are available
- First drawings have been made



DOORSNEDE INLAATWERKEN/POMPTURBINEBEHUIZING

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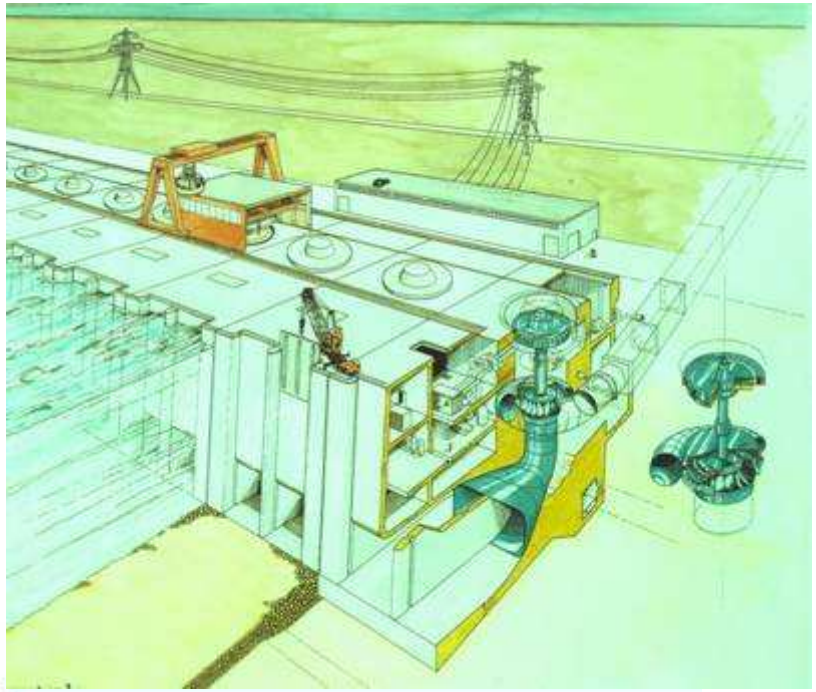
Investments costs based on budget offers and meetings with industry ...

- Dredging: Dutch offshore construction companies
- Pump turbines: Alstom
- Housing of pump turbines: construction companies
- Grid connection: Prysmian and Delta



… provides overview of total investment costs.

- Energy Island, PAC (1.5 GW, 20 GWh)
  - Dredging EUR 0,65 billion
  - Building pit EUR 0,15 billion
  - Housing of pumps etc. EUR 0,90 billion
  - Pump generators etc. EUR 0,50 billion
  - HV cable + grid connection EUR 0,25 billion
  - **Total costs** **EUR 2,45 billion**

- CCGT
  - EUR 500 per kW **EUR 0,80 billion**

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Input data economic analysis agreed upon after consultation with clients.

- Input data, scenario 2020
  - 9 GW of wind power
  - 20 GW of conventional power, mainly coal
  - Coal price EUR 2.1 per GJ
  - Gas price EUR 5.0 (low) to 7,9 (high) per GJ
  - CO_2 emission price EUR 20 per ton
- Base case: no storage capacity and no wind
- Second series with 1,500 MW of storage, no wind
- In other scenarios wind is included
- Storage systems replaces peak-load CCGT plants

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Large-scale energy storage reduces operational costs + CO_2 emissions.

- Annual costs and CO_2 emissions calculated with ProSym

Low price scenario	Cost savings (million EUR/yr)	Reduction of CO2 emission (kton/yr)
1,500 MW / 20 GWh	94	840 (2.5%)
2,500 MW / 30 GWh	96	640 (1.9%)

High price scenario	Cost savings (million EUR/yr)	Reduction of CO2 emission (kton/yr)
1,500 MW / 20 GWh	167	500 (1.5%)
2,500 MW / 30 GWh	190	350 (1.0%)

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Summary of our business case.

Energy Island: costs saving and CO_2 reducing

Input data (2020)	**Results**
9 GW wind power	1,500 MW / 20,000 MWh storage
20 GW centralized power plants	1.5-2.5% less CO_2 emissions [1)]
2% annual growth electricity demand	
Coal: EUR 3.0 / GJ Gas: EUR 5.6-8.5 / GJ (both including EUR 20 per ton CO_2)	Investment costs Energy Island: EUR 2,45 billion incl. dredging costs EUR 1,80 billion excl. dredging costs (EUR 1,65 or EUR 1,00 billion more compared to investment 1,500MW CCGT)
Exclusive import capabilities	EUR 80 – 130 mio annual costs saving [2)]
Economic life time: 40 years WACC: 6.4%	NPV: EUR 0.8 billion (excl. dredging costs, high gas price)

1) Download of coal increases emission as it replaces gas, download of wind reduces emission. In our business case the net result is reduction of CO2 emission

2) Compared to operating energy system with additional 1,500 MW CCGT power plant

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Secondary functions of Energy Island.

- The Energy Island offers opportunity for various additional functionalities
  - **Energy**
    - Wind energy on the island
    - Aquatic biomass in the subsurface lake
    - Biomass power plant + harbour for biomass
  - **Industry**
    - Harbours and port facilities, e.g. maintenance and assembly offshore wind turbines
    - LNG terminal
  - **Societal values**
    - Aquaculture + nature
- These functions should be able to lower required investment costs thanks to additional yearly earnings

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3. Social feasibility.

- Positive response from various stakeholders
- Value and necessity of LSES, a knotty problem
- Energy storage is becoming a board room topic …
- … and still patience and perseverance is required

Social feasibility – Positive feedback.

- KEMA and Lievense have visited departments, provinces, interest groups and many others to inform and to discuss results of first study
- Many invitations received for key note speeches, interviews and panel discussions in NL and abroad
- In general we received very positive feedback and discussions created enthusiasm in the audience
- Some interest groups added some critical remarks which will be taken into account in the next phase

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Pros and cons of the Energy Island.

Advantages of Energy Island	**Disadvantages of Energy Island**
Regulating and spinning reserve power	High investment costs
Trading opportunities	Political and societal issue → long-lasting until realization
Growing volume of wind power increases value of storage system	Energy losses: around 76% round trip efficiency
More interesting than investment in CCGT + adds flexibility in usage of portfolio of power plants	More CO_2 emissions if only used for download coal during off-peak hours
Wide range of secondary functions possible → reduces investment costs storage system (next slide)	Industrial activities create higher economic value, however nature creates higher societal value
Showpiece of The Netherlands (brand)	Several risks (next slide)

Risks of the project.

- **Technical risks**
  - Clay layer may not be large or not stable enough
  - Pump turbine generators might be hard to build in clay layer
- **Financial risks**
  - Investment costs could be underestimated
  - Annual cost savings might be lower than expected
  - No investors for secondary functions → investment too high
  - Other solutions could be available to incorporate fluctuating wind power in the European electricity system
- **Other risks**
  - Politicians will not cooperate in the permitting process
  - Societal resistance will cause very long permitting process

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Current status – Political attention.

- Prime Minister Balkenende during top conference ‘Winnen met Water’ (February, 2008): “We have to think big, simply because the social issues that we have to deal with are big”
- Multifunctional energy island on agenda of Innovation Platform …
- … and mentioned in EZ’s Energy Report 2008
- Besides, a location study (quick scan) has been performed by Deltares for Ministry of Transport and Communications

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Current status - Market parties ready to define business case.

- KEMA and Lievense initiated Energy Island project and defined extensive feasibility study (Phase 2)
- Meetings with CEO's of Dutch utilities and TSO: willing to invest if government shows commitment and if usefulness and necessity of large-scale energy storage (LSES) has been proved
- Ministry of Economical Affairs 'shows' commitment
- LSES not completed yet, seems to be a knotty problem with many variables and uncertainties
- Doing nothing will result in giant curtailment, and increased interconnection will hardly contribute

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Next step – proposal phase 2.

A. Business case: detailed calculations of economic value of electricity storage under various conditions
B. Detailed location study, including clay layer stability
C. Alternative for the construction of pump-generators in this clay layer, and other technical issues
D. Modelling the shape and size of the Energy Island, including morphology and environmental impact
E. Examination of possible market and ownership structures for large-scale storage facility
F. Assessment of secondary functions on the island
G. Social, administrative and political feasibility

Spin off ideas and projects created.

- Impact of Large-scale Energy Storage (TP DEV)
- Tulip at the North Sea (Innovatieplatform)
- Harbor at Sea (We@Sea)
- Value and necessity of Large-scale E-Storage (Utilities + Energy Council)

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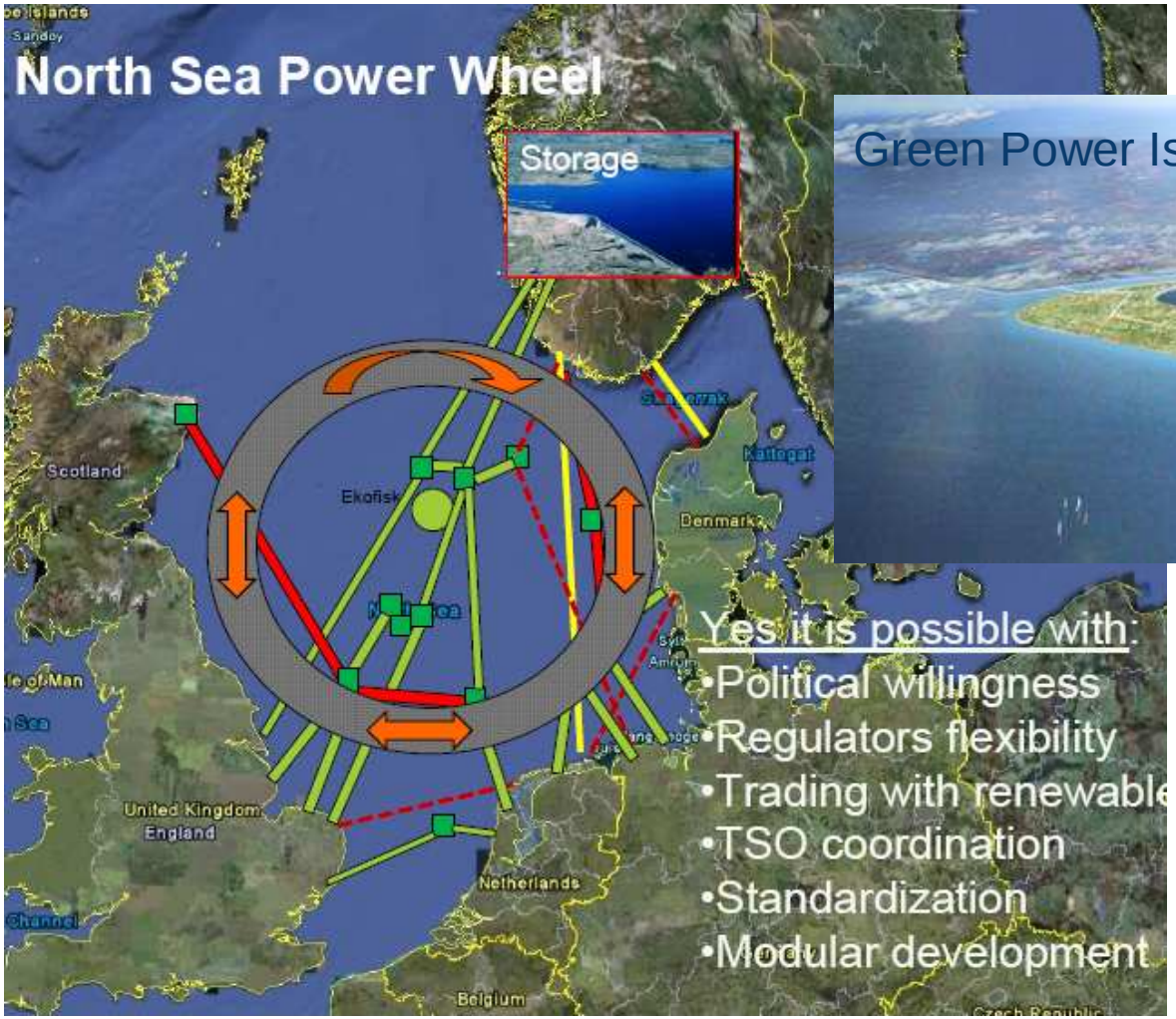
Others have similar ideas.



Yes it is possible with:

- Political willingness
- Regulators flexibility
- Trading with renewable
- TSO coordination
- Standardization
- Modular development

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Combine strengths of offshore industry with wind energy business and electro-technical expertise.

Thank you for your attention.

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