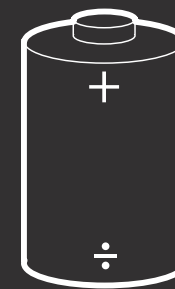
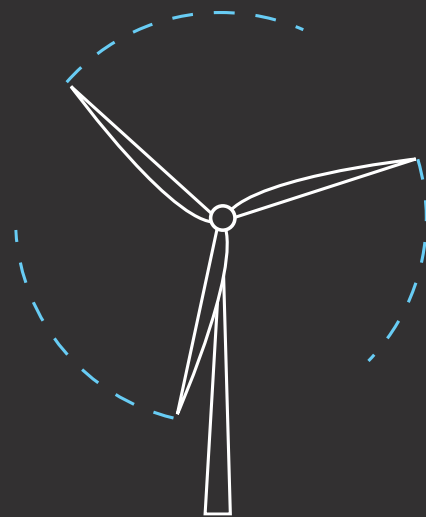




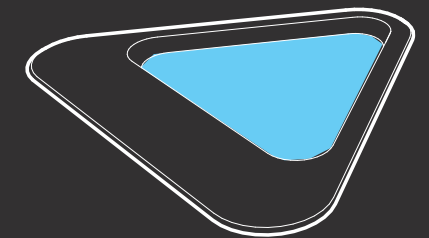
GREEN POWER ISLAND DENMARK

**GOTTLIEB PALUDAN ARCHITECTS
RISØ-DTU**

**- the instant and low tech answer
to the growing problem of green
energy overflow**



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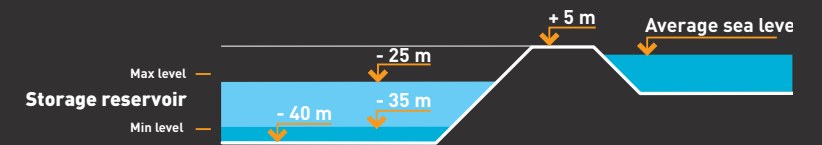


Pumped hydro

Definition:

"Pumped storage hydroelectricity is a type of hydroelectric power generation used by some power plants for load balancing. The method stores energy in the form of water, pumped from a lower elevation reservoir to a higher elevation. Low-cost off-peak electric power is used to run the pumps. During periods of high electrical demand, the stored water is released through turbines. Although the losses of the pumping process makes the plant a net consumer of energy overall, the system increases revenue by selling more electricity during periods of peak demand, when electricity prices are highest. Pumped storage is the largest-capacity form of grid energy storage now available."

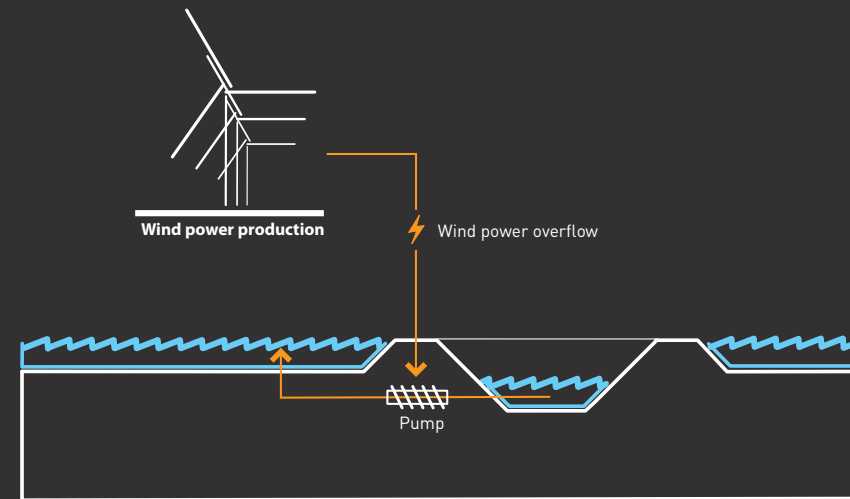
Wikipedia



Green Power Island WATER LEVELS

Perspective

Denmark consists of islands, water and wind. As Denmark moves towards a cleaner and greener energy system, wind power is taking its natural place as the main contributor of renewable energy. As a result, several large wind power plants, mainly at sea, are currently under construction or in the planning process and more will follow.



Storing wind power when demand is low, by emptying reservoir

Challenge

Wind is an unpredictable and uncontrollable natural force and subsequently constitutes an unstable energy source. Therefore the fluctuations of wind power production are inevitable and cannot be calibrated to match the variations in energy consumption. As a result, the wind turbines produce excess power in periods of low demand - known as energy overflow. In situations of high demand, on the other hand, the wind power capacity is insufficient to cover the need for energy. This problem already exists and will only increase as we rely more and more on wind power as a cornerstone in our future energy production.

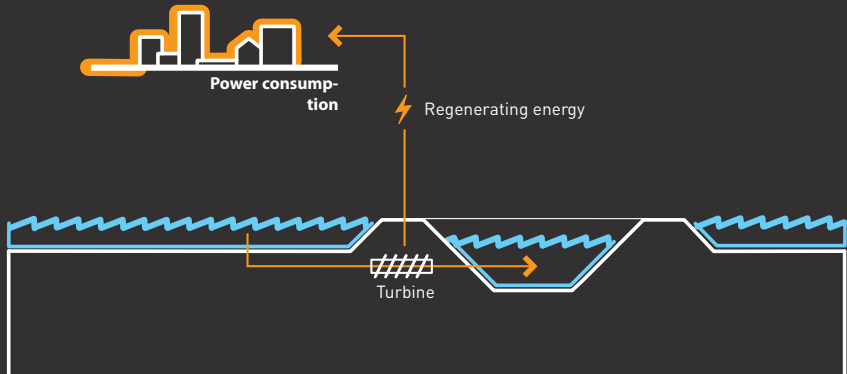




Solutions

In order to even out the mismatch between demand and capacity, existing and future wind farms can be combined with a number of Green Power Islands that are able to store the excess energy in pumped seawater and by means of turbines release the energy when needed. Green Power Islands have the potential to:

- Store and regenerate renewable energy in large quantities and hereby secure that the growing amount of excess wind power is accumulated within the energy system.
- Rapidly regenerate renewable energy at peak hours - also when the wind is down - and thus secure that supply and demand match each other.



Regenerating power through hydro turbines when demand is high.

Interacting with emerging technologies - such as power storage in electric car batteries and a more intelligent distribution system - Green Power Islands are the instant and low tech answer to the growing problem of green energy overflow.

The introduction of a flexible technology like *pumped hydro* on the Danish energy market on a large scale will also allow for the traditional CHP plants to run at constant full capacity, as the Green Power Islands are much better equipped to handle the short term fluctuations in energy consumption.

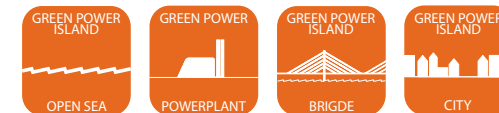
Location, Size, Function

Green Power Islands are atoll-like artificial islands that fill with seawater and hereby produce energy by hydro power techniques when demand is up. In times of energy overflow from wind turbines, the islands utilize this energy to empty again - and thus get ready to produce again.

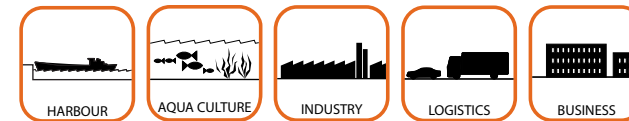
Depending on the specific functions and the focus on production or peak hour-regulation, the islands can be placed either at open sea, in connection with large infrastructural projects or in the vicinity of larger cities.

The islands may vary in size from approx. 1.5 to 45 km² with energy reservoirs ranging from approx. 800 MWh to 35,000 MWh. Depending on location and size, the islands house supplementary and symbiotic functions that fall into different categories and focus areas.

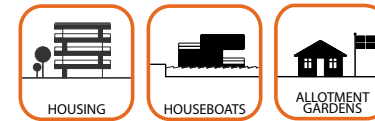
Context



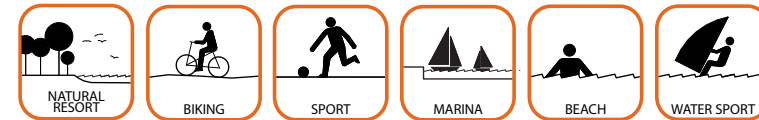
Business



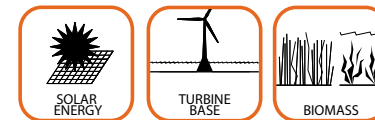
Living



Leisure



Energy

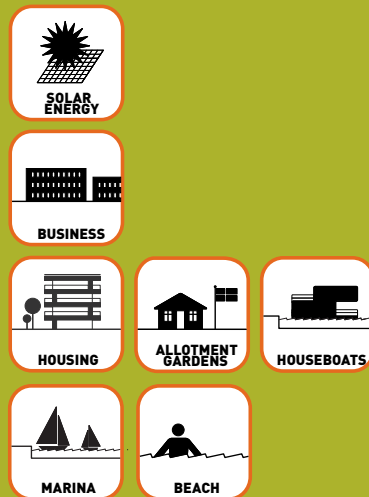
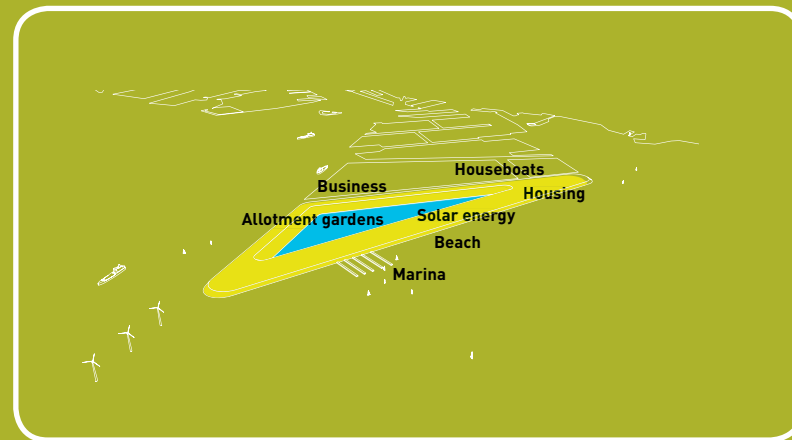


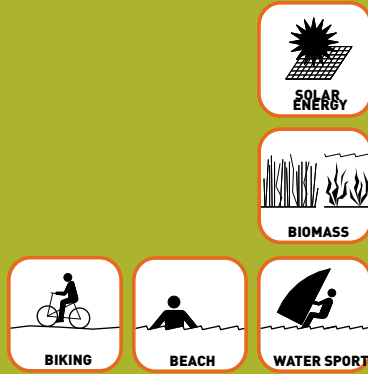
Nordhavn

Total area 1,5 km²

Storage capacity 440 mWh

The island is suggested to be part of a planned, future sustainable neighbourhood in Copenhagen. The Nordhavn island has a size and storage capacity that match the local needs, by providing 130.000 inhabitants with renewable energy for 24 hours.

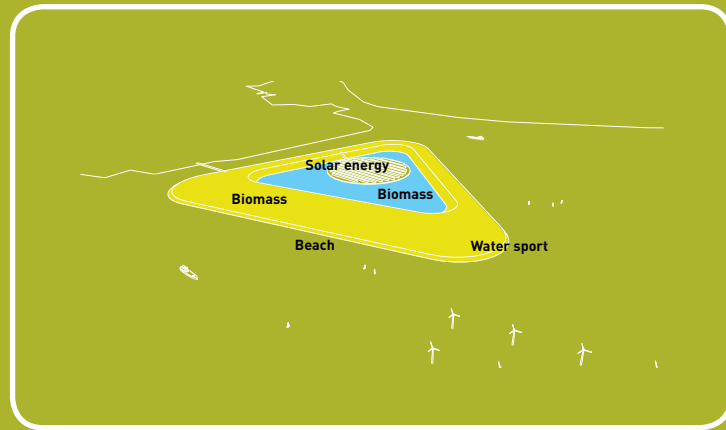


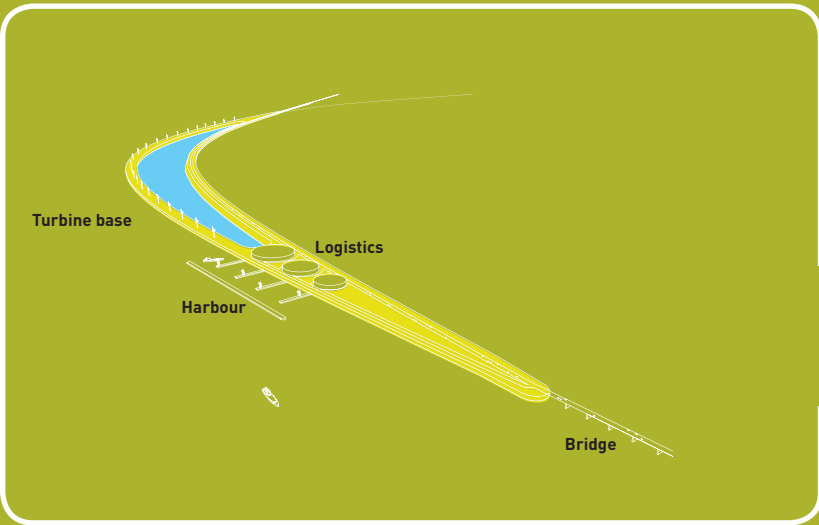


Copenhagen

Total area 4,9 km²
Storage capacity 2300 mWh

The island is placed on the outside of an existing artificial island near Copenhagen, in close connection with one of Denmark's largest and most efficient power plants.

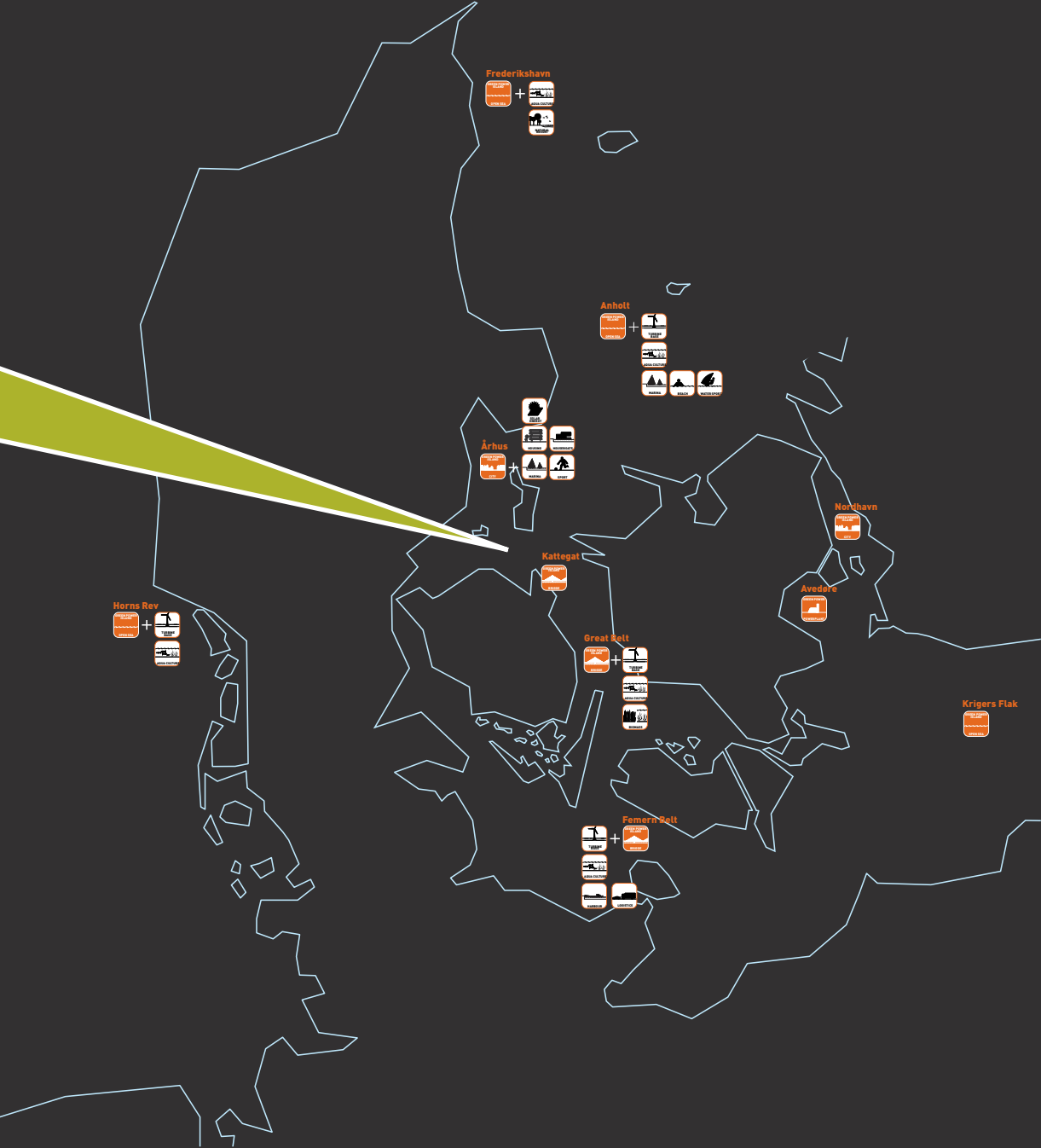




Kattégat

Total area 14 km²
Storage capacity 6700 mWh

The island is part of the future traffic connection between Zealand and Jutland across Kattégat. The island is placed directly south of Samsø - the island internationally renowned for its renewable energy- and establishes a junction with Samsø's own sustainable transportsystem.



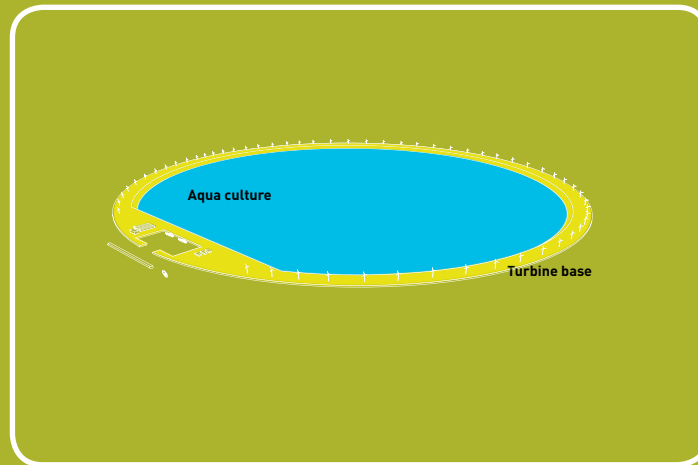


Kriegers Flak

Total area 44 km²

Storage capacity 34.000 mWh

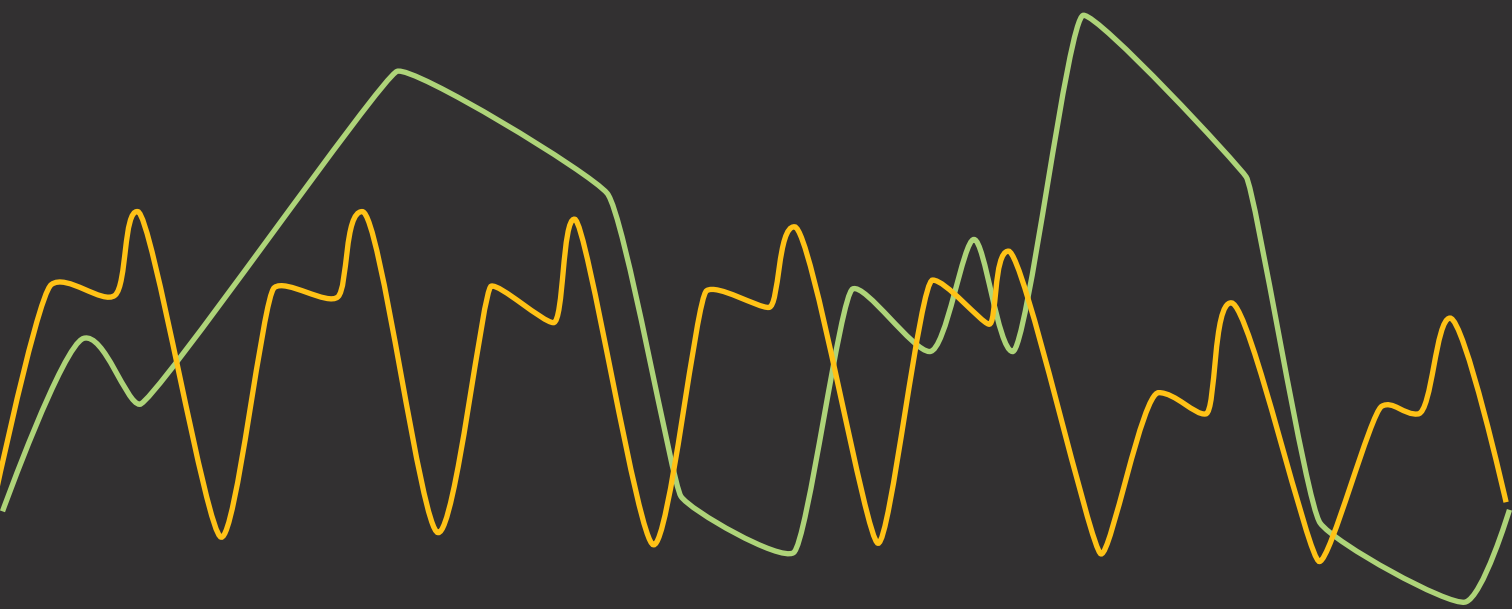
The island is placed at a future energy production and -distribution junction in the Baltic Sea at a place where Danish, German and Swedish wind power plants as well as electricity grid connections between the 3 countries is currently being planned. The open sea-situation permits for a very big island.





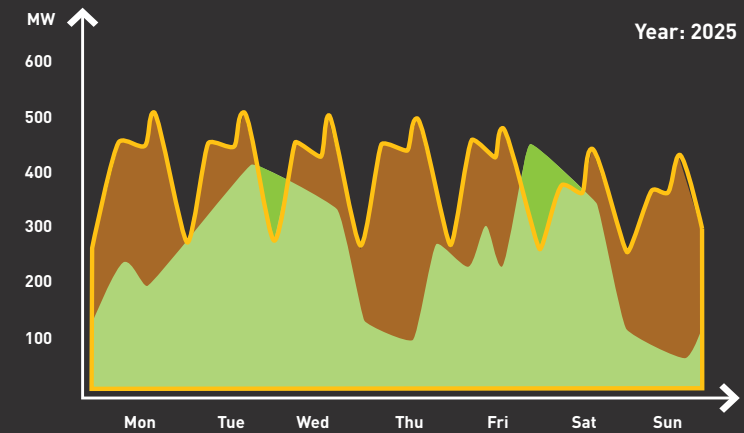
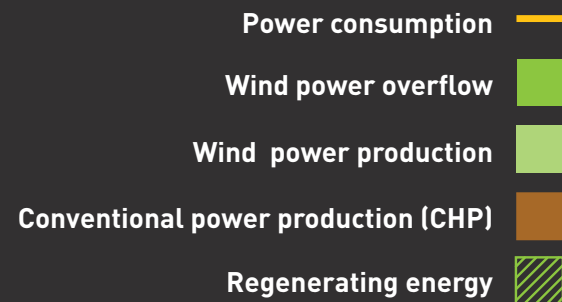
Why is Green Power Island such a good idea?

- Green Power Island addresses the growing problem of green energy overflow created as we move towards an energy system based on renewable energy sources.
- Green Power Island is based on known technology and can be constructed right now - no "rocket science" is needed.
- Pumped hydro is the most cost-effective means of storing large amounts of electrical energy with energy loss down to around 25%
- Green Power Islands can rapidly regenerate renewable energy at peak hours - also when the wind is down - and thus secure that supply and demand match each other.
- Green Power Islands utilize the most abundant and easily accessible resource in Denmark and the world - sea water - to solve an urgent environmental problem.



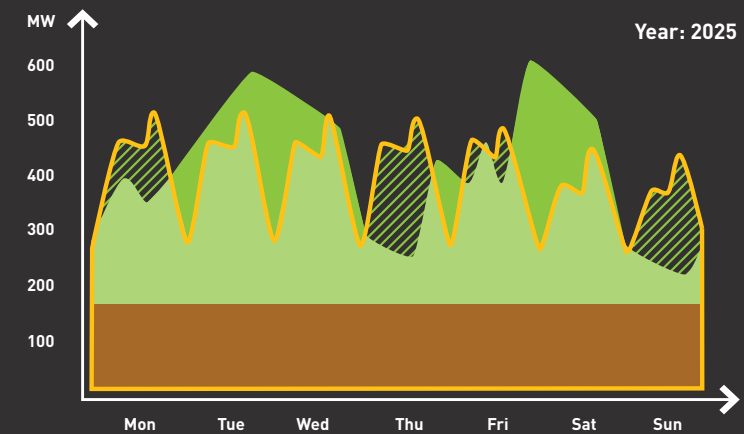
Example

Power consumption and wind production week 3, 2008 for East Denmark scaled to the population of Copenhagen and projected to 50% wind penetration (potentially the situation in year 2025). These data are the basis for scenarios 1 & 2 and are simplified to aid comprehension.



Scenario 1, Traditional energy pattern:

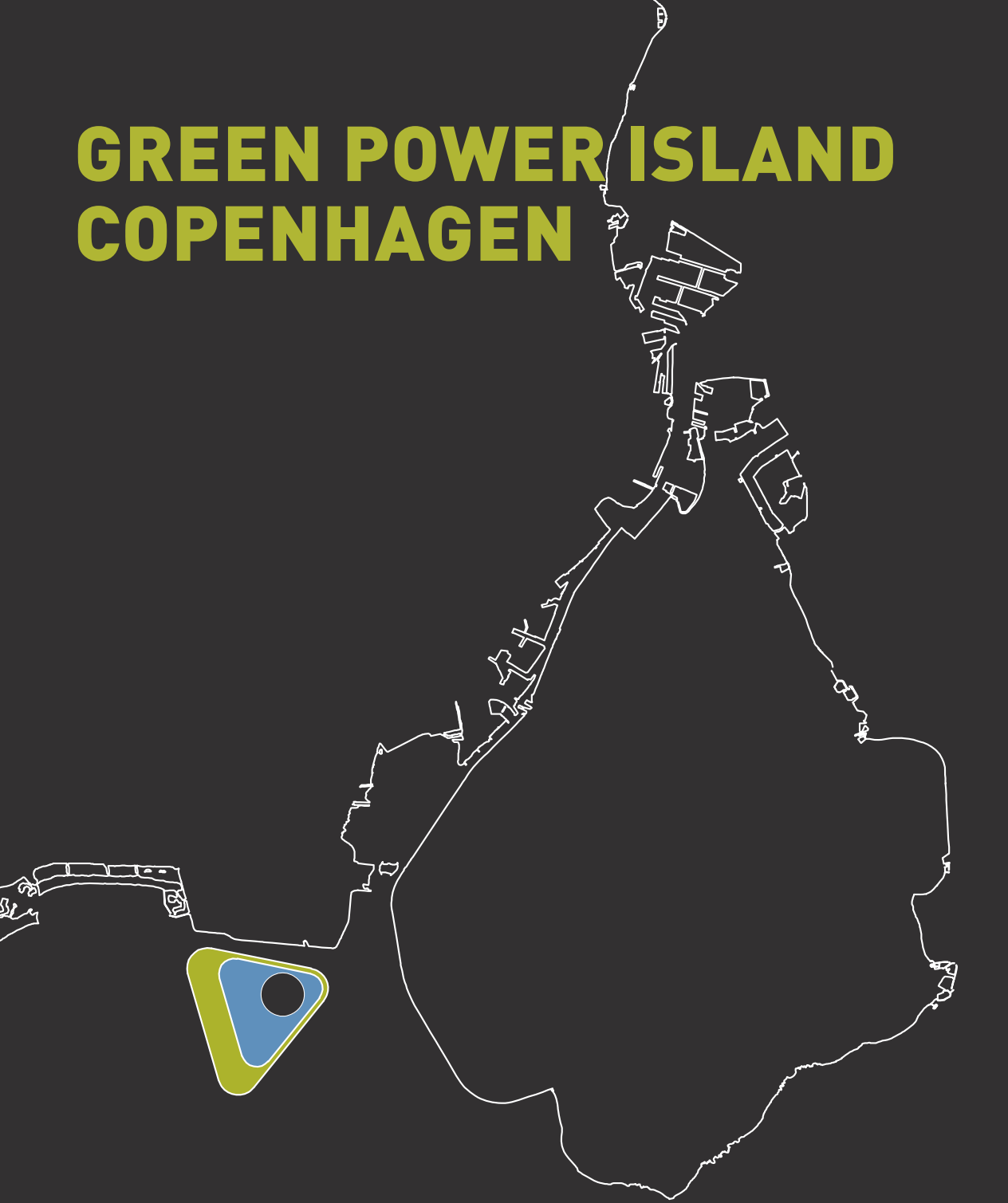
Energy scenario with a combination of wind power, CHPs (Combined Heat and Power plants) and other energy sources - **without** storage possibilities. CHPs must take care of fluctuations in combination with imported energy.



Scenario 2, New energy pattern:

Energy scenario with a combination of wind power, CHPs and other energy sources - **with** storage possibilities in Green Power Islands. Green Power Islands will enable the CHPs to focus on a steady power production because the wind power, in combination with the Green Power Island, is able to handle fluctuations.

GREEN POWER ISLAND COPENHAGEN



Green Power Island Copenhagen

Green Power Island CPH in connection with Avedøre Power Plant (APP), near the city of Copenhagen, enables the gradual transformation of APP from today's conventional energy production to become an integrated and sustainable energy center with

- Hydro storage
- Algae-production for biomass/biofuel, CO₂-cleansing and food ingredients
- Bio fuel crops
- The largest, most efficient solar power station in Scandinavia

Green Power Island CPH covers a total area of 4,9 km² including a water reservoir of 22.000.000 m³ with a generation potential of 2300 MWh of electricity - approx. the equivalent of APP's max capacity for a 3 hour period or the energy consumption of 230.000 households for 24 hours.

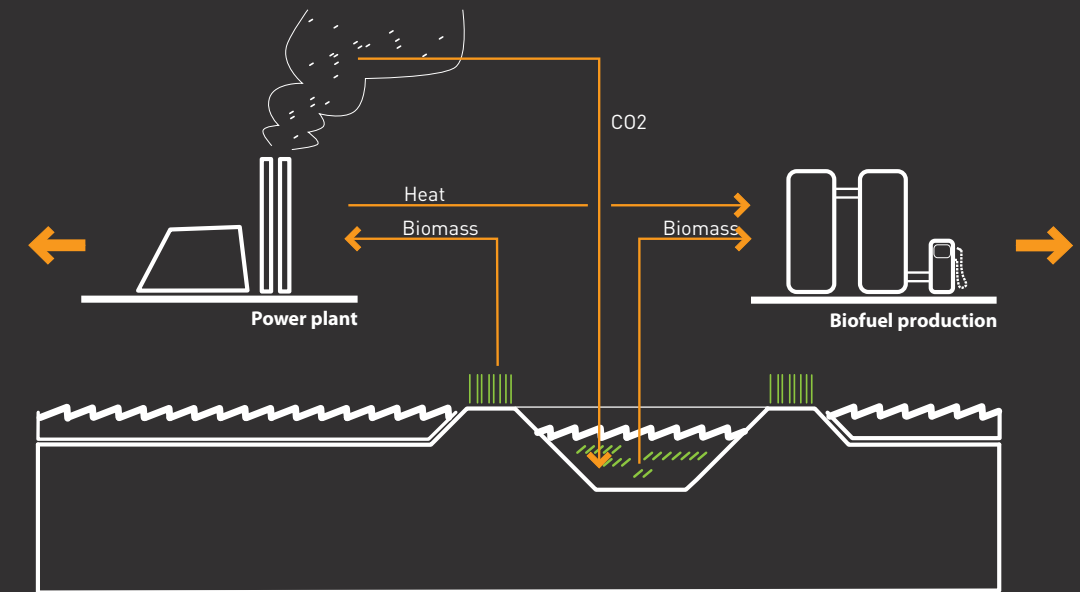
The island stores excess energy from the equivalent of 15 hours' production of 30 5MW wind turbines.

Architecture & Planning

For centuries reclaiming new land has been a way of expanding one's territory and adapting to new challenges - large parts of the city of Copenhagen and its surrounding fortifications have developed in this manner.

Green Power Island CPH is placed on the outside of Avedøre Holme, itself an artificial island housing i.a. the Avedøre Power Plant.

Green Power Island CPH will become a hub for production and storage of renewable energy and a cornerstone in the supplying of power to the Copenhagen area. The island is designed to adapt to its surroundings - the waves, currents and winds as well as to the flat lands of the southern coastal area.



Green Power Island Copenhagen SYNERGIES

Energy storage

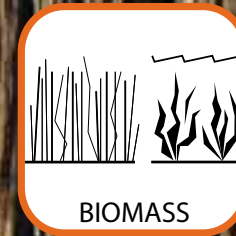
The island's main function is the storing of excess energy from wind power production. The water reservoir of 2.8 km² and 22,000,000 m³ holds a generation potential of 2300 MWh of electricity which is almost the total energy consumption of all the households of Copenhagen for 24 hours.





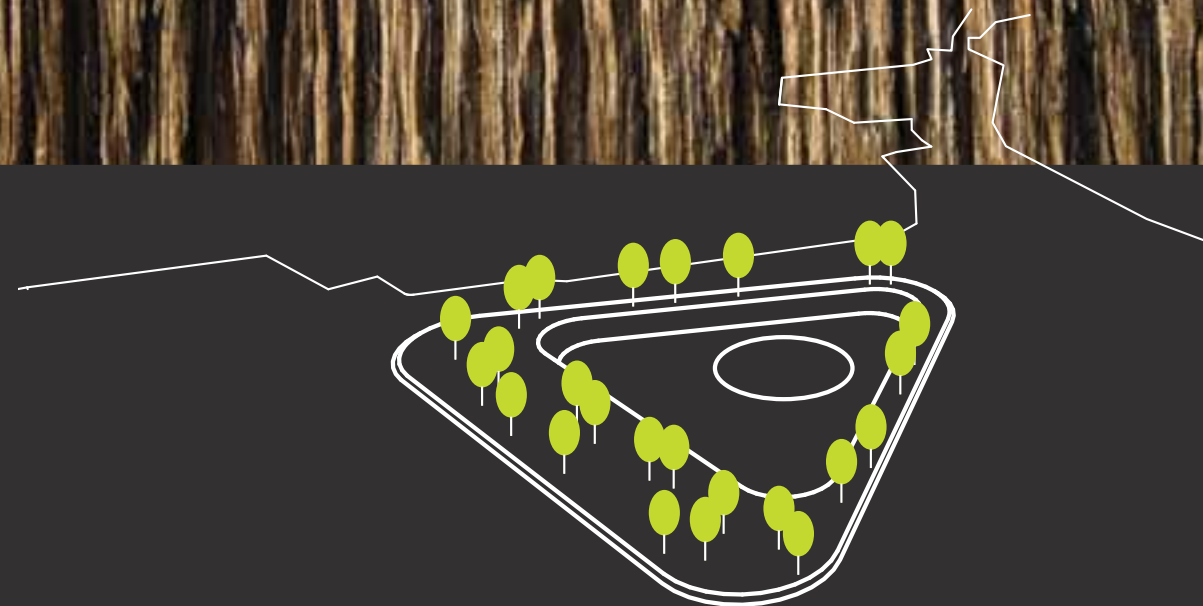
Recreational

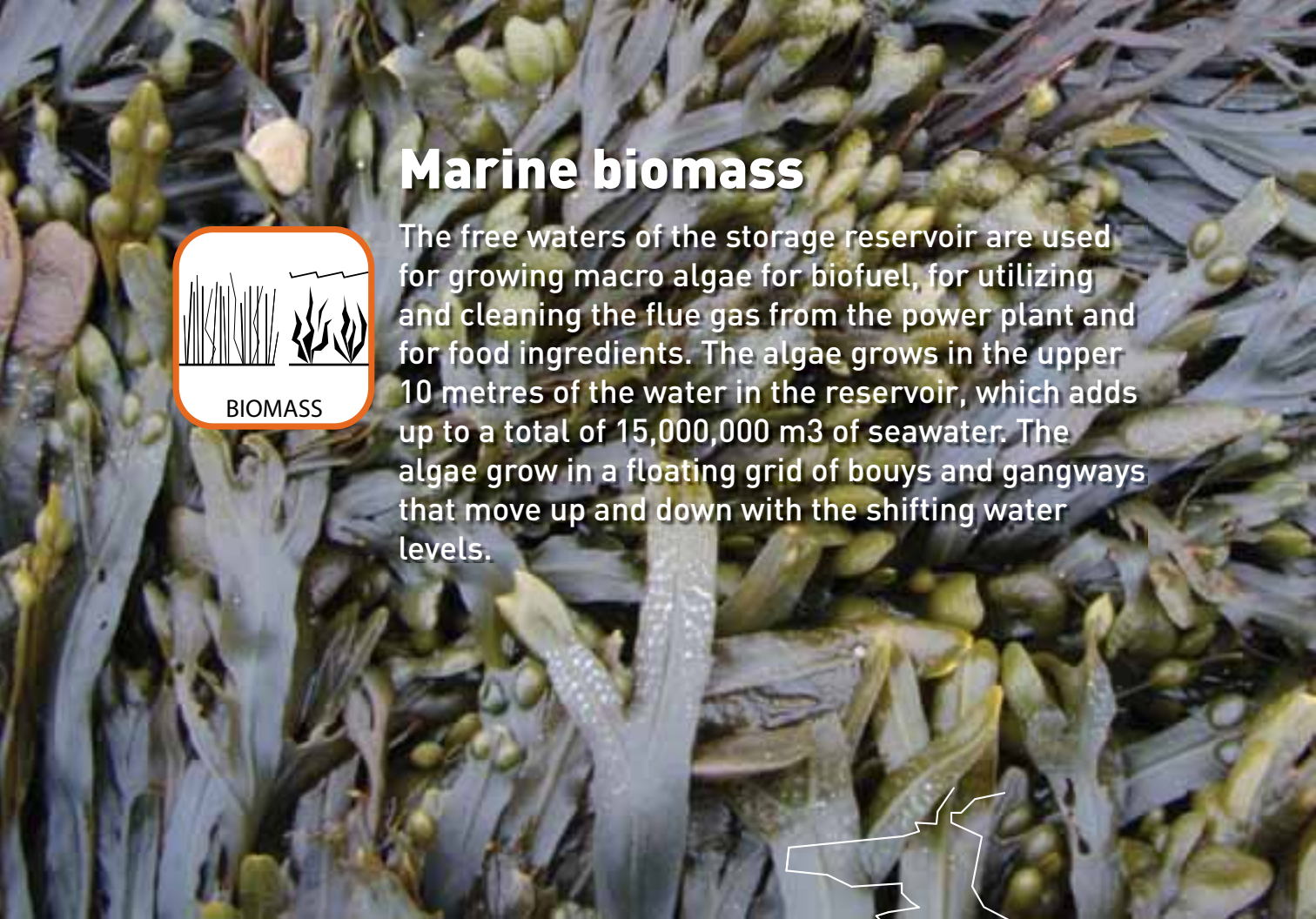
Public access and recreational values on the island are provided for by a bridge connecting the mainland with bicycle- and walking paths on the island. The paths pass through the young willow forest and give way for great views of the surrounding sea and the water reservoir in the centre of the island.



Energy Crops

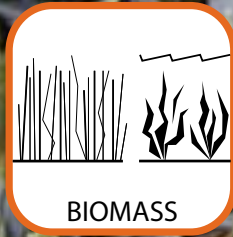
The 2.0 km² surface of the island is allocated to the cultivation of willow for biomass fuel and can potentially deliver the equivalent of 12,000 MWh a year.



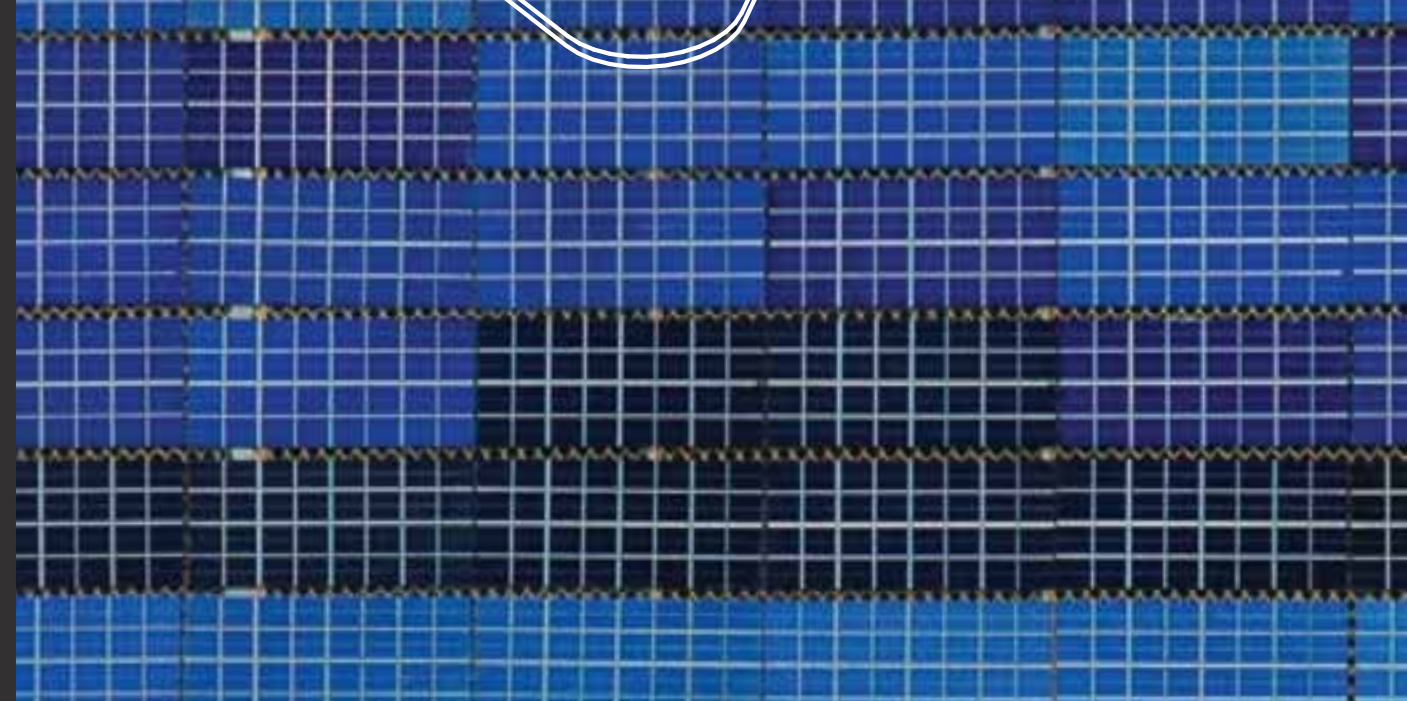
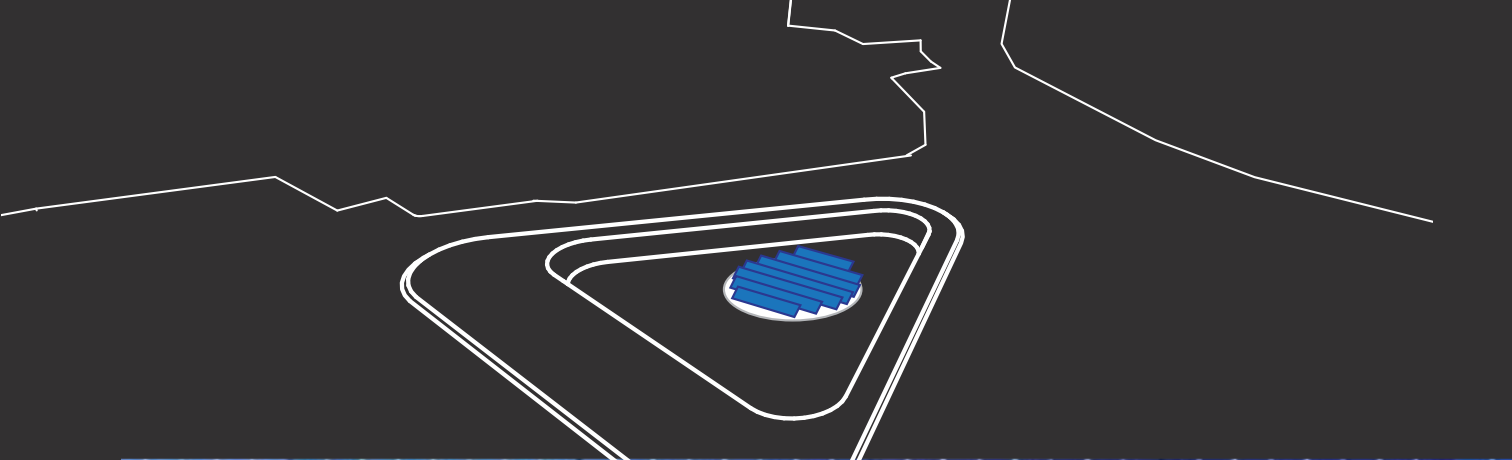
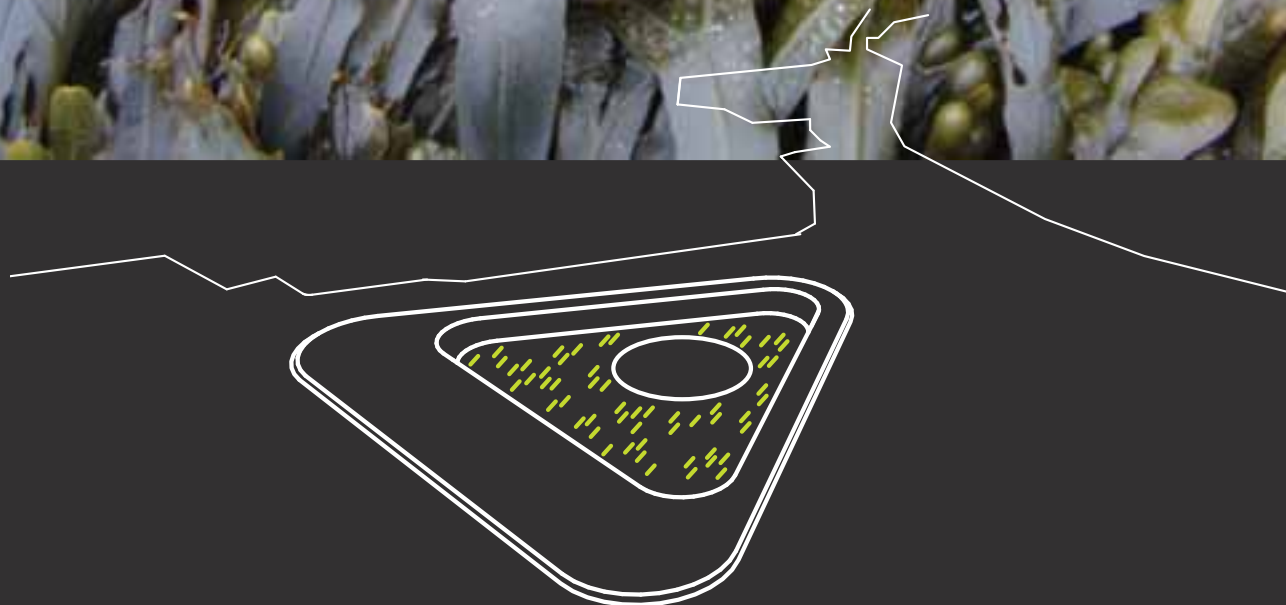


Marine biomass

The free waters of the storage reservoir are used for growing macro algae for biofuel, for utilizing and cleaning the flue gas from the power plant and for food ingredients. The algae grows in the upper 10 metres of the water in the reservoir, which adds up to a total of 15,000,000 m³ of seawater. The algae grow in a floating grid of bouys and gangways that move up and down with the shifting water levels.

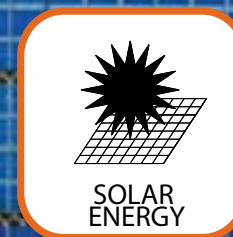


BIOMASS



Solar power

The largest PV solar plant in Scandinavia is placed on an island floating on the surface of the water reservoir. With an area of 0.5 km² and the ability to rotate with the sun, the plant will have a yearly output of approx. 23 GW.



SOLAR ENERGY



A lid on the greenhouse gas emissions requires that the leaders of the world cooperate on and pump money into projects, which in costs are comparable with a lunar landing, declared Danish Prime Minister Lars Løkke Rasmussen on a climate conference in Brussels.

“Let us in each our field pursue new Apollo-like projects so we can bring to reality the full potential of technology,” said the Prime Minister.

In his speech the Prime Minister also set the stage for Denmark increasing the percentage of wind power for power production from today’s 20 percent to 27 percent in year 2020. However, this calls for the ability to control the production.

“Proportionally to the considerable share of wind-generated electricity we acquire, we are forced to solve the problem of storage and peak demand,” said the Prime Minister.

From Ingenøren.dk 18.06.09

**Green Power Island Denmark
is created by:**

**Gottlieb Paludan Architects and Risø-DTU
with support from Danish and international
energy advisors.**

**The project is in its initial phases and further
research and development will include
economical, technical, environmental,
design and other studies done by a number
of parties.**

**Follow the project at:
www.greenpowerisland.dk
www.gottliebpaludan.com**

**Feel free to add comments and suggestions
on our blog.**