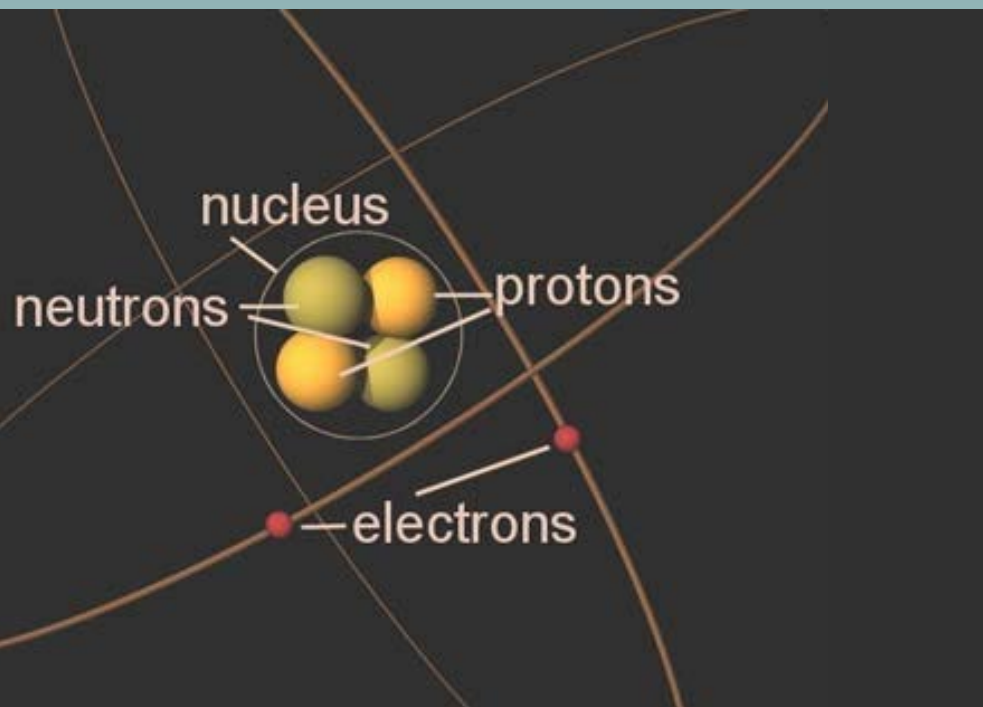


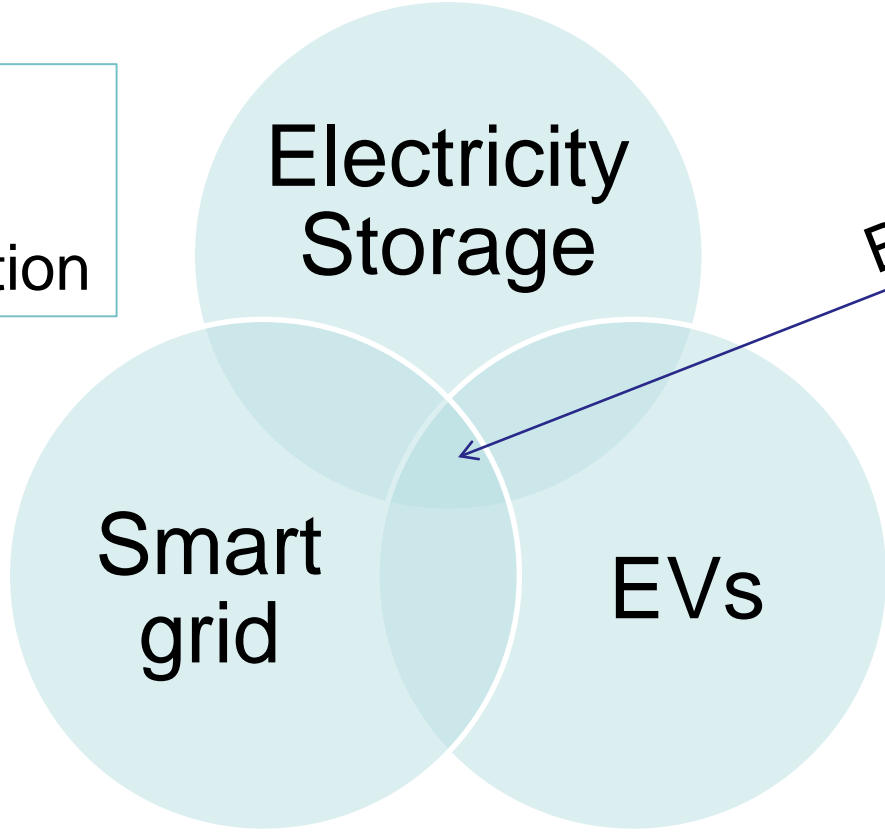
Energy Storage

Frederic Hauge



Overview

- Arbitrage
- Peak shaving
- Home generation



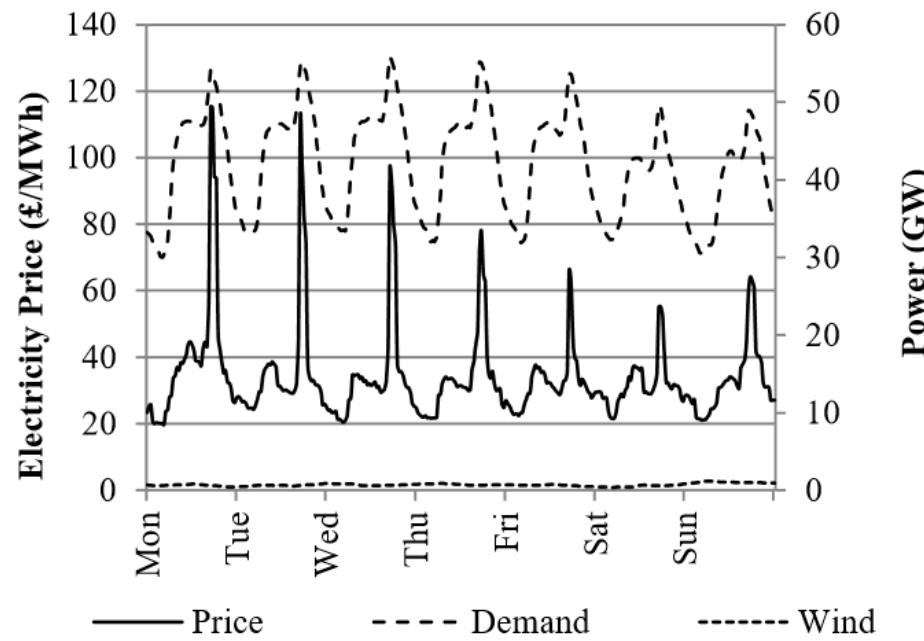
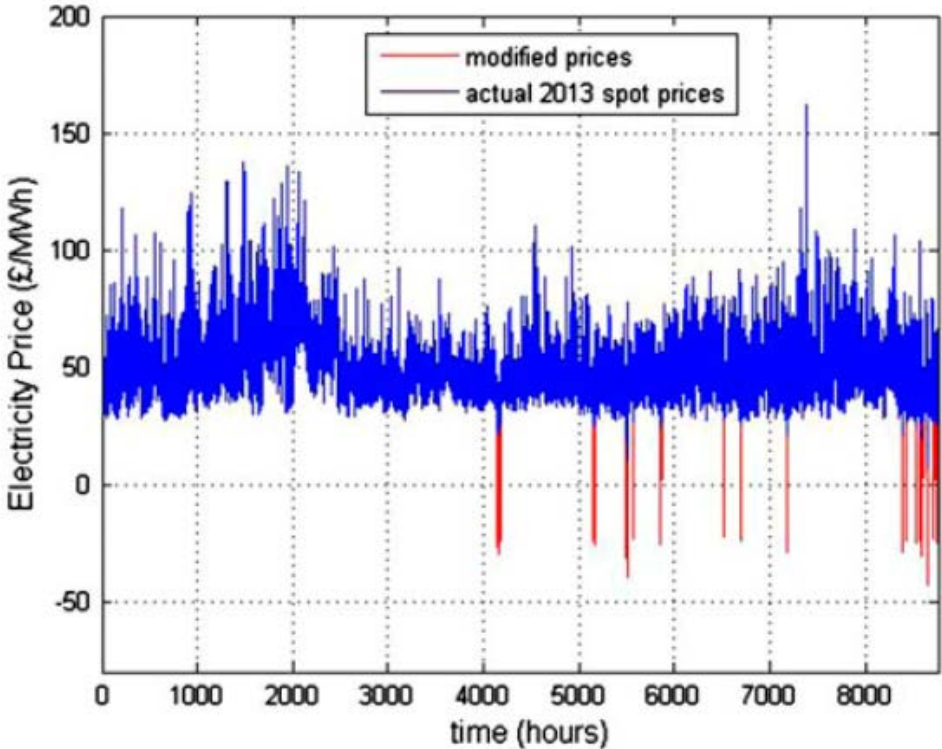
Bellona Messaging
**** COMPLEX ****

- Energy services
- Frequency regulation
- Demand response
- 2-way flexibility

- Subsidised energy storage
- Delinked market

Wholesale (Arbitrage)

Using the original electricity prices for 2013 and again simulating a 75% efficient 200 kWh 50 kW energy storage device, we find the available revenue over the course of the year is £1317.



Source: Can negative electricity prices encourage inefficient electrical energy storage devices?

How Spiky will the electricity market get?

What influences the spiky'ness?

Variable RES will be 30% of electricity generation Europe wide

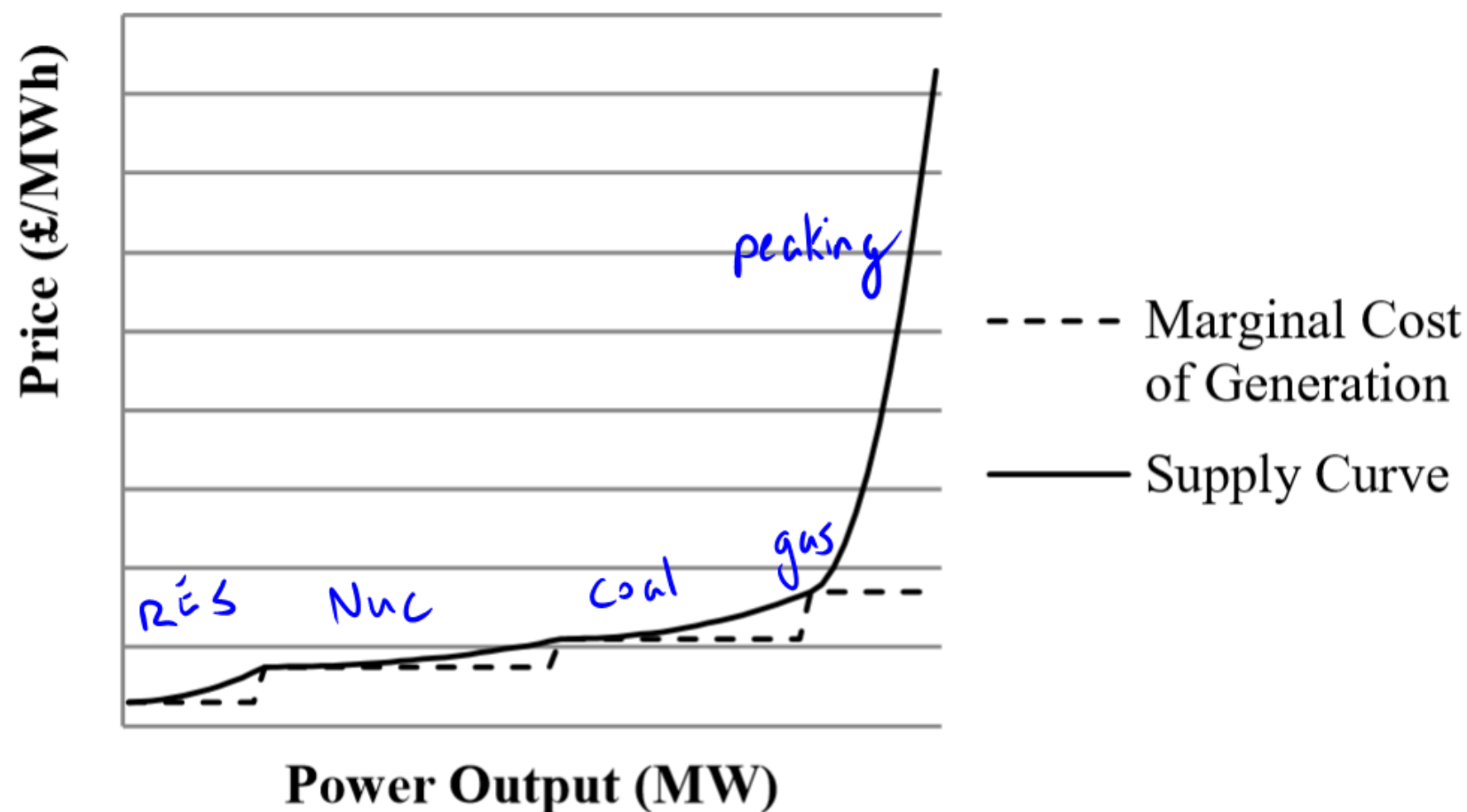
How much ramping this produces in dispatchable plants will be largely dependent on the size of the network –

Large interconnected grids throughout Europe will have less variance

National grids will be much more variable – require much more flexible non RES energy providers

Island example = a windy day energy system and a parallel fossil generation backup system

Shallow or Steep dispatch curve



Steep curve is better for energy storage – large price difference between periods of over supply and constrained supply

- UK may be an example of this post coal phase out (2025). Price jump from RES to Gas

Behind the Meter

Dynamic Pricing & Smart Grids

- Will consumers be given effective dynamic pricing?
- How can consumers benefit from dynamic pricing?
- Local pricing?

Ancillary services

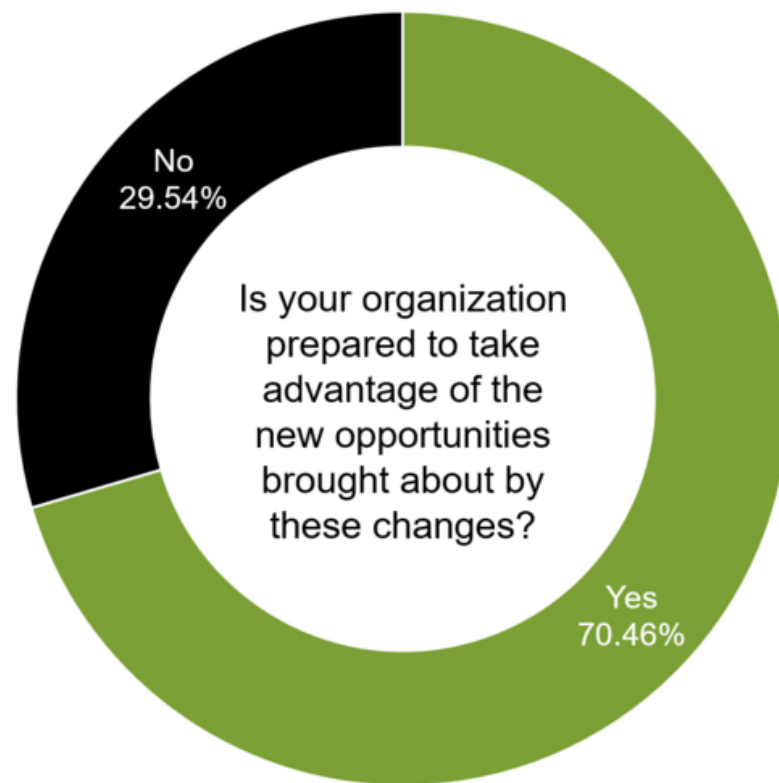
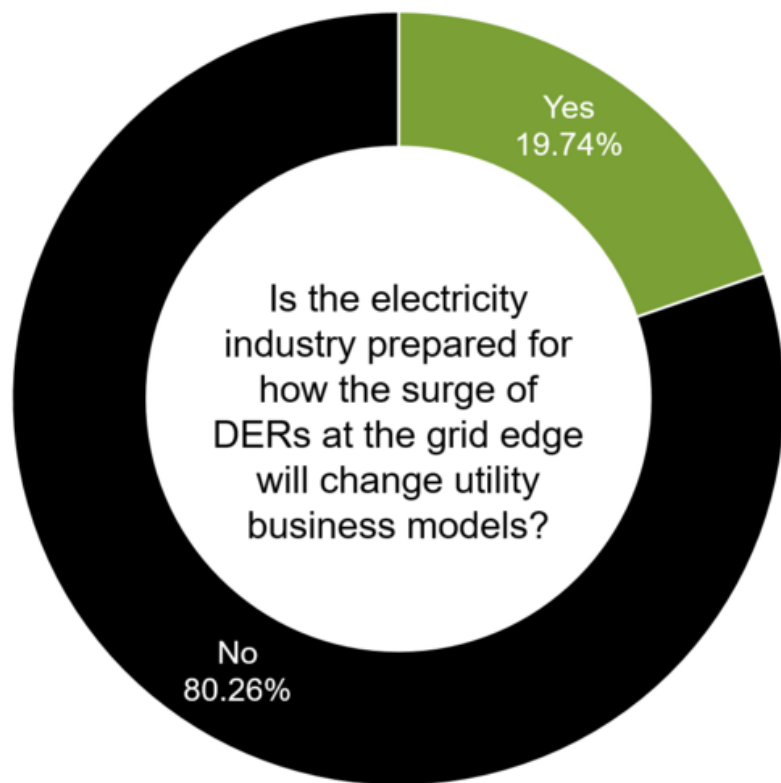
- ERCOT tested a fleet of electric delivery trucks for frequency regulation last year.
- Micro Grids
- Positive and negative flexibility
- Frequency and voltage regulation



Energy Utilities and Energy Storage

Many new technologies interacting in difficult to predict ways.

Distributed energy resource (DER) solutions, such as demand response, energy storage, and solar.



The transmission system operator (TSO) are currently not allowed to deploy energy storage

TSO want to use energy storage:

- Energy storage in its early deployment phase fits well with TSO objectives
- Reduces infrastructure investments
- Helps maintain quality of supply, frequency regulation

However

Large scale energy storage in relation to energy use would make the technology a price maker.

- Give TSO huge power over energy producers and energy consumers
- The long term benefits of energy storage would be sewn up by the TSOs
- TSO would be in a position to block out new business models
 - Micro grids
 - Home generation
 - Generation and storage Co-Ops
 - Value flows to households

Early Grid Entrants

GridBanks are energy reservoirs that store and deliver grid-scale electricity on demand.

- Stores electricity when too much is produced
- Delivers electricity when too little is produced
- Balances the transmission so the voltage and frequency are constant – fluctuation creates costly and damaging disturbances
- Allows fossil fuel power-plants to operate more efficiently – reducing pollution and cost
- Enables smooth renewables integration

- **Strong, undistorted spot price reflecting the real time value of electricity is required to manage the *complexity* efficiently.**

- **Barriers need to be removed to allow household to take part in the energy market**



BEBA structure – Designed to identify and develop opportunities and build a portfolio of companies in partnership with industry leaders

BEBA

Managing ownership and development of subsidiaries

- BEBA develops companies and subsidiaries to commercialize and scale up

Continuous process for identifying and verifying opportunities, e.g.

- BEBA is constantly evaluating new opportunities in e.g. battery R&D, applications or energy storage to find new areas of activity and/or companies to invest in and further develop

Four focus areas where BEBA already has partnerships and concrete plans for timely expansion

BEBA Battery

- Battery Box System
- Cell Portfolio of today
- Battery assembly
- Cell development with partners
- Beba Future Cell 500 wh/kg
- Beba Cell 500 Spin off
- Battery Management
- Recycling/reuse
- System, EMS, chargers, inverters,
- Solutions' and services

Rensea

Electric maritime solutions

Established portfolio company where BEBA will have 30 % ownership share

Heavy EV

Electric solutions for heavy machinery

Plans to establish portfolio company in partnership with industrial players

Energy Storage

Use and re-use of batteries for balancing energy

Solar
Wind
Fish farming
Charging
Gateway-services

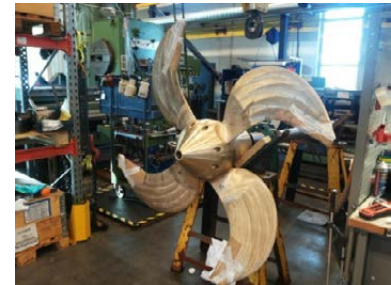
BEBA Finance

Leasing and Plans to establish portfolio company in partnership with industrial players

Rensea – From research and practical development to company

- **The Rensea company** is established based on the results from research project Rensea, a 4 years research program funded by the Nordic Innovation Fund to develop Regenerative pligin Hybrid-electric propulsion RPHE for ships.
- **Rensea Research Partners were:**
 - (North Sailing - Iceland, Anel AS, Bellona Foundation, Innovation Centre- Iceland, Lakeside Excursion –Faroe Iceland, Wave Propulsion -Norway, Catepillar Propulsion, Clean E-Marine - Denmark, Icelandic Energy)
- **Goal** is to develop systems for fully-integrated hybrid-electric and electric propulsion for ships
- **RENSEA** has a established network with suppliers, of engines, propeller, design, battery and energy management systems, chargers and inverters.
 - RENSEA have solutions for electric propulsion drivelines and batteries box systems
 - RENSEA has a BMS & cell portfolio with different performance to fit the Rensea Battery Box System.

No noise, no emissions and no vibrations – ideal for use in sensitive areas

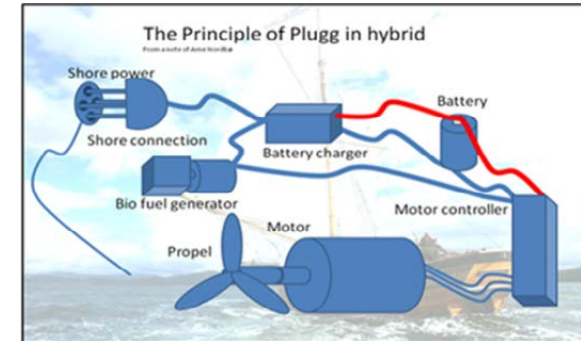


Rensea's maritime Regenerative, Plug inn, Hybrid- or full electric electric driveline,

Rensea Electric Propulsion Driveline

Engine, Shaft, Propeller & Rudder

- Electric engine
 - high torque, long lifetime
- Shaft
- Electric propel design
 - using the torque
 - Pitch –propel
 - Fixed propeller
- Regenerative propeller
 - The high efficient regenerative propeller system optimized for the electric engine with high torque, and produced in cooperation with Caterpillar propulsion
- Rudder /propel extender concept
 - to enable wider diameter of propeller when retrofit to use the torque in the electric engine
- Hybrid-electric or Full electric solutions



Rensea's E SeaWay Hull, Superstructure and Solarwing concept

Rensea E-Sea Way Hull

- High efficiency hull designed for electric propulsion.
- Catamaran
- 10, 14, 24 meter
- Designed to fit E-SeaWay Superstructure alternatives
- Speed , up to 30 knots
- Superlight structure
- Heavy-duty structure



Rensea E-Sea Way superstructure

- Flexible Superstructure concept
- Designed to fit E-Seaway Hull
- With or without Rensea SolarWing concept
- E-SeaWay Superstructure alternatives
 1. Ferry
 2. Fish Farming
 3. Pleasure
 4. Turistboat
 5. Yacht/expeditions

Rensea SolarWing

- A New way of sail-charging
- Will be developed for E-Sea Way Hull and superstructure
- Will also fit other types of vessels
- More information to be released.
- Ready 2018

BEBA Battery Box System with cell service

BEBA Battery Products

The BEBA/Rensea Battery Box System

- Rensea will tailor and deliver the right kind of battery package to the right use. We call it the RBBS (Rensea Battery Box System)
- With Rensea Battery Box System your vehicle will operate better and cheaper related to at any time most cost/efficient cell produced later.
- Buy the Box – Rent/lease or buy the cells
- The Rensea Battery Box System consist of:

The BEBA Battery box

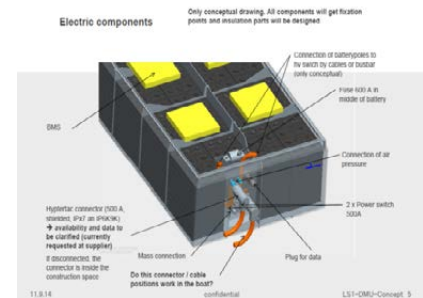
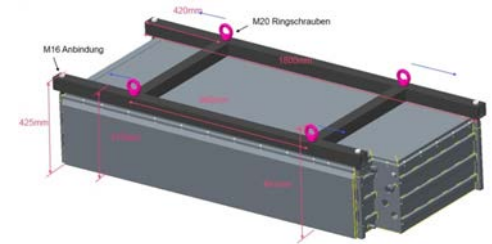
- Heavy duty – high temperature range, high reliability
- Long lifetime – designed to last the boat's lifetime
- Compact rectangular shape to fit all mobile and stationary applications
- The box has IP 67 standard -tolerate frost and water

Easy cell shift design

- The box has a «easy cell shift» design this enable: The RBBS is designed to fit different types of cells performing right to the user's demand.

CELL & BMS service

- Updating Cell Program
- Minimum Performance warranty service agreement
- Battery Management Systems



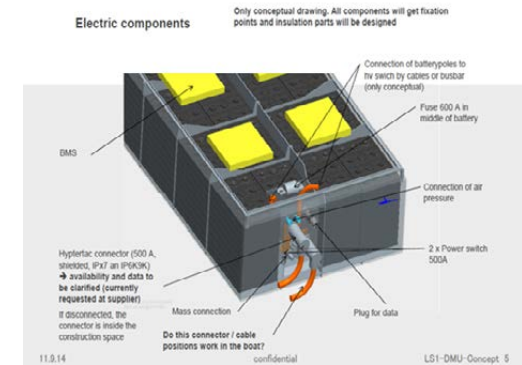
BEBA/Rensea Battery Box with Easy Cell-Shift Concept

BEBA BATTERY PRODUCTS

The BBBS (BEBA Battery Box System) is designed with an easy cell-shift concept .

The BBBS is designed to fit different types off cells performing right to the users demand. The BEBA Battery box therefore has an «easy cell shift» design, with the following benefits:

- Easy shift and upgrade to new cells with better performance, when viable, without shifting the battery box and surrounding equipment.
- Upgrade the Battery box system with better-performing cells and lower cost when available in the market.
- By monitoring each cell pack through the BMS, the BBBS will send information on cell status. Instead of shifting the whole battery, when a problem or reaching performance warranty, BEBA targets the cells that are reducing the all over performance in the system and replace them.
- BEBA Easy Cell-Shift concept avoids a “cell tech lock-in situation” for the customer. In many applications in mobility, and particular in shipping, we expect the cells to last so long that the customer wants to change to new cells with better performance when coming to the market, in to the BEBA battery box system
- Reduce maintenance and service cost of existing cells to keep the minimum warranty to performance above 80 % of DOD
- Easy shift of cells during operation of the ships will create reduction of non –operational time. The shift of cells can be done on-board,
- The BBBS is designed to fit different types of cells. The BBBS can therefore be fitted with different cells, depending on the user’s demand.
- EBA work with Cell-suppliers provide our customers with new cells to update the batterybox
- BEBA has also established a partnership to reach 500 Wh/kg – 2000 DoD (BEBA 500)



BEBA Battery Box

Long lifetime – designed to last the boat's lifetime

- **Compact rectangular shape to fit all mobile and stationary applications**
- **Heavy Duty – high temperature range, high reliability**
- **The box has IP 67 standard -tolerates frost and water**
- **The RBBS can be offered in Stainless steel, galvanized steel or aluminum.**
- **Closed system structure**
- **Intelligent self-control**
- **Secure design to meet all regulations**
- **Overpressure control and pop off**
- **Designed for easy shift of cells**

Samarbeid med Lithium Storage

- Electric conversion of an 18-ton Truck
- 4 times better energy consumption than Diesel
- Range up to 300 km with no emissions
- With such a high load capacity, this electric truck is the first of its kind.

As it is emission-free, it is exempt from regular road taxes, making it a very realistic investment option for future delivery.

- In cooperation with Lithium Storage we have developed a battery pack for marine applications



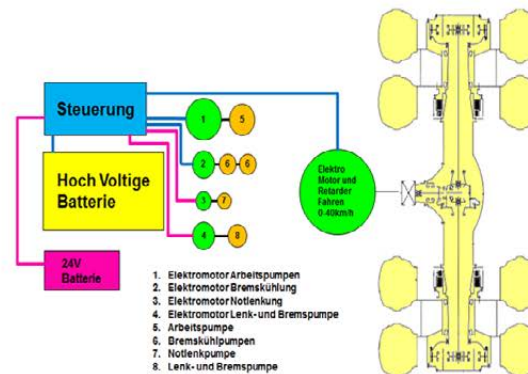
Key markets for BEBA – Heavy EV

Electro mobility

■ Mining

110t Dumper

- 700kWh batteries, in 4 battery packs
 - Speed max. 50km/h, 1200kW motor (12'000Nm on differential)
 - Save 50'000l diesel (130t CO₂) per year, generates 77MWh electricity per year
- Largest battery vehicle, first plus Energy vehicle on the world



Chassis: Komatsu 605-7, 110t total weight.

Drive train: Synchronous electric motor, 590kW (800 HP) continuous power, up to 9'500Nm torque

Battery: 700kWh Lithium-Ion

Lithium Storage GmbH builds together with Kuhn Switzerland AG the world's largest battery-operated dumper. Planning started in March 2015, and realization of the first E-Dumper in February 2016. The completion of the E-Dumper is scheduled for December 2016. The specifications are as good as or better than the diesel version:

Key markets for BEBA – Heavy EV

- Bellona and Omsorgsbygg partnership
- Emissions-free construction sites a condition in public procurement processes
- Dialogue with equipment producers and suppliers, leasing companies, construction entrepreneurs, public institutions



Jan Gunnar Halstvedt viser hvor batteriet plugges inn når anleggsmaskinen skal lades. (Foto: Mari Gisvold)

BYGGEPLASS PÅ SOLKRAFT

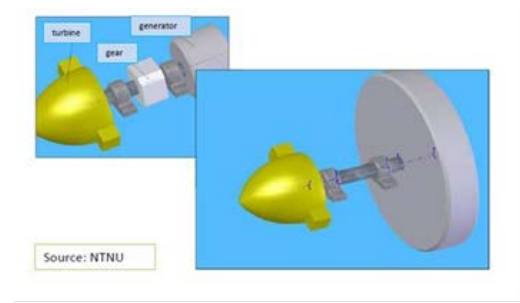
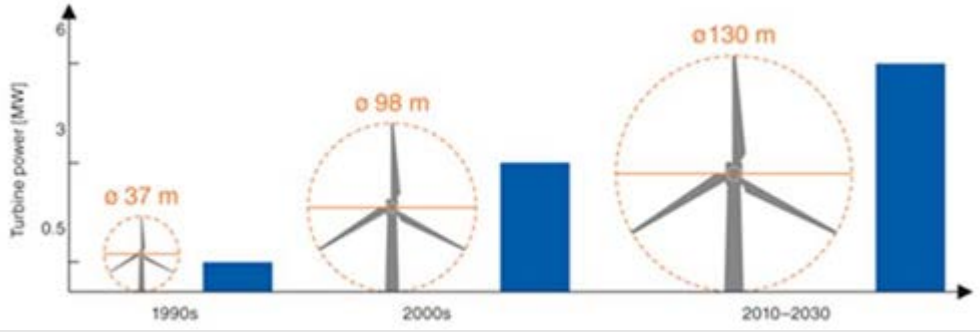
På denne byggeplassen drives anleggsmaskinene av solceller

På vei mot utslippsfrie byggeplasser.

Teknisk Ukeblad, 27.6.2016

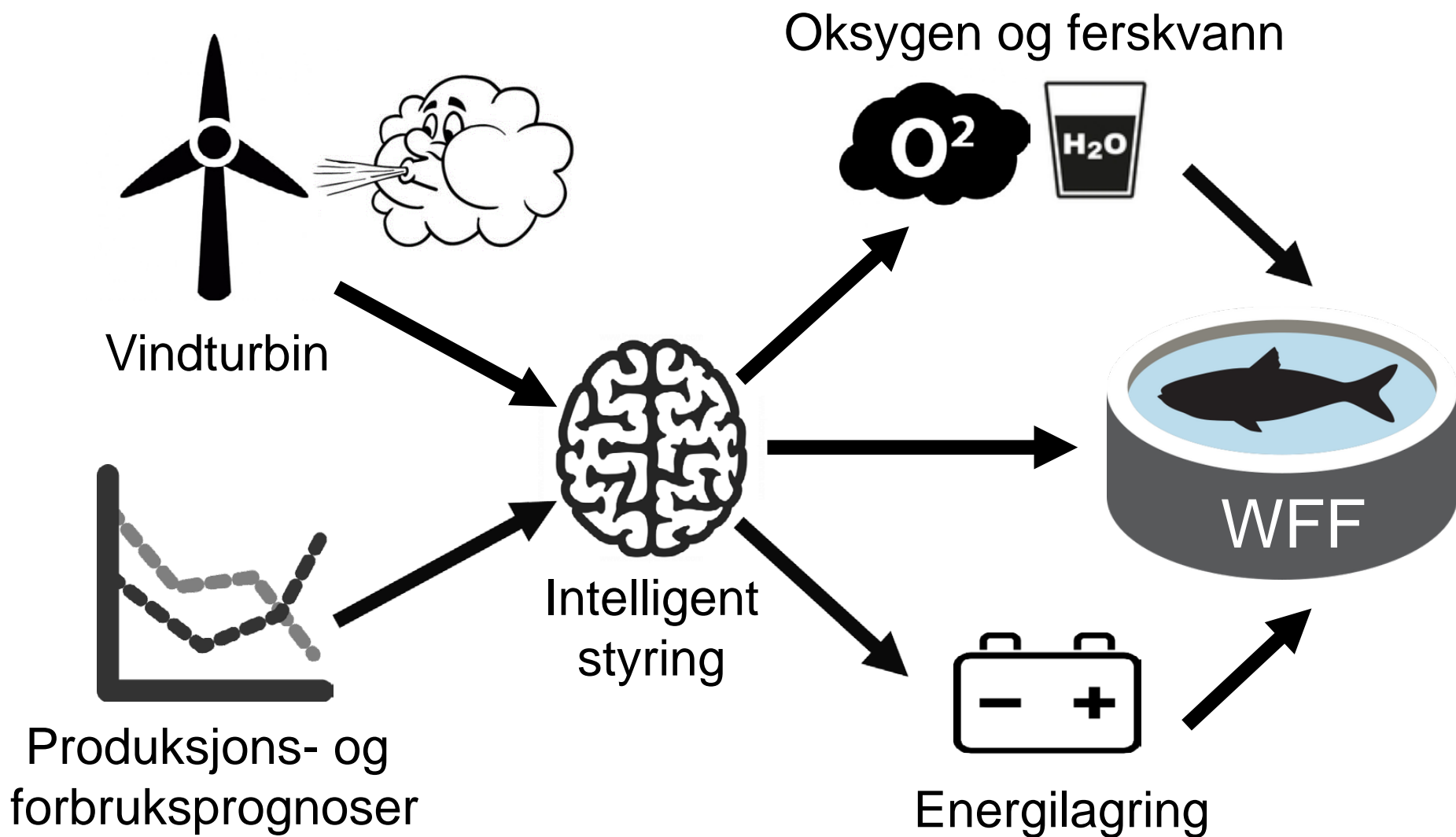
BEBA Battery & Wind

- The market for offshore is shifting to gearless options with large generators.
- Batteries may have the potential of limiting the DC-AC equipment in the



- Reliability and ruggedness of all components are especially important for the fast-growing number of offshore installations.
- Also, with the increasing size of the rotor, especially in offshore installations, doubling the power increases the torque on the gearbox 8-fold, escalating the cost of the gearbox itself and its associated maintenance costs.
- Advantageous to lose the gearbox when increasing in size.
 Reduced maintenance” The multiple wheels and bearings in a gearbox suffer tremendous stress because of wind turbulence and any defect in a single component can bring the turbine to a halt.
- This makes the gearbox the highest-maintenance part of a turbine. Gearboxes in offshore turbines, which face faster wind speeds, are even more vulnerable than those in onshore turbines”. Direct-drive turbines have a 1:1 connection between their rotor and generator.
- Permanent magnet direct drive motors. These are larger, but forgo the gearbox.
- An issue is the consumption of rare earths, which is much higher. These are now commercial, with Siemens and ABB building them.

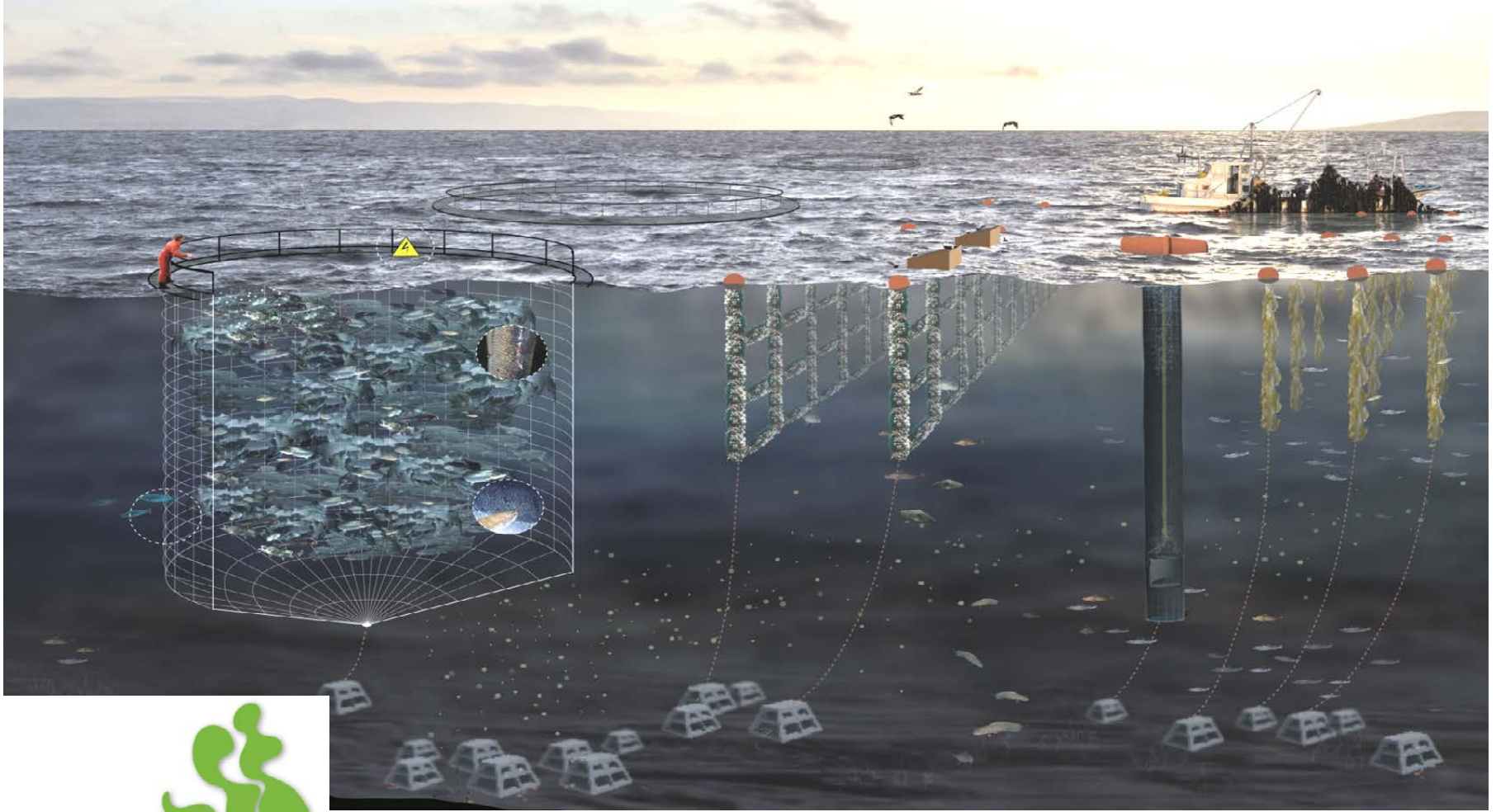
Vind og batterier i oppdrettsnæringen



Ta krafta i bruk!
Elektrifisering i norsk havbruksnæring



Aquaculture: with seaweed, mussels and benthic (IMTA)



OCEAN
FOREST

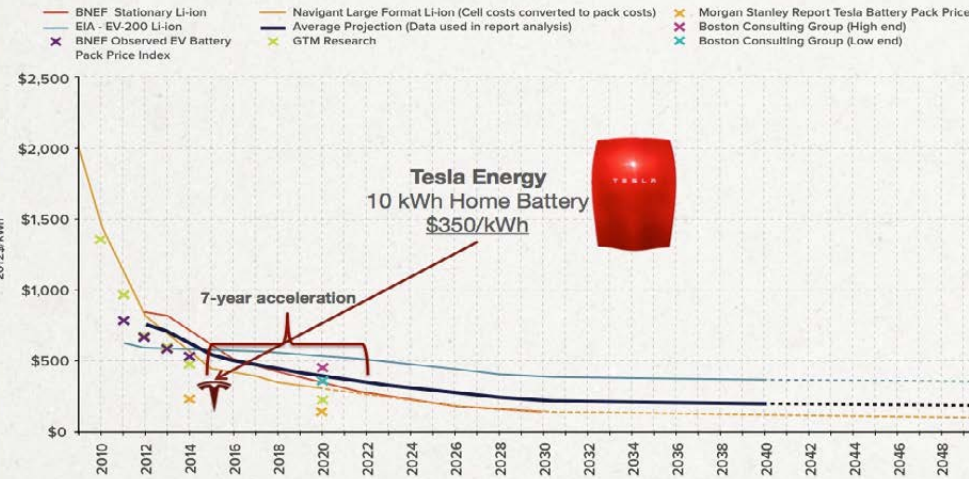
A collaboration between



Sun and og Battery

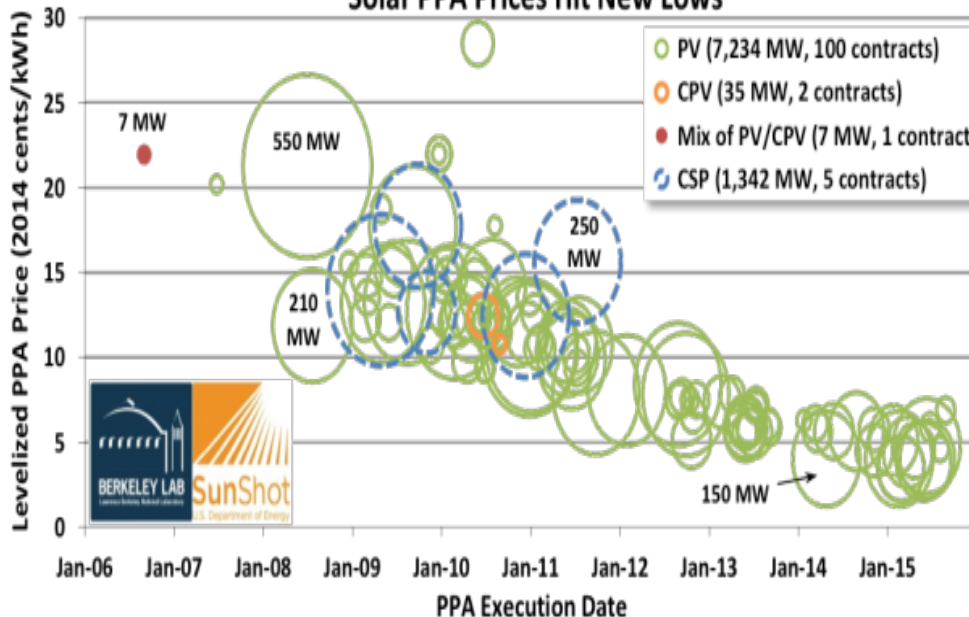
DECLINING LITHIUM-ION BATTERY COSTS AND FORECASTS

LITHIUM-ION BATTERY PACK PRICES: HISTORICAL AND FORECASTED



- The biggest disruptive change will happen when we get a price on CO2 emissions
- When solar and battery become cheap enough will the monopolistic structures in the energy sector be broken up.
- As a consequence of this the basic structure in the energy market be dramatically . This will influence goods and services and the whole distribution of value creation in a global scale
- This will result in a democratisation of energy with huge political and economic dimensions with enormous disruptive effect

Solar PPA Prices Hit New Lows



Tesla Gigafactory

Gigafactory Projected Figures	
2020 Tesla Vehicle Volume	~500,000/yr
2020 Gigafactory Cell Output	35 GWh/yr
2020 Gigafactory Pack Output	50 GWh/yr
Space Requirement	Up to 10M ft ² w/ 1-2 levels
Total Land Area (acres)	500-1000
Employees	~6,500

New Local Renewables Solar and Wind



