Science City – Efficient Renewables

A manufacturing opportunity for innovators

John F Hill, 11th December 2009

CONVERTEAM

THE POWER CONVERSION COMPANY

Power conversion – efficient Renewables

- **The Renewables market**
  - Recent history and an overview of the challenge
- **Commercial forecast**
  - Both a challenge, and a massive opportunity
- **Technical opportunity**
  - Innovation
- **Manufacturing opportunity**
  - Capacity and potential
- **Results**
  - Achievements

Renewables – competitive energy

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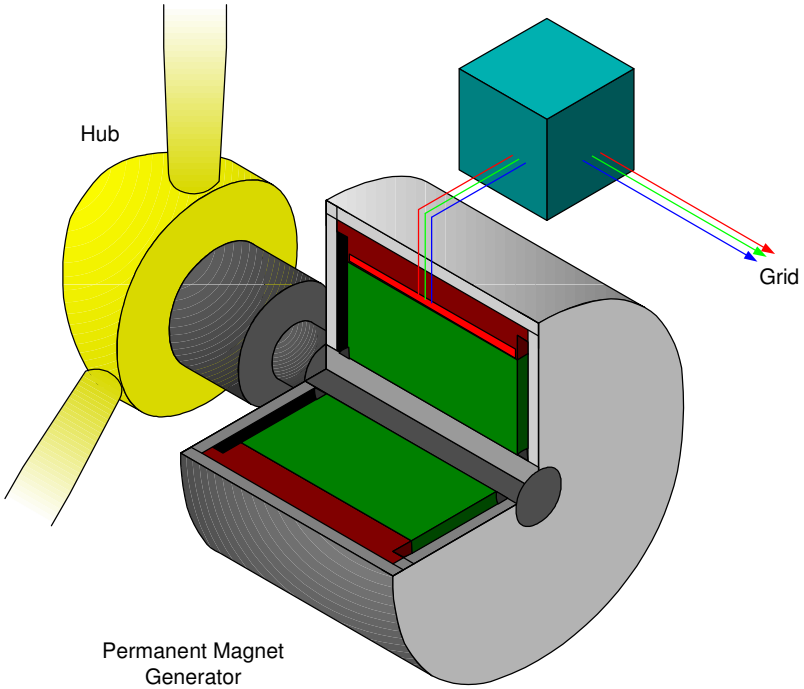
Giant Renewables – early work

Converteam Renewables pioneering in the 1990's

The Orkney 3MW experiment

The Osprey wave energy experiment

The Permanent Magnet Generator



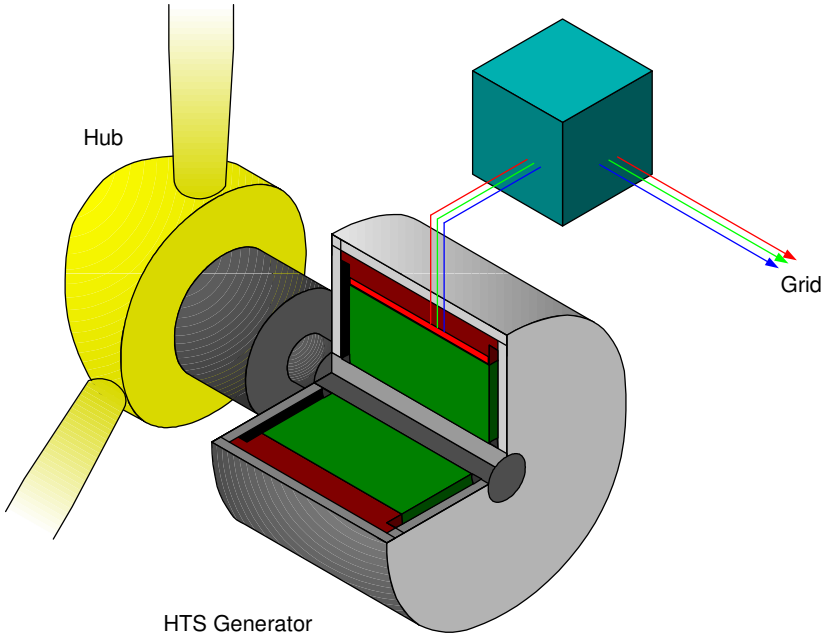
Typical Permanent Magnet Arrangement

- **Rated from 2MW up to 6MW+**
- **Either Low Voltage or Medium Voltage**
- **Either Direct Drive, Intermediate or Standard Speeds**
  - Simpler (or no) gearboxes, fewer bearings, novel load paths
- **Generator and grid protected by converter**
  - Full control of the grid interface
  - Full control of generator

- **Benefits Offshore, for Wind and Wave**
  - **Excellent for today's turbine power ratings**
    - Inherent power quality control and improved reliability
    - Productivity dividend from high part-load efficiency
  - **Providing increasing MWhr cost reduction as power increases**

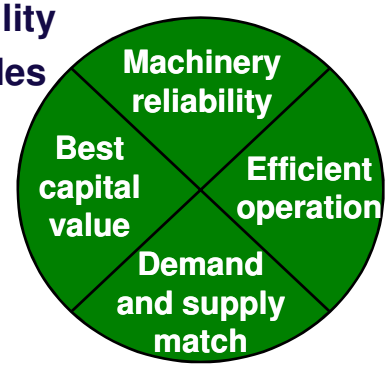
- **…but challenges remain**
  - Same mass as conventional geared solutions
  - Single piece transportation limit
  - Offshore cranage costs
  - Material supply shortages

The High Temperature Superconducting Generator



Possible HTS Arrangement

- **Half the material mass of the PMG**
- **Compact and lightweight**
  - Viable nacelle sizes defined by tower design and cost constraints
  - Stator connected to grid through converter
  - Full control of the grid interface
- **Rated at 5MW and above**
- **Medium Voltage**
  - Lighter current, lighter cabling
- **Direct Drive**
  - The blades will be turning at around 10 - 12 rpm, and a gearbox becomes very difficult at this torque
- **Designed for maximum availability**
- **Designed for emerging grid codes**



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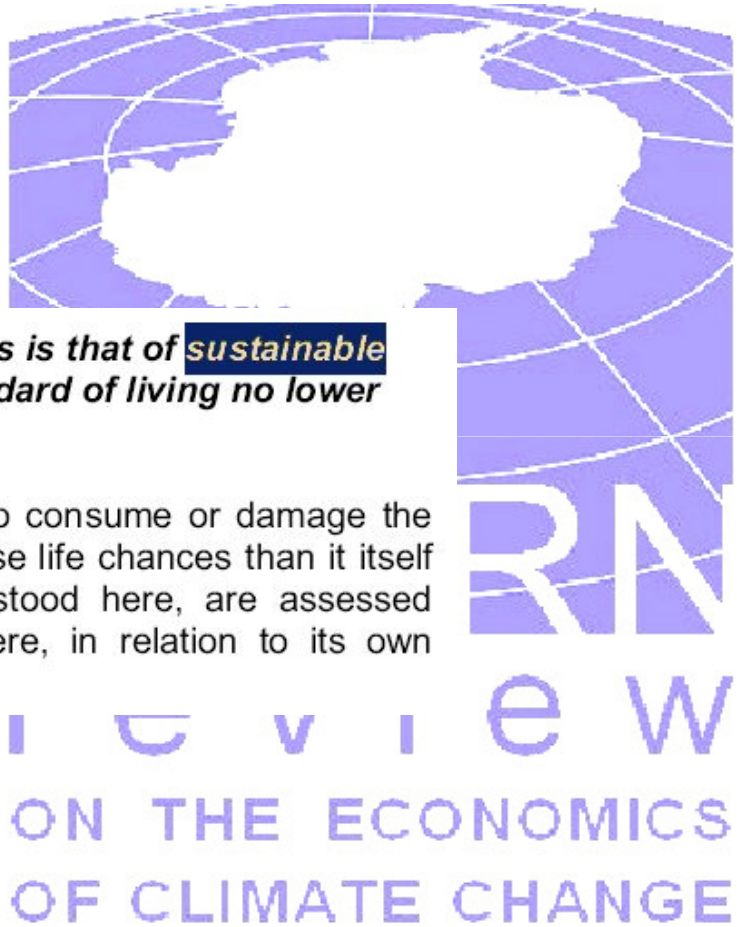
Finally, the challenge was defined

- UK Treasury 'Stern Review', October 2006



A concept related to the idea of the rights of future generations is that of sustainable development: future generations should have a right to a standard of living no lower than the current one.

In other words, the current generation does not have the right to consume or damage the environment and the planet in a way that gives its successor worse life chances than it itself enjoyed. The life chances of the next generation, it is understood here, are assessed assuming that it behaves in a sustainable way, as defined here, in relation to its own successor generation[7].

- **A low carbon economy….**

With continued growth

Powering Europe to 2030

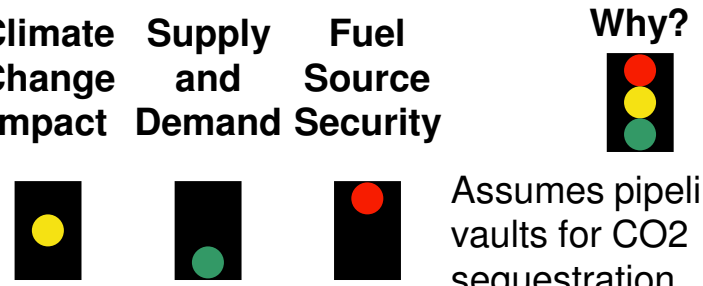
- **The challenges for electricity**
  - **To constrain** Climate Change
    - while growing the EU economies
  - **To balance** electricity supply and demand
    - when the EC demand forecast to 2030 is
      - Year 2000 plus 52% (350GW+)
    - and in the intervening years
      - We need to replace 55% of our electricity generation (365GW)

Source: European Commission

  - **To secure** the fuel (plus enough to allow for some additional unknowns - like air-conditioning the workplace)
- **To provide more new power capacity than exists today, clean and ready-fuelled**

Sources of Fuel for Europe

Powering Europe to 2030



- **'Clean' fossil fuels**
  - Raw fossil fuel costs rising, some secure, limited supply

  Assumes pipelines to vaults for CO2 sequestration

- **Nuclear fission**
  - Raw mineral costs rising, politically fragile, limited supply

  Arrives late

- **Energy thrift and efficiency**
  - Raw material free, secure, but diminishing returns

  Conversion to electricity is a one-off opportunity, but electricity efficiency gains are ongoing

- **Renewables**
  - Raw material free and safe, secure and abundant

  A great opportunity for the the EU, which can get better and better

UK Crown Estate - Rounds 1 and 2 progress

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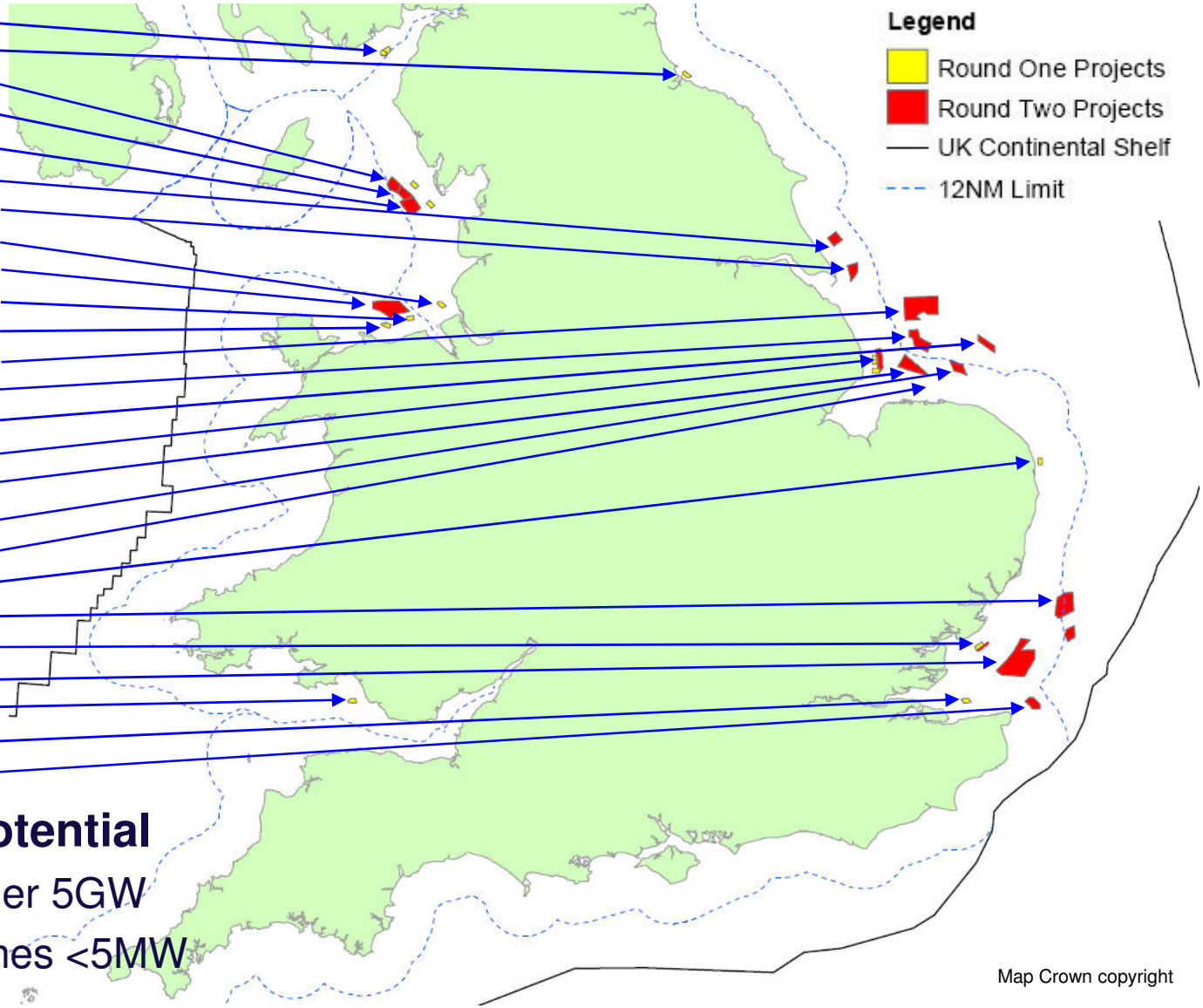
R1	Solway Firth	Vestas V90
R1	Teeside	SWP 3.6 - 107
R2	Walney	
R2	West Duddon Sands	
R1	Barrow	Vestas V90
R2	Westermost Rough	
R2	Humber	
R1	Burbo Bank	SWP 3.6 - 107
R2	Gwynt y Mor	
R1	North Hoyle	Vestas V80
R1	Rhyl Flats	SWP 3.6 - 107
R2	Triton Knoll	
R2	Race Bank	
R2	Dudgeon East	
R1	Lynn/Inr Dowsing	SWP 3.6 - 107
R2	Lincs	
R2	Sheringham Shoal	
R2	Docking Shoal	
R1	Scroby Sands	Vestas V80
R2	Greater Gabbard	SWP 3.6 - 107
R2	Gunfleet Sands	SWP 3.6 - 107
R2	London Array	SWP 3.6 - 107
R1	Scarweather Sands	
R1	Kentish Flats	Vestas V90
R2	Thanet	Vestas V90

Operational
Installation
Development
Delayed



2014 potential

- Another 5GW
- Turbines <5MW

Map Crown copyright

UK Crown Estate - Round 3 progress

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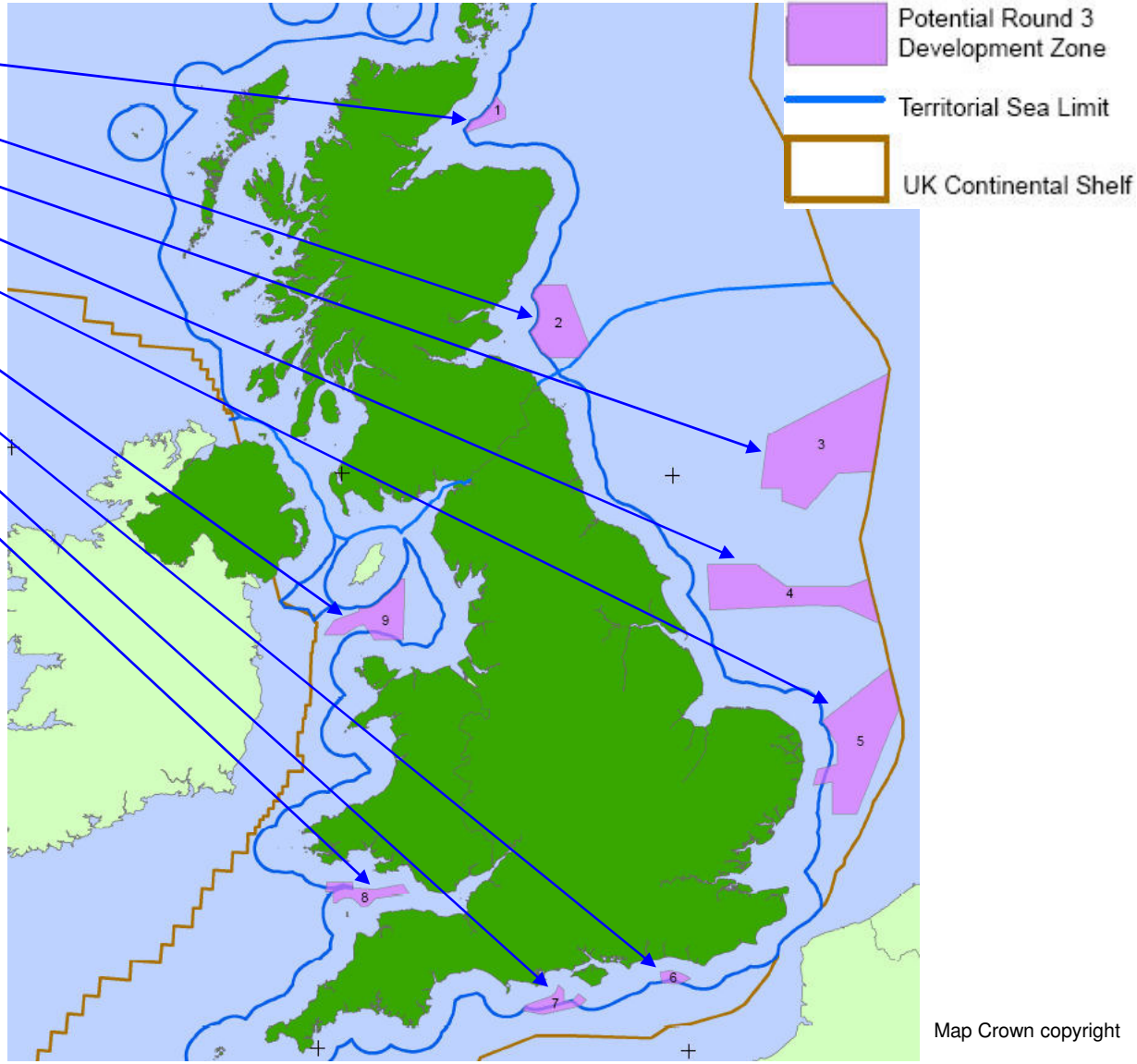
R3 Z1 Moray Firth
R3 Z2 Firth of Forth
R3 Z3 Dogger Bank
R3 Z4 Hornsea
R3 Z5 Norfolk
R3 Z9 Irish Sea
R3 Z6 Hastings
R3 Z7 West Isle of Wight
R3 Z8 Bristol Channel

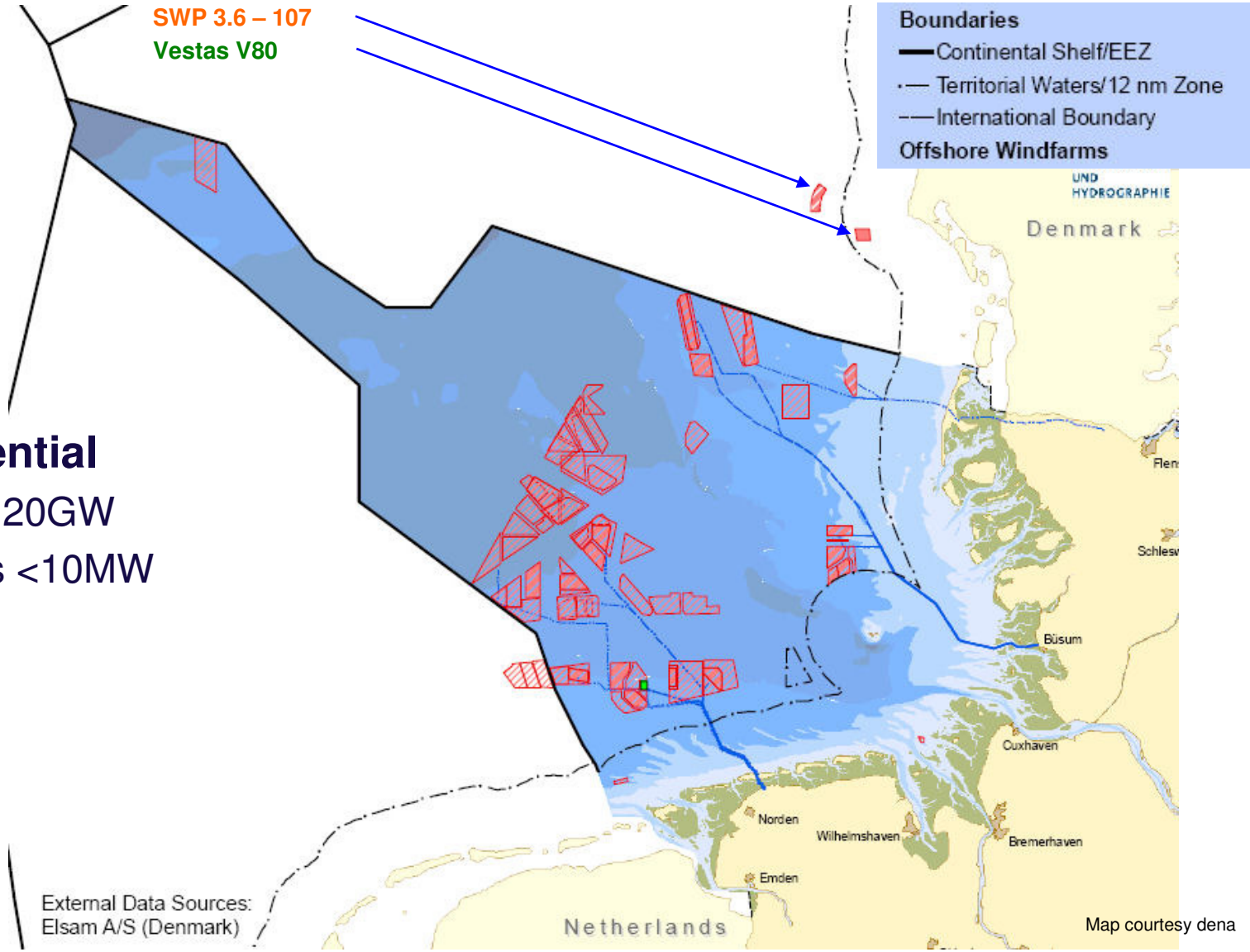


- **2020 potential**
  - Another 25GW
  - Turbines <10MW

Map Crown copyright

Germany DENA – North Sea Wind progress

ND Horns Rev 2 SWP 3.6 – 107
ND Horns Rev Vestas V80

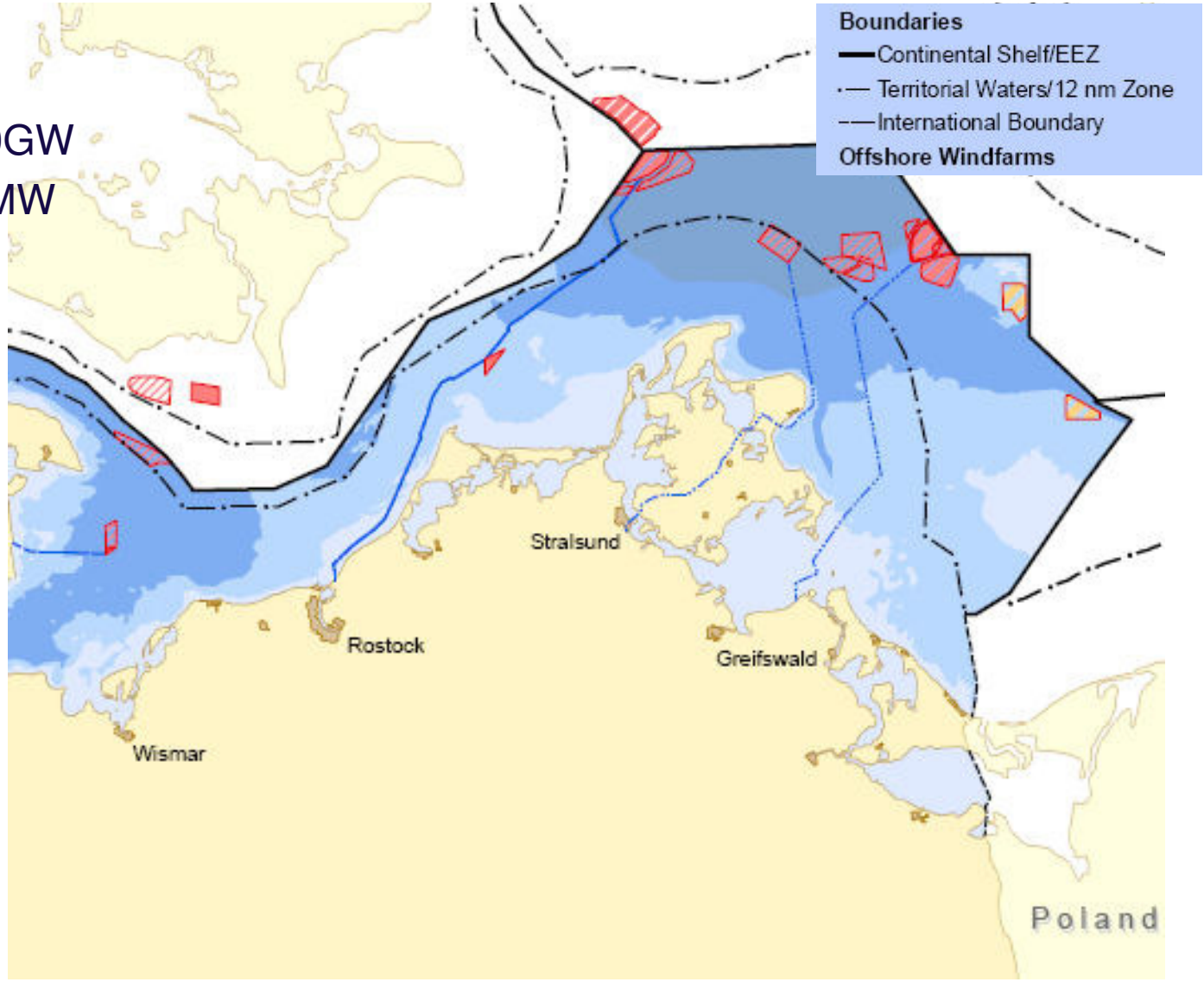


- **2020 potential**
  - Another 20GW
  - Turbines <10MW

Map courtesy dena

Germany DENA – Baltic Sea Wind progress

- **2020 potential**
  - Another 10-20GW
  - Turbines <10MW



Map courtesy dena

The Simple Arithmetic

- **Minimum offshore Europe opportunity alone**
  - 150,000MW by 2030, (40,000MW to 60,000MW by 2020)
- **Approximate cost at €2M / MW**
  - €300bn (€300,000,000,000)
- **Average wind turbine to 2030**
  - 10MW
- **Turbines needed offshore Europe by 2030**
  - 15,000
- **(And onshore is bigger for a while, and then there's the USA, and then there's wave and tidal, and then there's Eastern Europe, and what about Africa, Middle East, Asia, Australasia, South America,….)**

…and onshore

- **Energy when and <u>where</u> its needed**
  - Feed-in Tariffs will give earning power to us all
    - Micro Renewables
      - allow individuals to show commitment to climate change reduction
      - can be very efficient
      - but can be low yield
      - can offer payback from the grid
      - but ultimately needs massive investment in control and QA

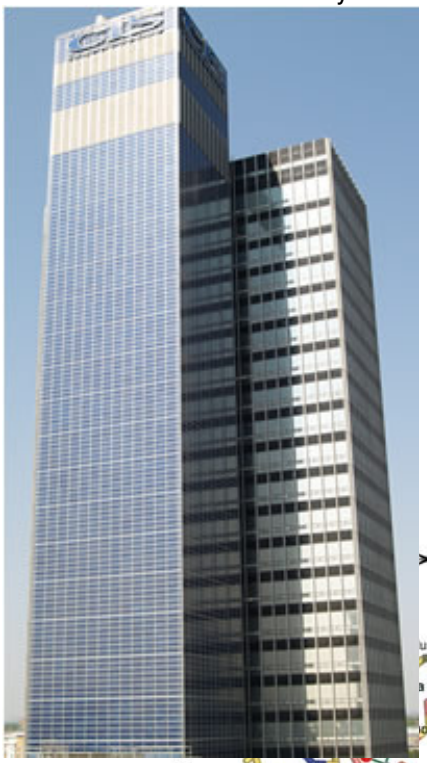
Courtesy: BBC/David Nisbet

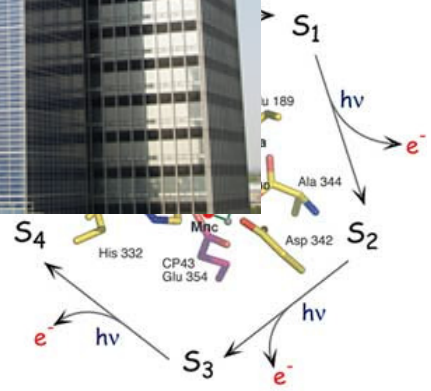
Courtesy: National Energy Foundation

…and onshore

- **Energy when and <u>where</u> its needed**
  - Feed-in Tariffs will give earning power to us all
    - Solar Energy
      - is there in Manchester!
      - Planning consents are easy
      - Is best where power is difficult to produce – e.g. deserts / wildlands
      - Presently gathered using materials that are 98% sand (well silicon), but...
      - Needs to move up two orders in volume to be globally competitive
      - Possible bio-technologies
      - Needs support technologies to get best value

Courtesy: CIS





…and onshore

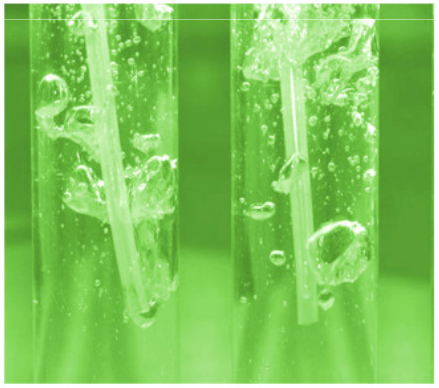
- **Energy <u>when</u> and where its needed**
  - Smart grids will provide the opportunities for complex energy flows
    - Plugged-in cars are power stores

Tesla S (courtesy Tesla Motors)

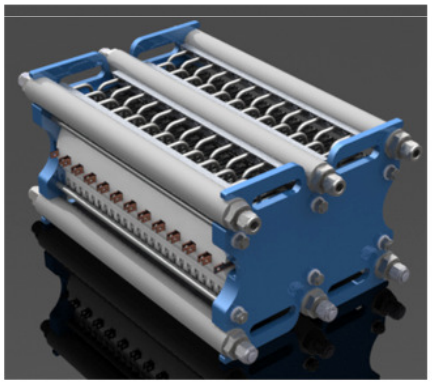
FCX Clarity (courtesy Honda)

…and onshore

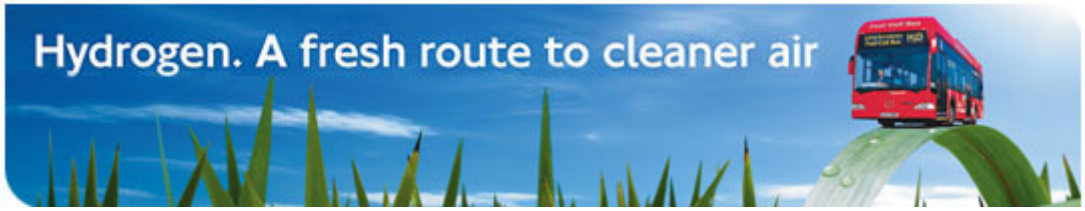
- **Energy <u>when</u> and where its needed**
  - Storage allows us not to lose the night wind, hot midday sun on cold nights, surplus power station heat when we need only electricity...



Courtesy ITM



Courtesy TfL



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A long history of design and manufacturing innovation

The Boughton Road, Rugby site is the actual location of the development of the jet engine

Our Leicester Road, Rugby site is the place where Dennis Gabor invented the hologram in 1947

The Nelson Site, Kidsgrove built the world's first industrial computer (DEUCE) in 1955 based on work done at Bletchley Park in WW2

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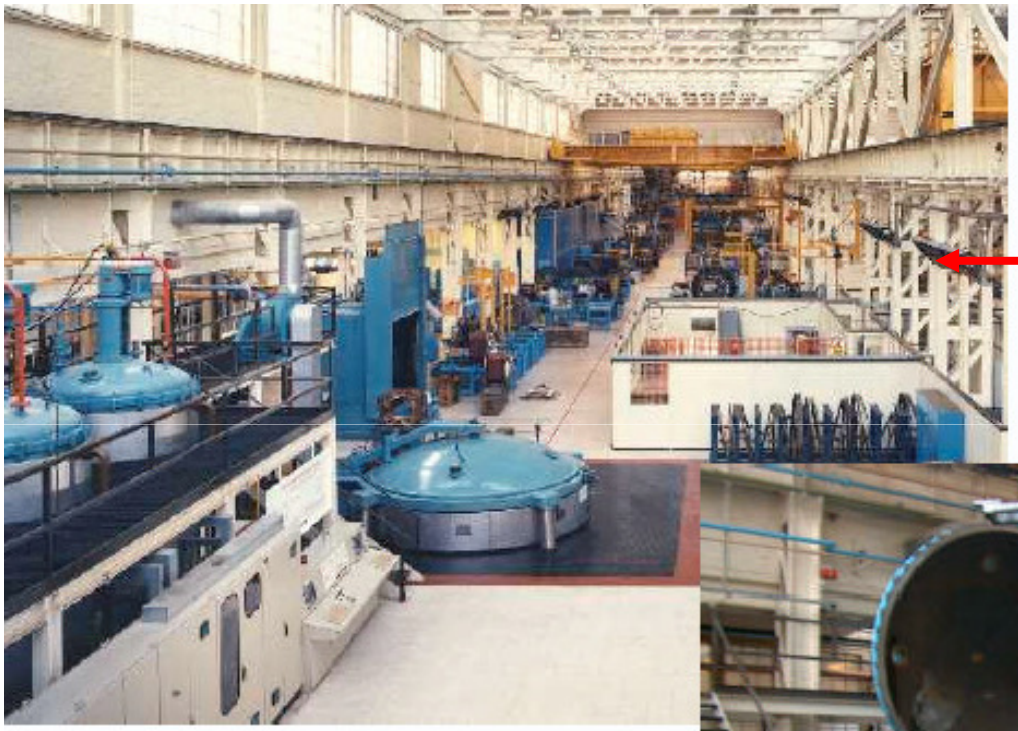
Manufacturing – using our resources

Activity in the 1950's

Activity at Kidsgrove was quite diverse ranging from the design and manufacture of portable instruments to control gear and systems - primarily for the steel industry. The computer age had just begun and English Electric started to design and make digital and analogue computer systems called 'DEUCE' and 'LACE'.

Cubicle Assembly Post Hoshin

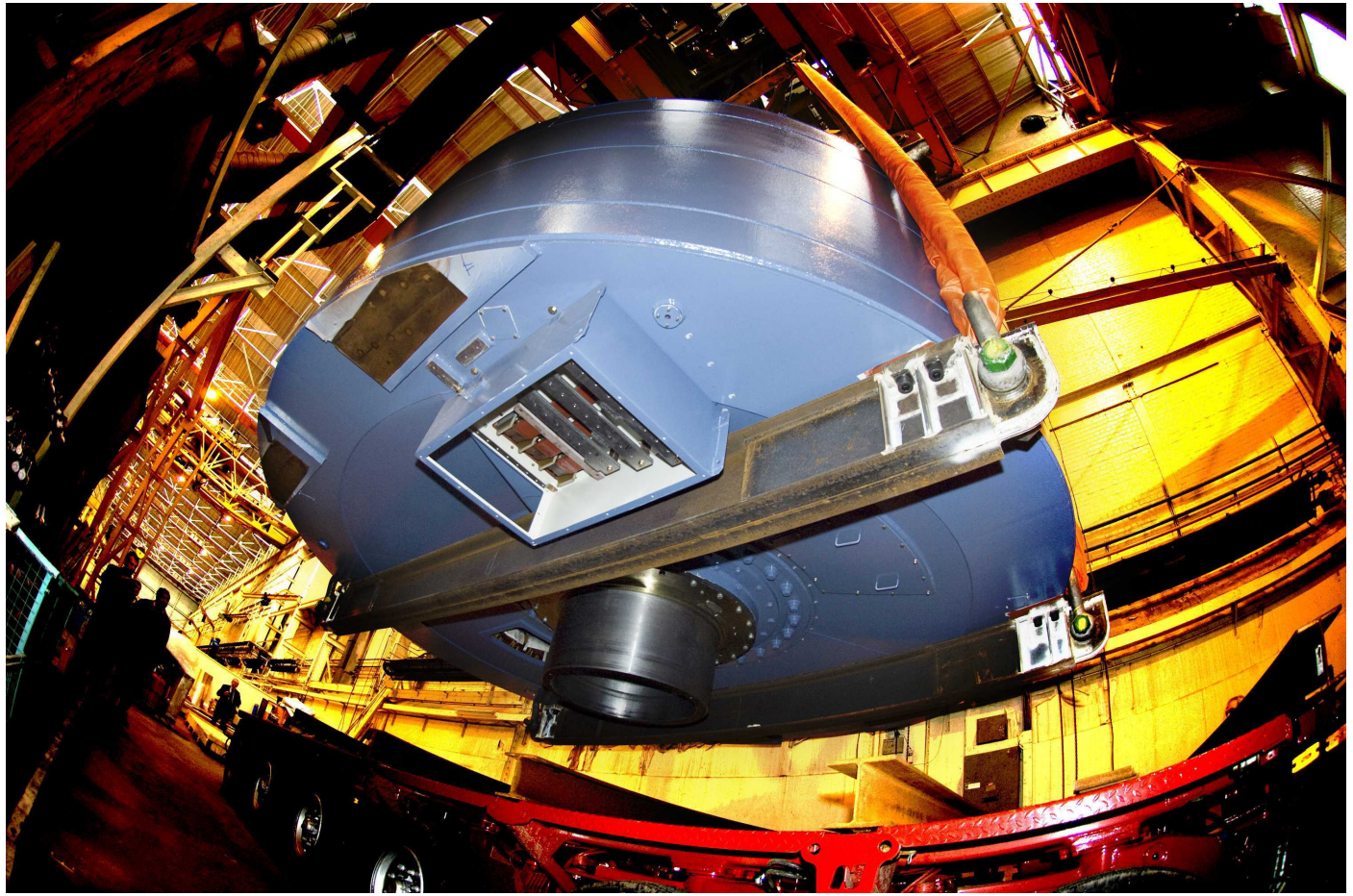
Second generation - in all shapes and sizes



- This is part of generator and motor factory in Rugby.
- We have capacity to VPI the complete stator of the largest Wind PMG known today.
- We own exclusive rights to CIG technology - the highest generator power-density in the industry.

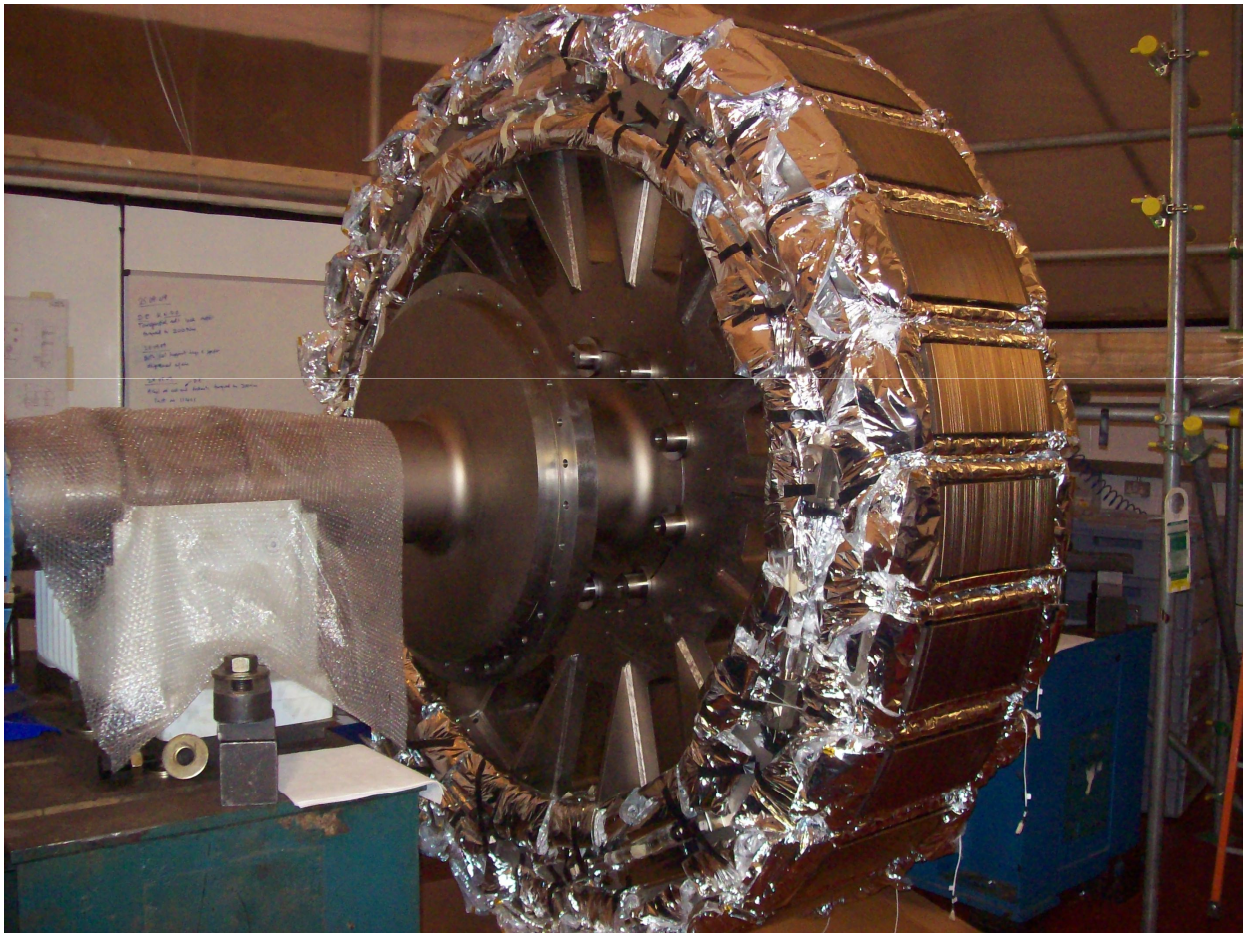
Second generation - the machines

- Direct Drive for the minimum number of components



Third generation - the machines

- Direct Drive and Superconducting for the smallest and lightest



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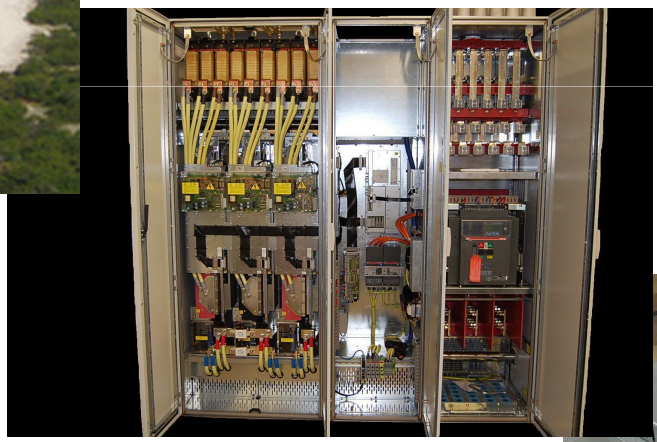
Giant Renewables – today's reality

Converteam at work - onshore

SWP 2.3-93 at Horse Hollow, USA (courtesy: Siemens Wind Power)

Power Converters

- Power electronics and microprocessor control to take natural energy and convert it to be grid compliant electricity



Type 28, 2.3MW power converter (Converteam)

Liquid Cooled Delta power module (Converteam)

Converteam at work - offshore

SWP 3.6-107 at Burbo Bank, UK (courtesy: Siemens Wind Power)

Power Converters

- **World's largest independent supplier**
  - Over 1000 converters; 4 - 5GW; per annum

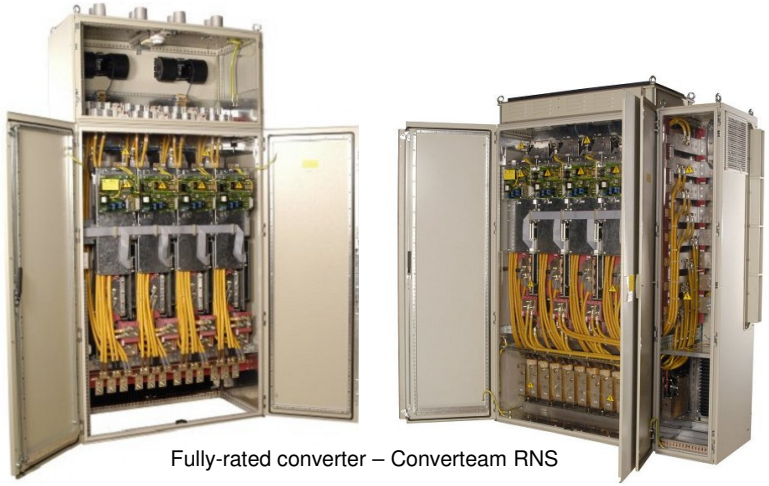
SWP 2.3-82 at Lillgrund (courtesy: Vattenfall)

Converteam generators and power converters at work - future

SWP 3.6DD on test at Tim (courtesy: Siemens Wind Power)

Drive train

- **Direct Drive**
  - Permanent Magnet Generator
  - 3.6MW, 14rpm
  - Minimum components
  - Optimum reliability



Fully-rated converter – Converteam RNS

Giant Renewables – the state of the art

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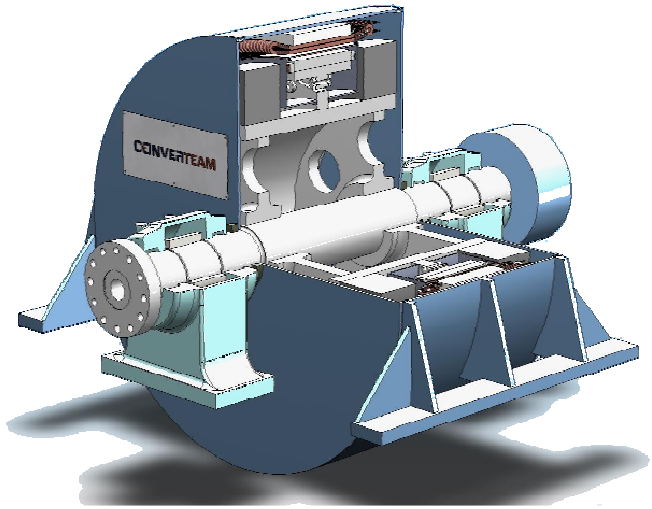
The 'Hydrogenie' Drive Train

- HTS upgrade to revamp an existing generator
- Hydro generator of 1.7MW; 214rpm; 28 poles
- Conventional stator winding, rotor with warm magnetic pole bodies and HTS field winding
- Project within EU-FP6 program

Advantages for customer

- HTS enabling:
  - Power upgrade (+40%)
  - Maintain given space
  - Maintain civil construction
  - Raise efficiency (+2%)



For the UK manufacturing base

HRH The Duke of York with the EcoF3 car (courtesy: University of Warwick)

…the biggest opportunity for a generation…

- **To meet tomorrow's energy demand**
  - with an endless supply
- **To offer the UK energy security**
  - whatever world politics has in store
- **To renew our manufacturing base**
  - with world class, competitive plant
  - using our unique capacity for invention
- **To replace yesterday's jobs**
  - with skilled, future-focussed careers
- **To provide a sustainable future**
  - and a world worth living in

Thank you for your attention

www.converteam.com

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