RENEWABLE ENERGY

Building the supply chain

John F Hill, Summer 2010

CONVERTEAM

THE POWER CONVERSION COMPANY

Renewables – Supply chain development

- **Renewables market**
  - Sizing, scoping, timing, global context
- **Routes to market**
  - Turbine makers, farm developers, site owners, utilities
- **Market pull**
  - Value, through innovation, quality, volume and support
- **Technology push**
  - R&D, demonstration, manufacturing, references
- **The B-B solution**
  - Contracts, risks, sustainability

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EU power production – Forecast

Achieving the long term goals

- **The EU commitment to 2020**
  - 20% of energy consumption from Renewable sources
  - All 27 countries legally bound

Source: EU Directive of 23rd April, 2009

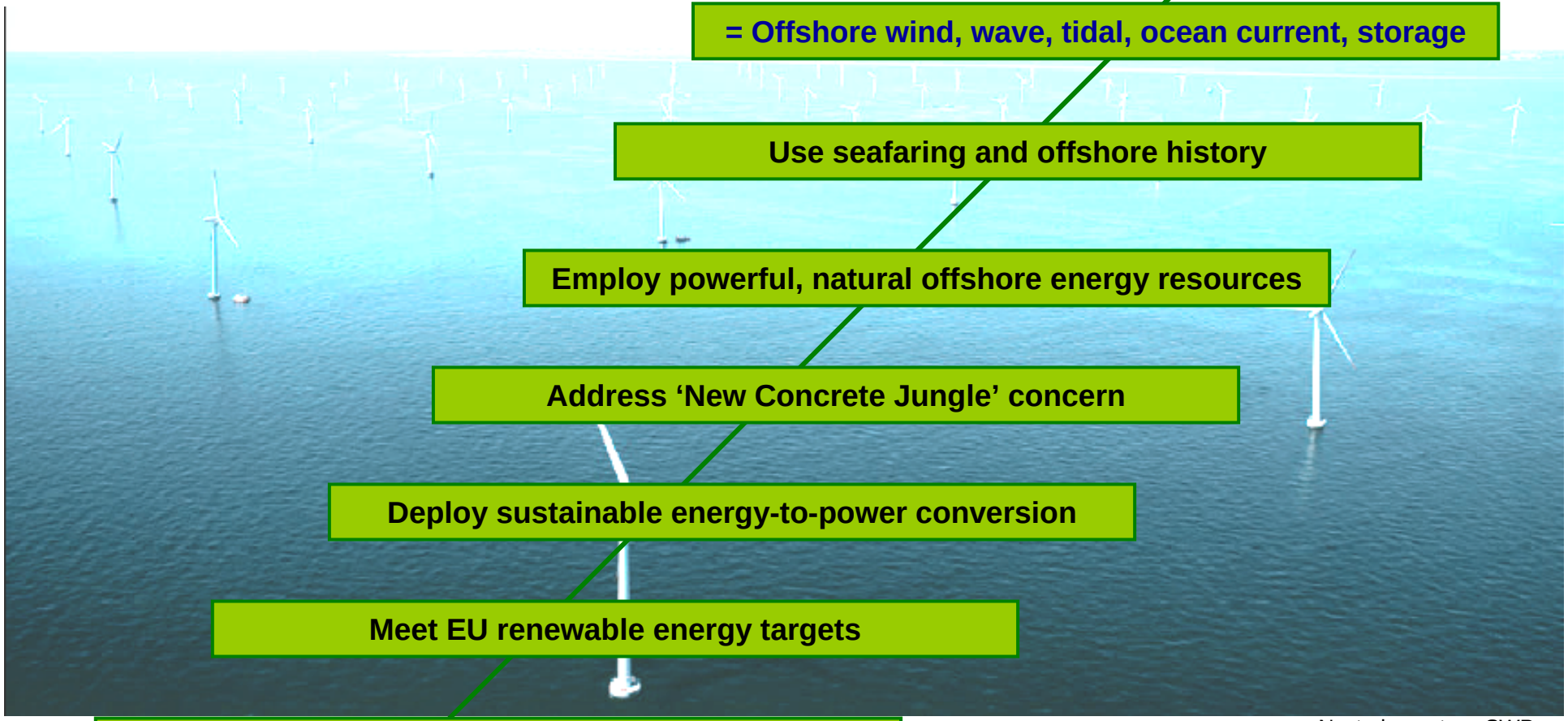
- **Why?**
  - Carbon reduction
  - Electricity - balancing supply (Year 2000 656GW) and demand
    - Supply
    - EC supply forecast to 2030: 365GW power plant replacement
    - Impact? Periods of supply shortage.
    - Demand
    - EC electricity demand forecast to 2030: Year 2000 plus 52%
    - Impacts? Fuel shortages, fuel conversions, fuel cost

Source: European Commission

    - Summary
    - A greater capacity to build by 2030 than currently exists
    - Fuel choices needed
    - Fuel diversity imperative

Sources of Power for Europe

Securing power to 2020



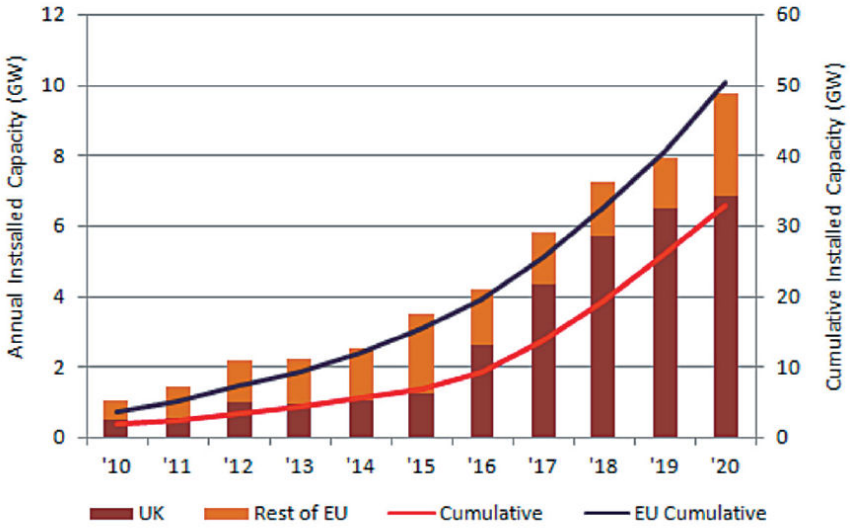
Nysted, courtesy SWP

EU Offshore – Forecast

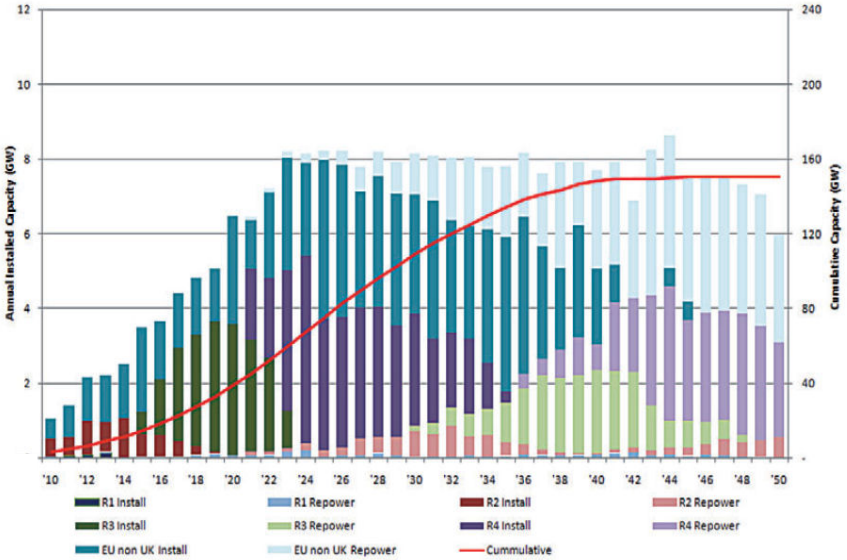
Achieving the long term goals

- **EU Offshore to 2020**
  - >8,500 turbines
  - Rated 5MW – 10MW

Projected annual and cumulative EU offshore installation to 2020 in GW.



Courtesy: BVG Associates report for Crown Estate Q2/09



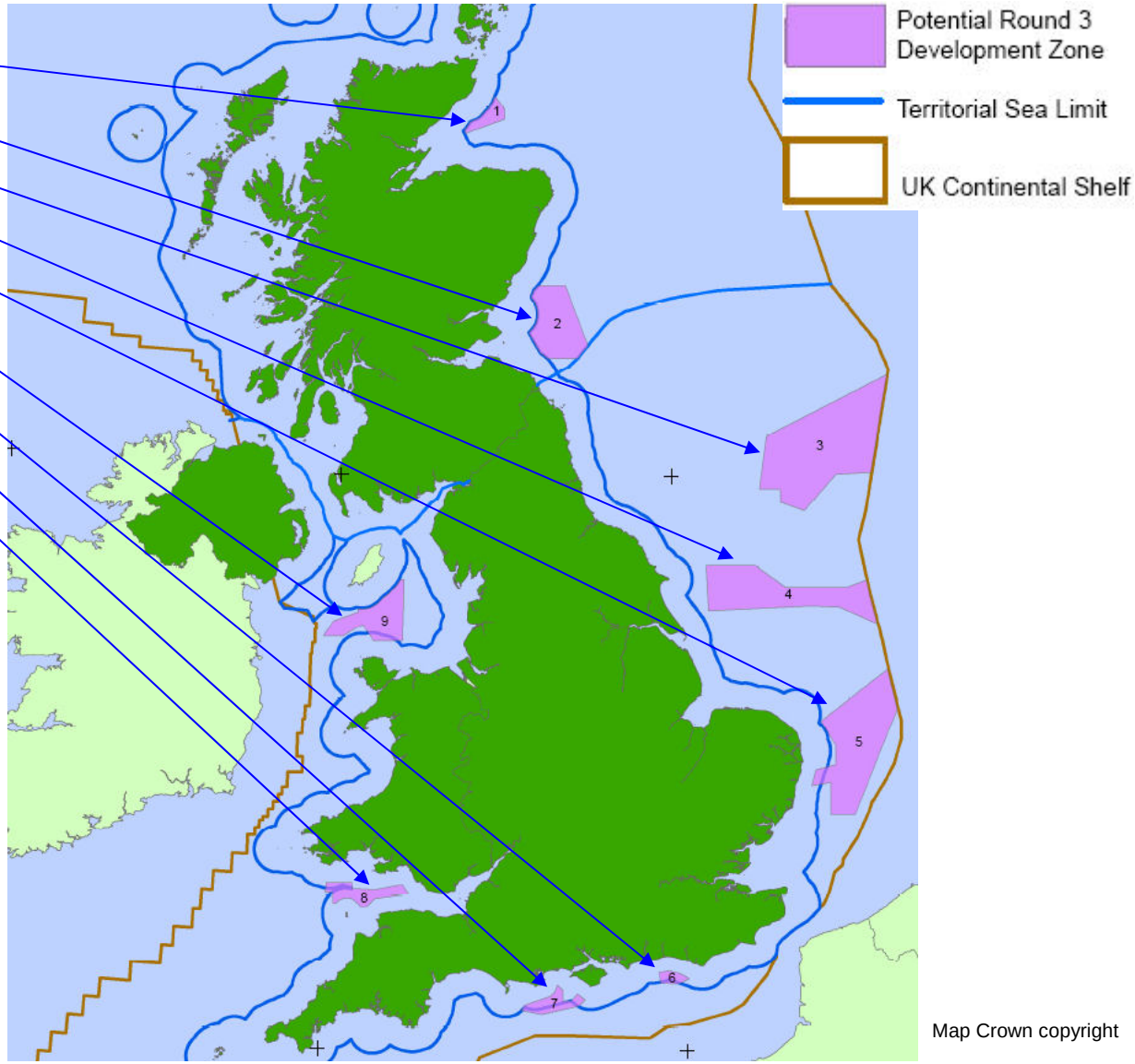
Projected annual and cumulative EU offshore installation to 2050 in GW.

- **Manufacturing conclusion…**
  - Sustainable, long term volume
  - A business in the new economy,
  - Supported by political commitment

UK Round 3 – Zones

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

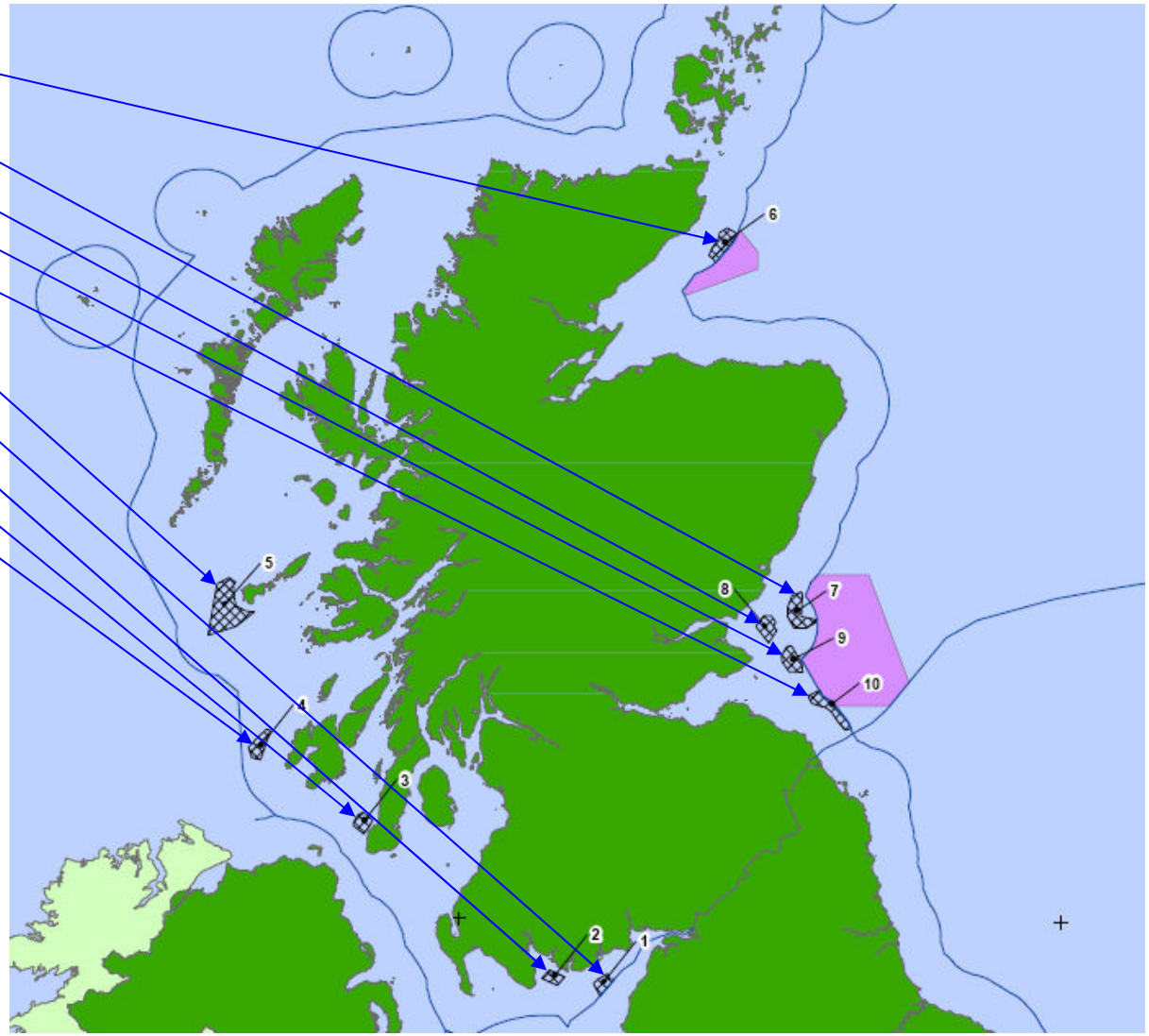
- **2020 potential**
  - 25GW
  - >2,500 turbines



Map Crown copyright

UK Scottish Round – Zones

6 Beatrice
7 Inch Cape
8 Bell Rock
9 Neart na Gaoithe
10 Forth Array
5 Argyll Array
1 Solway Firth
2 Wigtown Bay
3 Kintyre
4 Islay

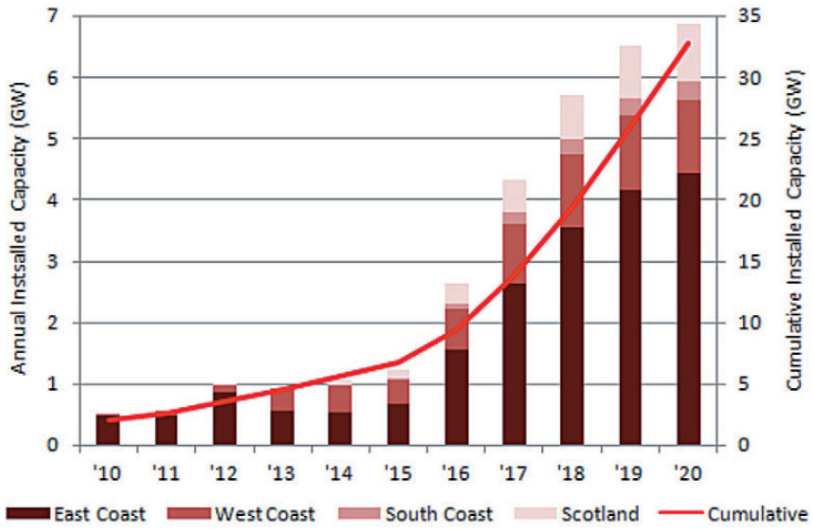


- **2020 potential**
  - Another 6.5GW
  - >650 turbines

Map Crown copyright

UK Offshore 2020 – Forecasts

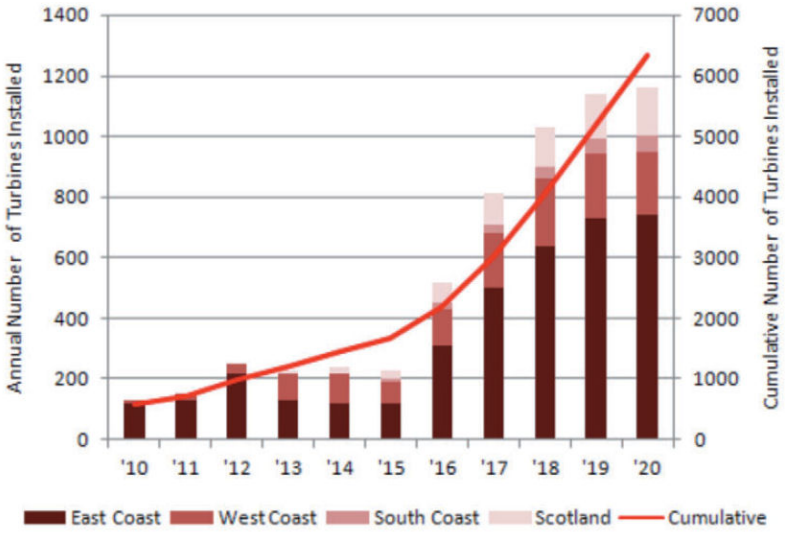
Achieving the legally enforceable targets



Projected annual and cumulative UK offshore installation to 2020 in GW.

- **Round 3 and Scotland only**
  - >5,000 turbines
  - Rated 5MW – 10MW

Projected number of turbines installed offshore UK to 2020.



Source: BVG Associates report for Crown Estate Q2/09

The forecasts assume that installation in Scottish and Northern Irish territorial waters supplement Round 3 activity. It is anticipated that the average power rating of turbines to be installed each year will rise to just below 6MW by 2020.

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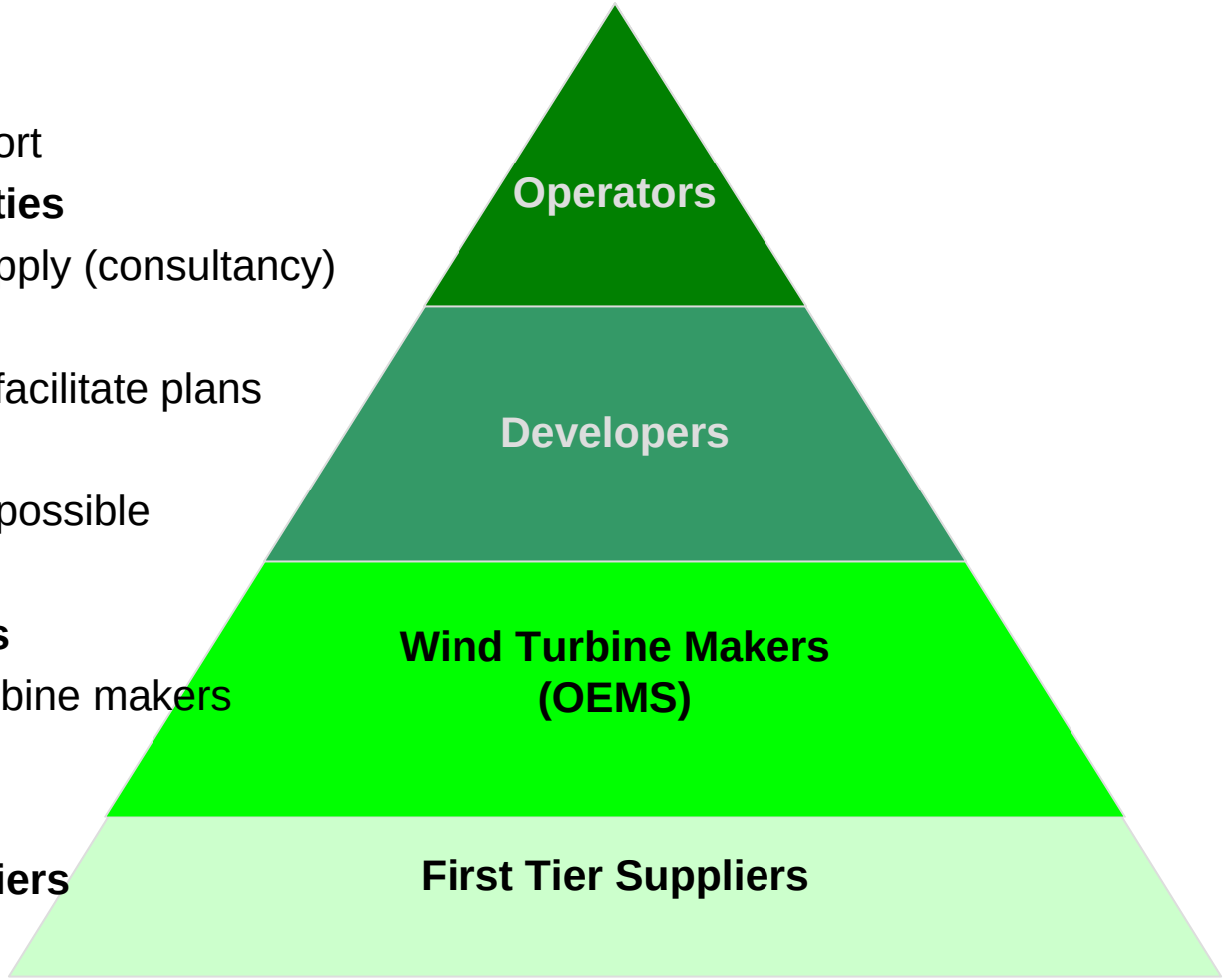
UK Offshore 2020 – route to market

Over-arching strategy – for a Tier One supplier to wind turbine makers

- **Government**
  - Involve and support
- **Regulators / authorities**
  - Inform, assist, supply (consultancy)
- **Utilities**
  - Provide comfort, facilitate plans
- **Developers**
  - Associate where possible
- **Wind turbine makers**
  - Offers to giant turbine makers
- **Other tier one suppliers**
  - Partnering?



UK Offshore 2020 – gaining references

Converteam at work

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

Converteam Power Converters

- The leading offshore wind converter
- 25% of the world non-integrated converter market

SWP 2.3-82 at Lillgrund (courtesy: Vattenfall)

Converteam DD-PMGs

- SWP 3.6DD remains the largest Direct Drive in operation worldwide

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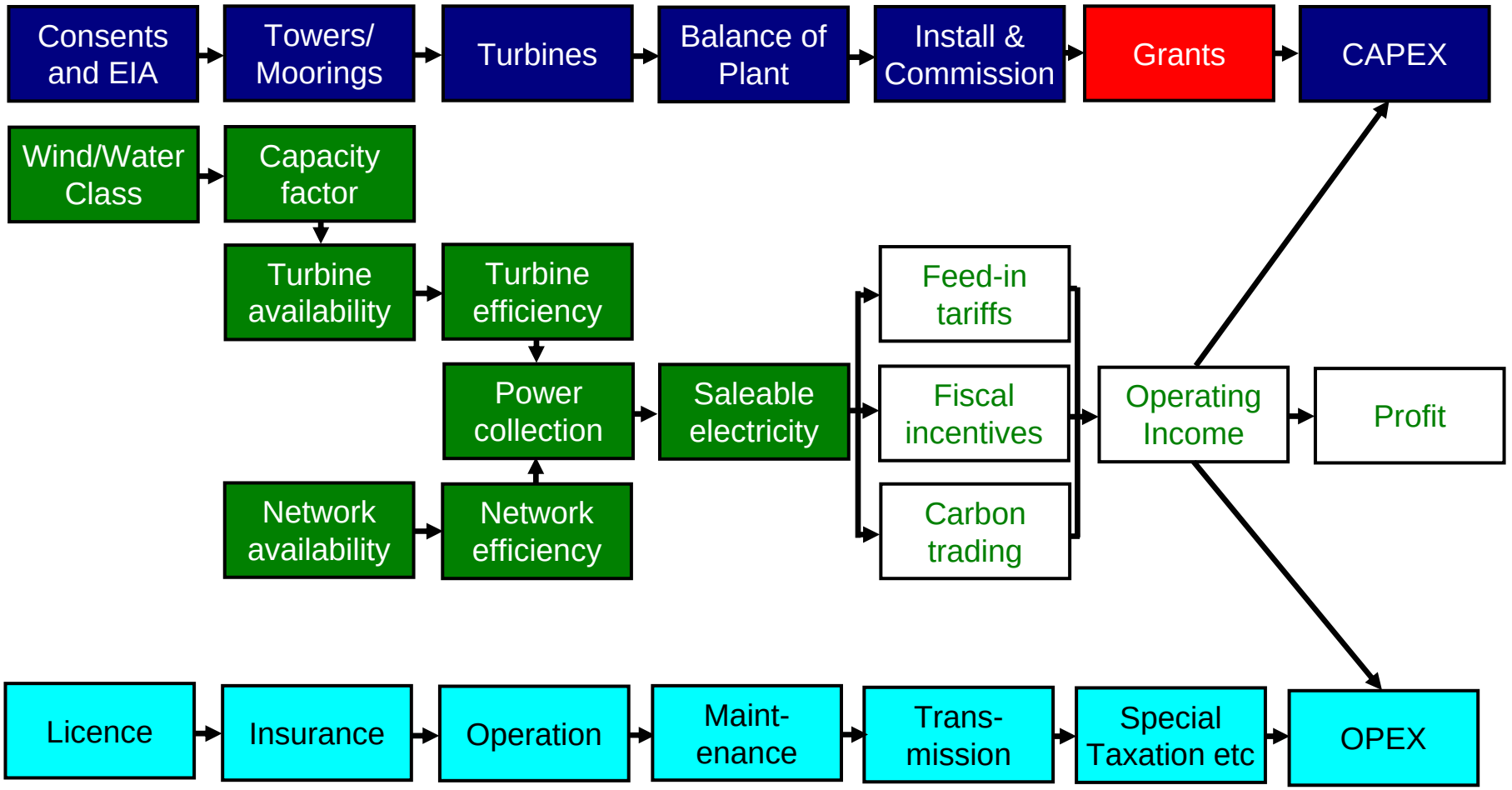
Renewables - End user business model



Notes:
EIA – Environmental Impact Assessment
Income sources vary with territory

Renewables – Value in the marketplace

Tier One supplier qualification

- **Reduced CAPEX**
  - Smoothing consenting
  - Smallest civil infrastructure
  - Lower turbine costs
  - Lower turbine lead times
  - Simpler installation

- **Increased Operating Income**
  - Superior operational envelope
  - Superior availability
  - Increased generation efficiency
  - Increased collection and transmission efficiencies
  - Grid compliant power

Burbo Bank (courtesy Elsam

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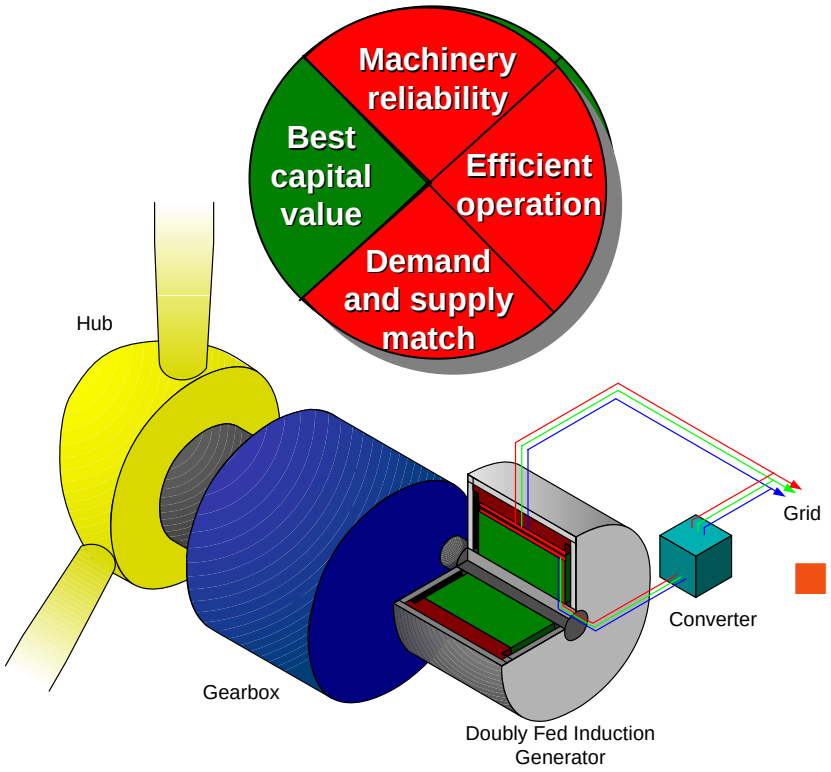
The first generation of wind turbines

The Doubly-fed Induction Generator



Typical DFIG Arrangement

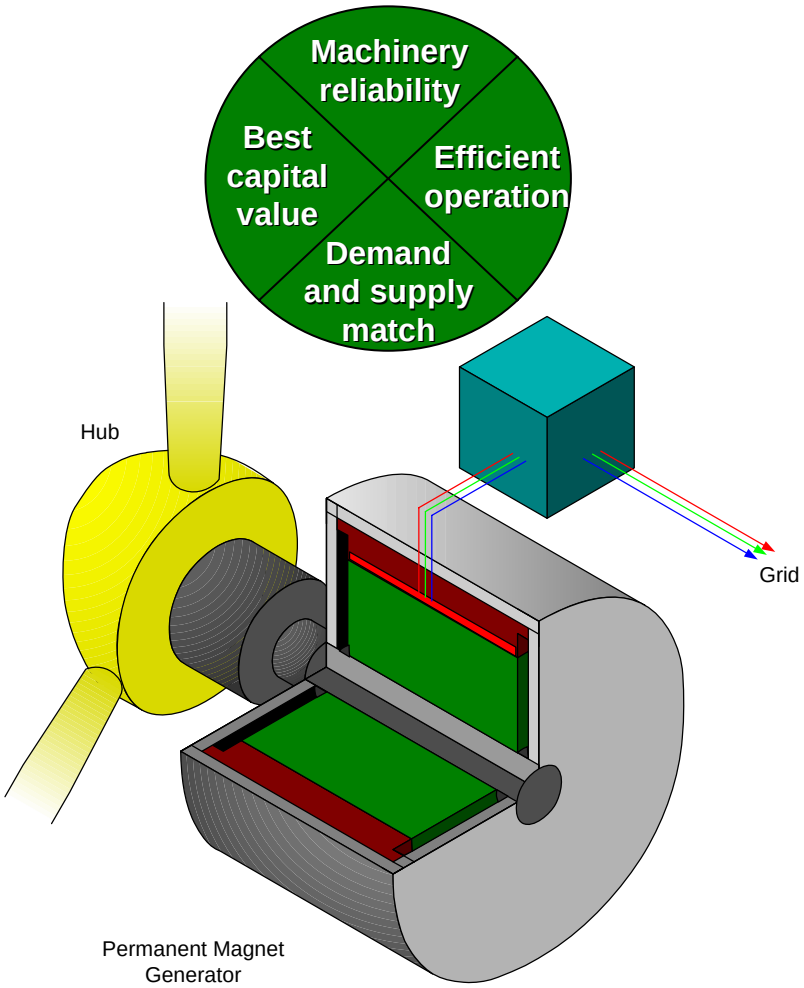
- Rated 0.5MW to 5MW
- Generally Low Voltage
  - Typically 400V to 690V
- Medium Speed
  - 1000 rpm + requiring a 3-stage gearbox
- Stator connected to grid, Rotor connected via a converter
  - Converter is typically 30% of the total rating

Issues for Offshore Wind

- Difficult to achieve ride-through of bus dips
- Severe grid faults can damage generator and gearbox
- Slip-rings for large power generators are operating at significant current
- Additional measures often required to achieve power quality
- Requires regular low-level maintenance

The second generation of wind turbines

The Permanent Magnet Generator



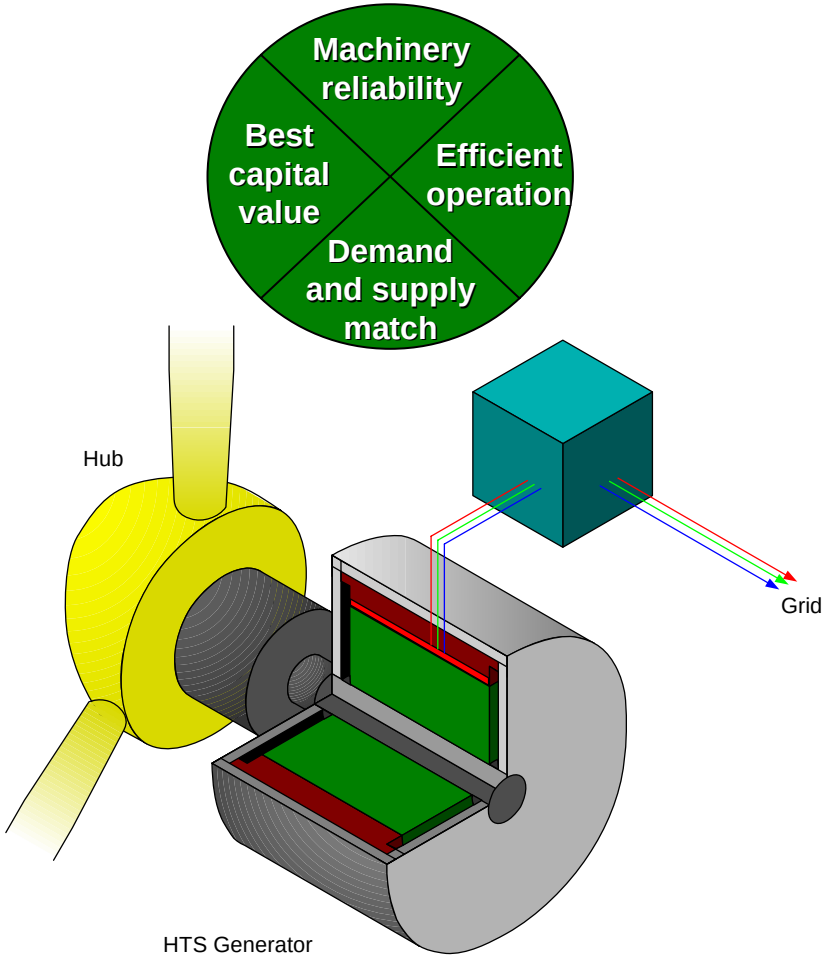
Typical Permanent Magnet Arrangement

- **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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UK offshore 2020 – An opportunity

A typical generator can consist of…

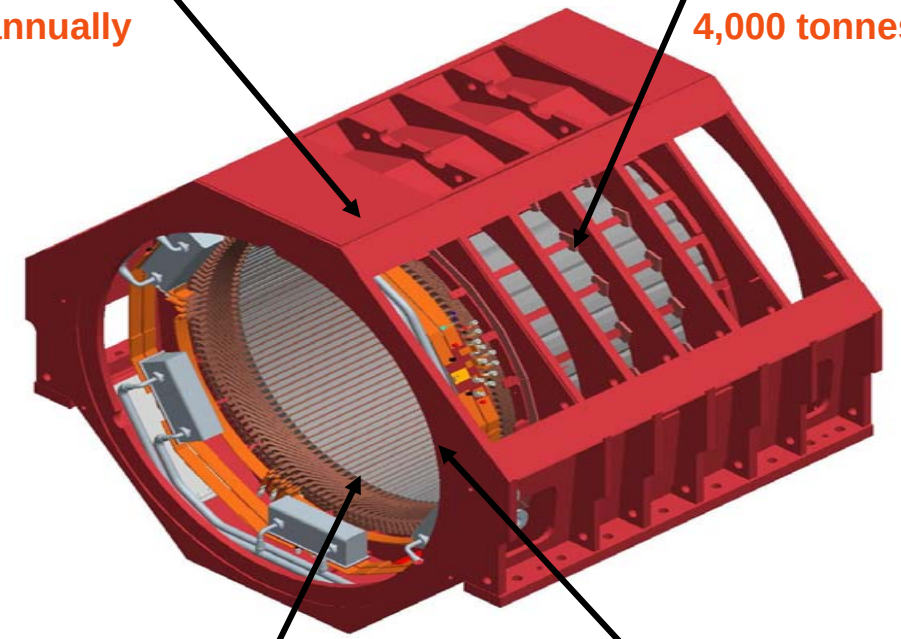
Which translates to…

30 tonnes of fabrications

30,000 tonnes annually

4 tonnes of permanent magnets

4,000 tonnes annually



7.5 tonnes of copper conductor

7,500 tonnes annually

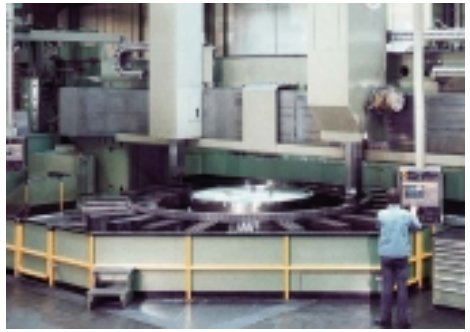
16 tonnes of punched laminations

16,000 tonnes annually

UK offshore 2020 - Logistical challenge

Up to 4 Generators a day coming off a production line means….

- 240 tonnes of outgoing shipments a day
- 4 escorted wide loads a day
- 250 tonnes a day of incoming materials
- An articulated lorry delivering goods every 15 minutes
- £150+ million worth of capital plant being used continuously in the supply chain



UK offshore 2020 – Finding parallels

- **Capital plant producing capital plant**
  - **The supply of goods to make money**
    - **Like automotive, Advanced Manufacturing Technology crucial to competitiveness**
    - **Sizes and tolerances compatible with aerospace**
    - **Lifecycle cost analysis and reduction akin to civil engineering**
    - **As in computing, a continuous, high-rate technology improvement**
    - **Multi-sourcing for delivery assurance**
    - **Framework agreements**
    - **End customer supplier criteria reflected down the supply chain**

SWT 3.0-101 (courtesy Siemens Wind Power)

UK offshore 2020 - Supply chain considerations

- **Strategic Empathy**
  - Need strategically aligned suppliers
- **Capability & Capacity**
  - Understand critical and bottleneck processes
  - Capacity planning & production rate readiness to fully understand and predict the ability to support full production volumes
- **Investment**
  - Supply partners of the right size and profile to grow with the market
  - Understanding of investment breakpoints and forward planning to support market growth
- **Co-Location**
  - New factory provides the potential to co-locate
- **Commercial & Technical**
  - Challenging cost targets, driven by the market price
  - Ability to contribute to and support Design To Cost (DTC) events
  - Supply Framework Agreements – a share of the orders for a share of the risk

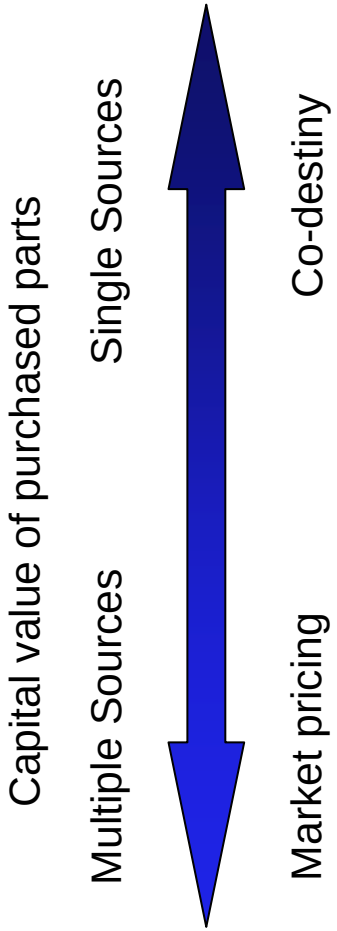
SWP 3.6DD (courtesy Siemens Wind Power)

UK offshore 2020 - Supply chain considerations

- **Quality**
  - Minimum 5 Sigma quality performance
  - Capable processes
  - First stage worst case 233 unsatisfactory DPPM (Delivered Parts Per Million)
  - Roadmap to world class 3.4 unsatisfactory DPPM
  - Right first time, every time
- **Process**
  - Lifecycle process support
    - Configuration management
      - Often known as traceability – but is not merely a question of recording serial numbers
      - Multi-source compatibility
      - Backwards compatibility / exchangeability
      - Product update facilities and procedure
      - Product upgrade options and process
      - National characteristics
    - Change management
      - *Specification* over five to seven year model lifetime
      - *Legal framework* as the national regulatory systems mature

Schuler 2.7MW (courtesy Schuler Pressen GmbH)

UK offshore 2020 – Supplier model



What do we need from our Suppliers?

- Proven ability to deliver
- Strategic Commitment to the Project
- World class cost and quality
- Decreasing Lead Times
- Contractual Commitment to the Project/CVT
- Sharing of risk
- Financial ability to fund the project
- Ability to commit at concept stage
- Technical assistance where needed
- Agreed background/foreground IPR
- Flexibility of delivery schedule
- Non Compete Clauses
- Integration capability

Qualifications

- **The growth hormone**
  - Manufacturing innovation to match your design innovation
  - Measures to guarantee delivery volumes
  - Demonstrably sound finance
  - A ‘can-do’ mentality
  - Commitment
- **The quality bug**
  - Attention to absolute detail
  - Methodical reliability
  - Perpetual simplification
  - Care
- **The desire**
  - The will to achieve a solution to the challenge we face

Lynn & Inner Dowsing (courtesy Centrica)

Let’s just do it!

Thank you for your attention

www.converteam.com

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