# MAKO

RENEWABLE ENERGY AND MARINE TRANSPORTATION INFRASTRUCTURE

# INTRODUCTION

Douglas Hunt, CEO at Elemental Energy Technologies Ltd

Infrastructure and real estate investment background, mainly M&A and fundraising.

Lawyer and Chartered Accountant, with fundraising and transaction focus.

EET had pioneered tidal energy technology, but was not cost-effective as a product.

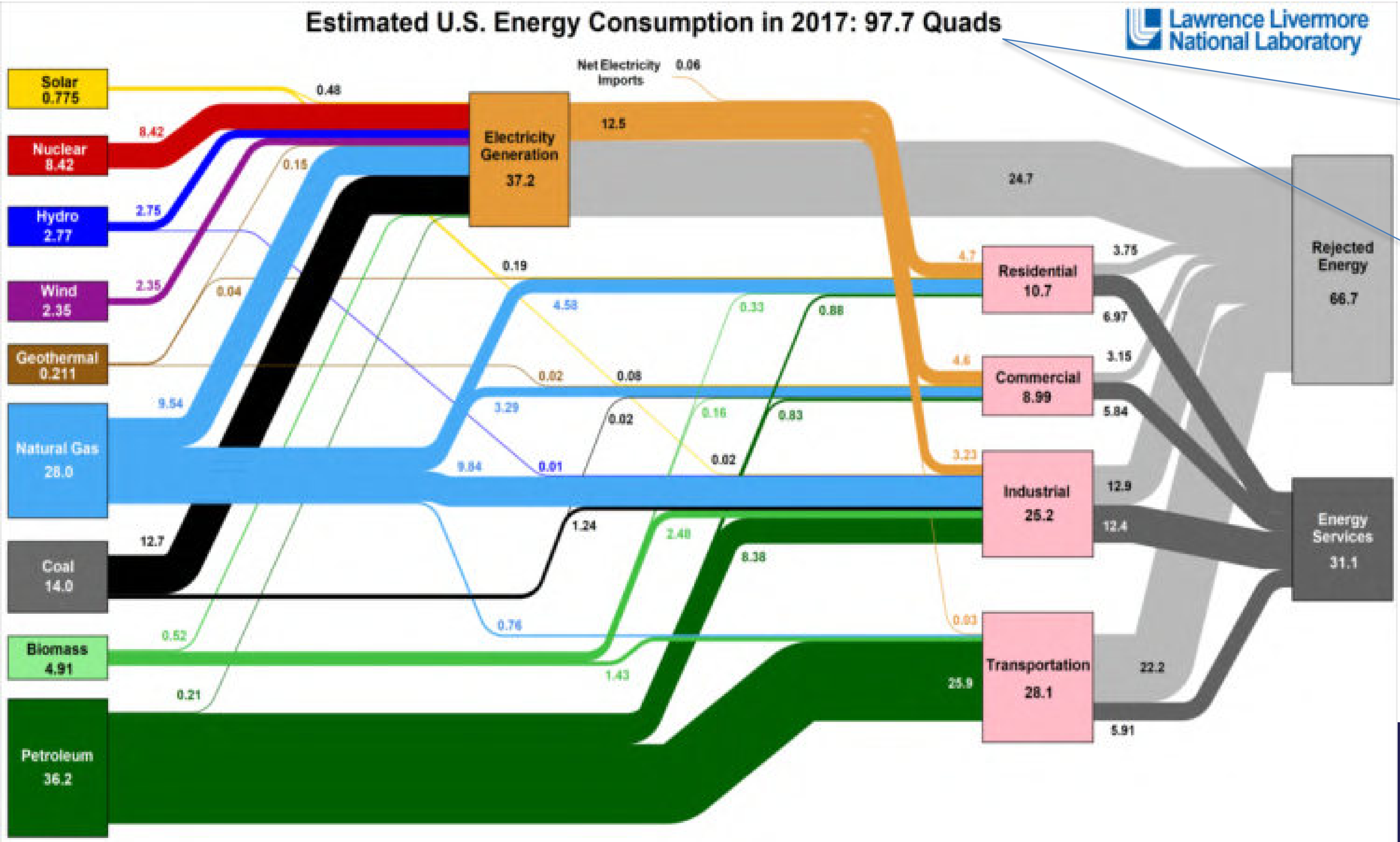
Key shareholders were convinced that a cost-effective tidal energy system could be developed.

Recruited a new team with diverse skillset, including automotive, aerospace, computing backgrounds.

Worked with potential customers to determine the optimal scale.

First product, the MAKO.7 being rolled-out at ports, bridges and tailraces canals.

# ENERGY LANDSCAPE




"Quad" =

- 8,007,000,000 gallons (US) of gasoline
- 293,071,000,000 kilowatt-hours (kWh)
- 293.07 terawatt-hours (TWh)
- 33.434 gigawatt-years (GWy)
- 36,000,000 tonnes of coal
- 970,434,000,000 cubic feet of natural gas
- 5,996,000,000 UK gallons of diesel oil
- 25,200,000 tonnes of oil
- 252,000,000 tonnes of TNT
- 13.3 tonnes of uranium-235

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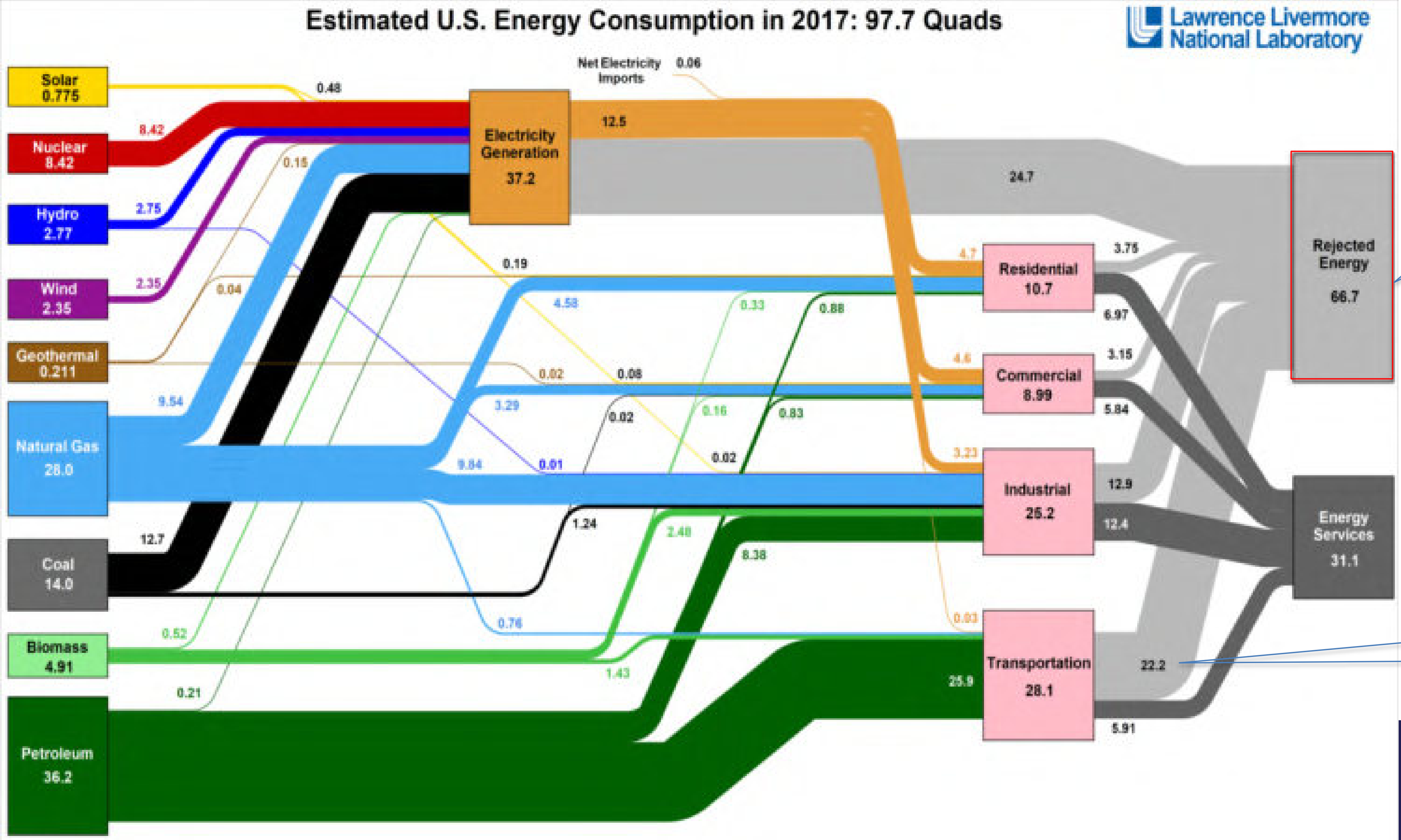


>70% of energy is wasted ! ! !
66.7 / 97.7

80% energy wasted in transport sector

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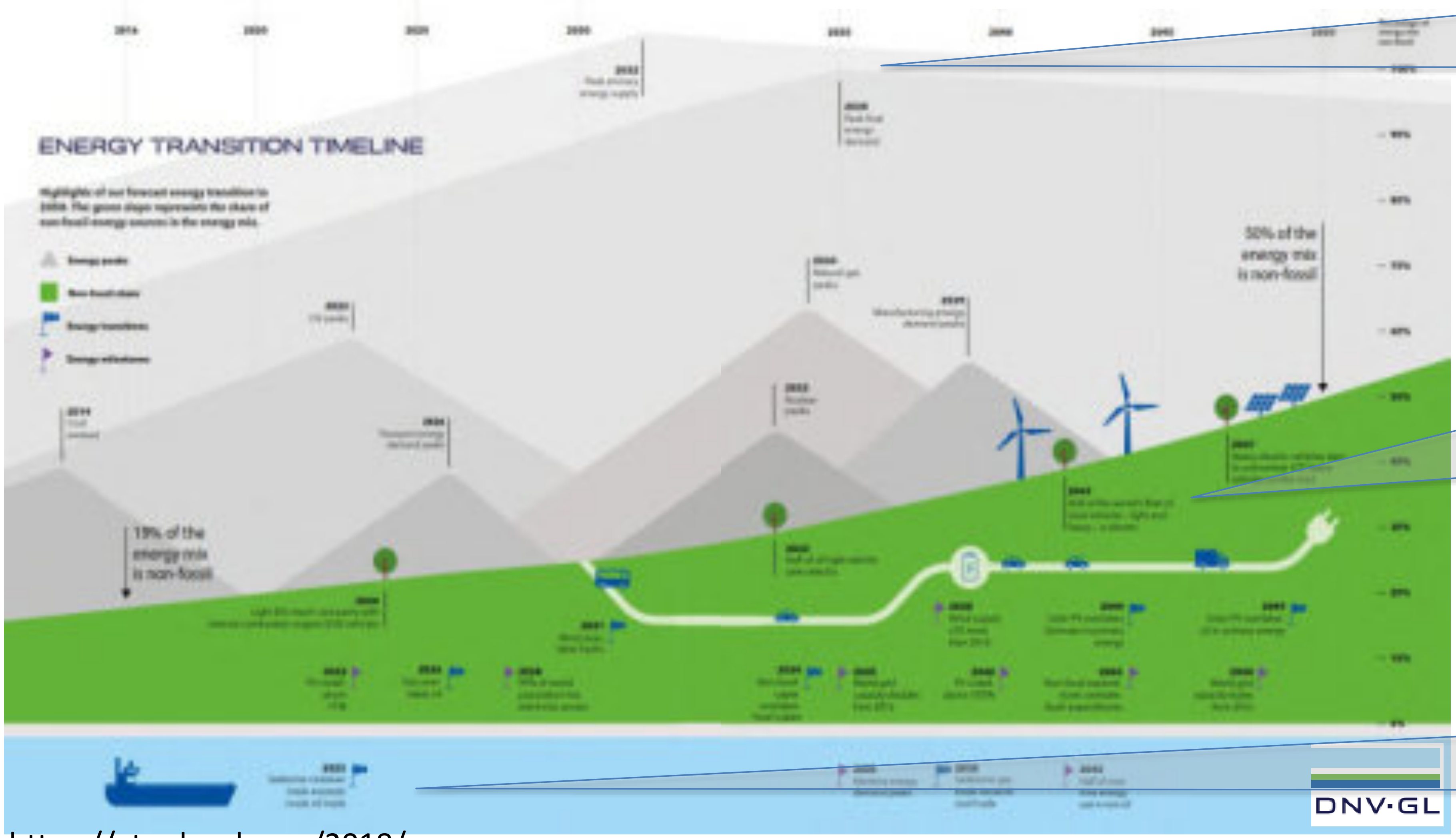
# ENERGY OUTLOOK




**"Peak Energy" in 2035**

*The triumph of energy efficiency over growth*

**Growth in Renewables**

*Cost reductions and regs drive substitution*

**Secondary Impacts**

*Cargo mix changes, as does transport energy*

https://eto.dnvgl.com/2018/

# ENERGY OUTLOOK – DNV-GL FINDINGS

HIGHLIGHTS OF DNV-GL REPORT

**1. The world will need less energy from the 2030s onwards owing to rapid energy efficiency gains; we forecast that primary energy supply will peak in 2032.**

2. The world's energy system will decarbonize, with the 2050 primary energy mix split equally between fossil and non-fossil sources.

3. Oil demand will peak in the 2020s and natural gas will take over as the biggest energy source in 2026. Existing fields will deplete at a faster rate than the decrease in oil demand. New oil fields will be required through to 2040.

4. Electricity consumption will more than double by mid-century to meet 45% of world energy demand, and solar PV and wind energy will supply more than two thirds of that electricity.

5. The energy transition is affordable. As a proportion of world GDP, expenditure on energy will be lower in 2050 than today. Big shifts in investments are expected: more capex will go into grids and renewables than into fossil projects from 2029 onwards.

6. The rapid transition we forecast will not be sufficient to achieve the less than 2° C climate goal. A combination of more energy efficiency, more renewables and more carbon capture and storage (CCS) is needed to meet the ambitions of the Paris Agreement.

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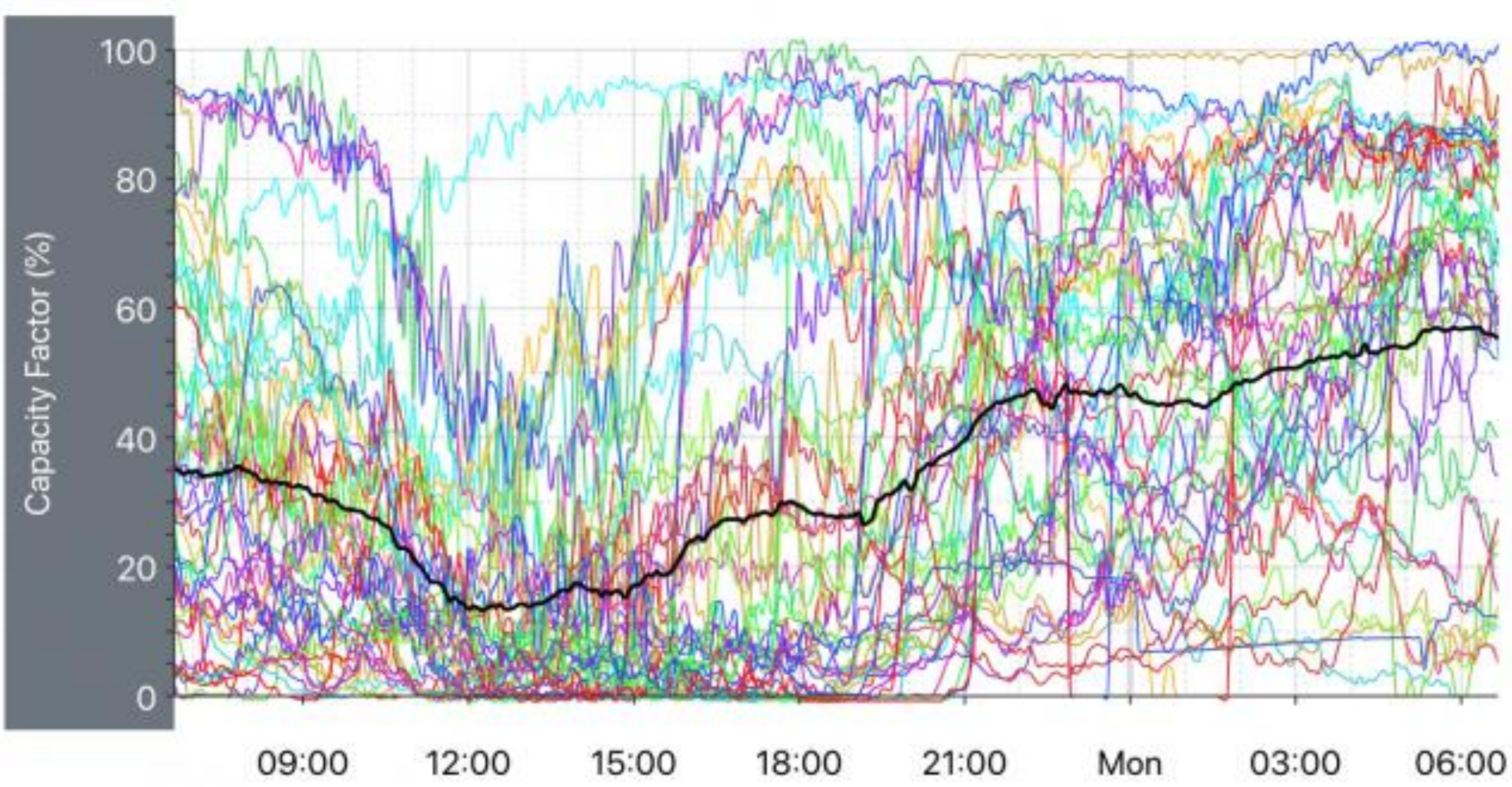


https://anero.id/energy/wind-energy

**Not an abstract artwork**

Graph of the electricity output from all Australian wind farms over a single day



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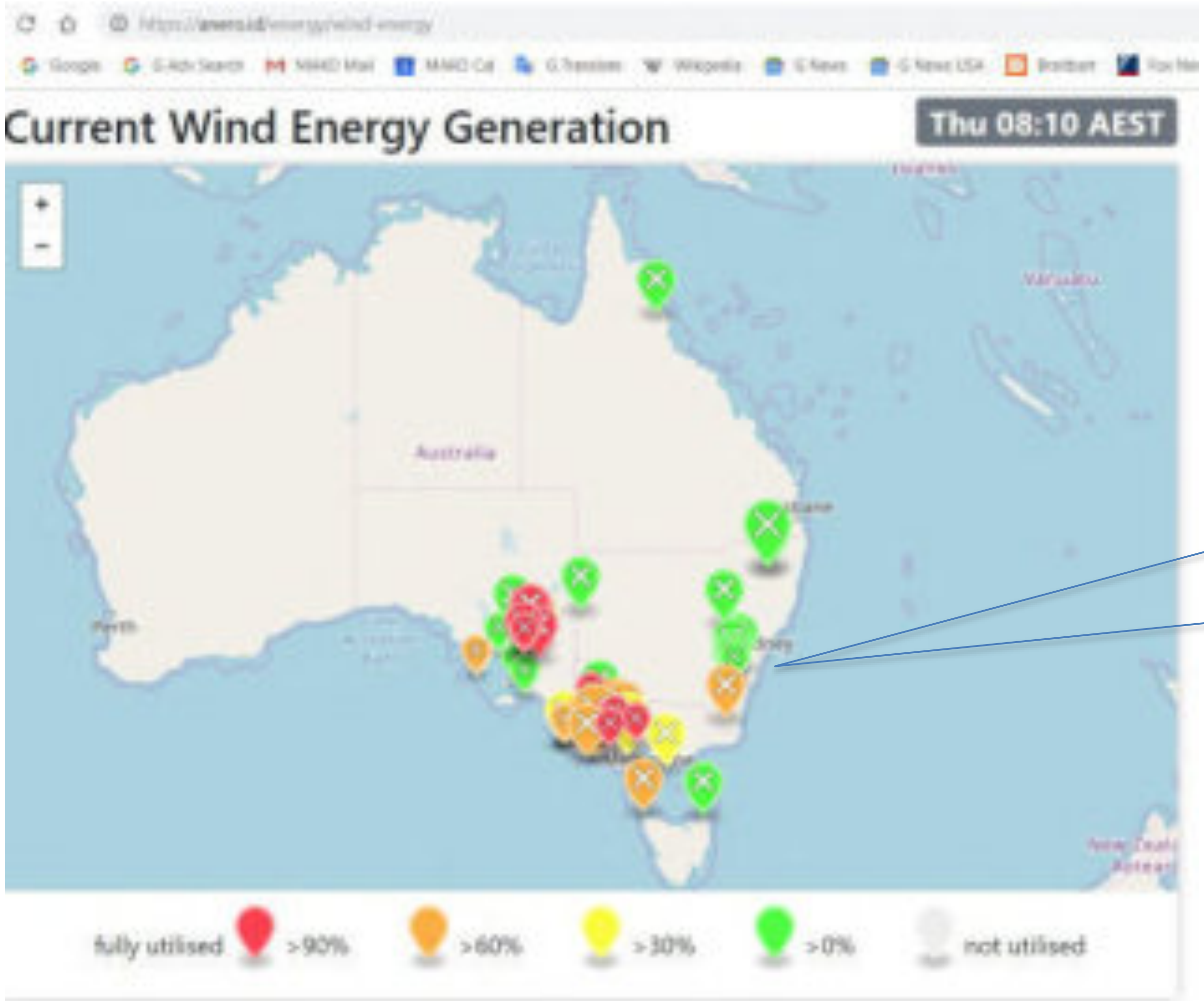
# RENEWABLE ENERGY IN AUSTRALIA

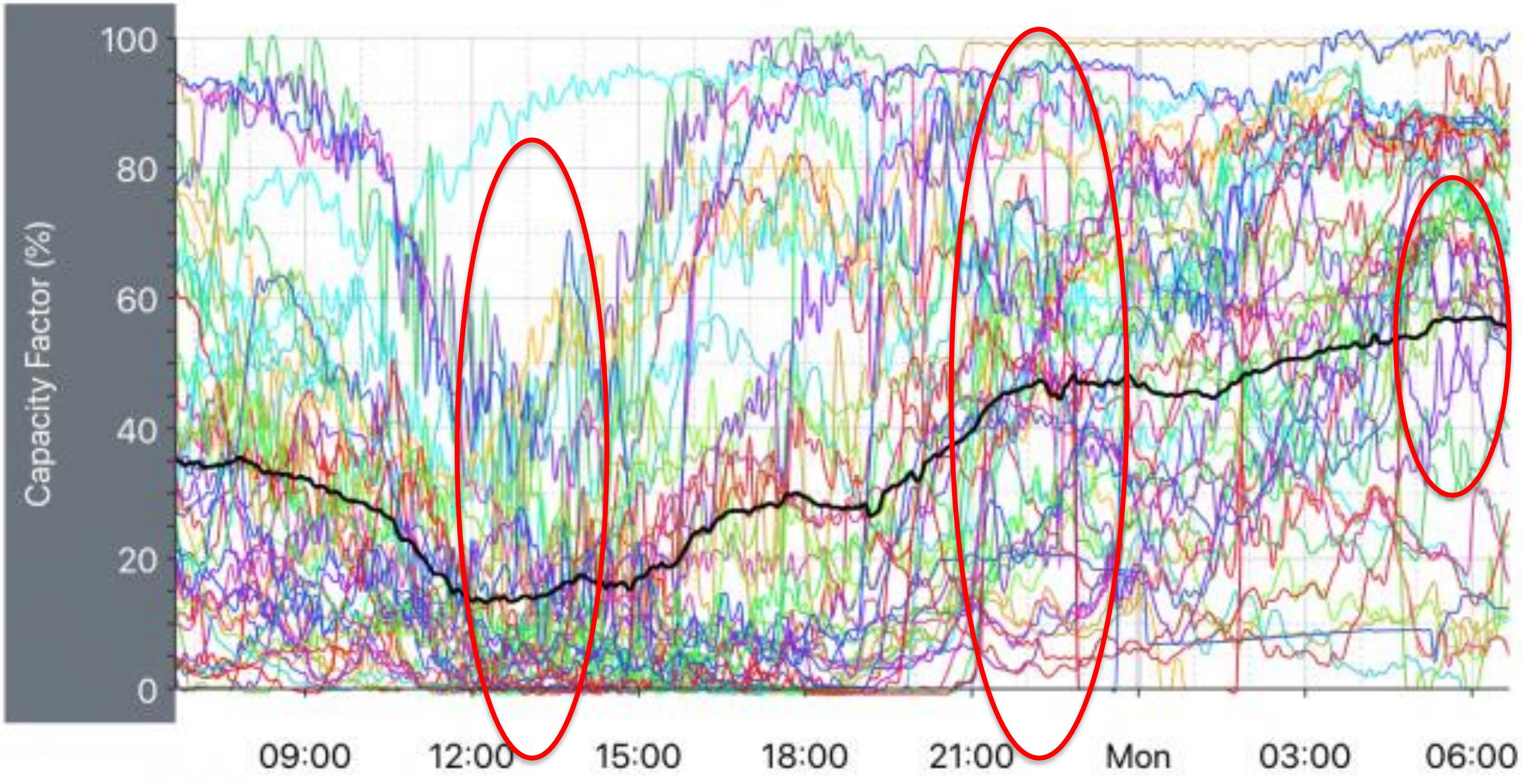



Utility-scale wind farms connected to the East Coast Grid – the longest interconnected grid in the world.

6,160MW total rated output

Average Capacity Factor of 30-35%

# ENERGY OUTLOOK




Points to note:

Correlation across Australia at mid-day and diversification 6 hrs later

Peak daily output at 5:00 AM

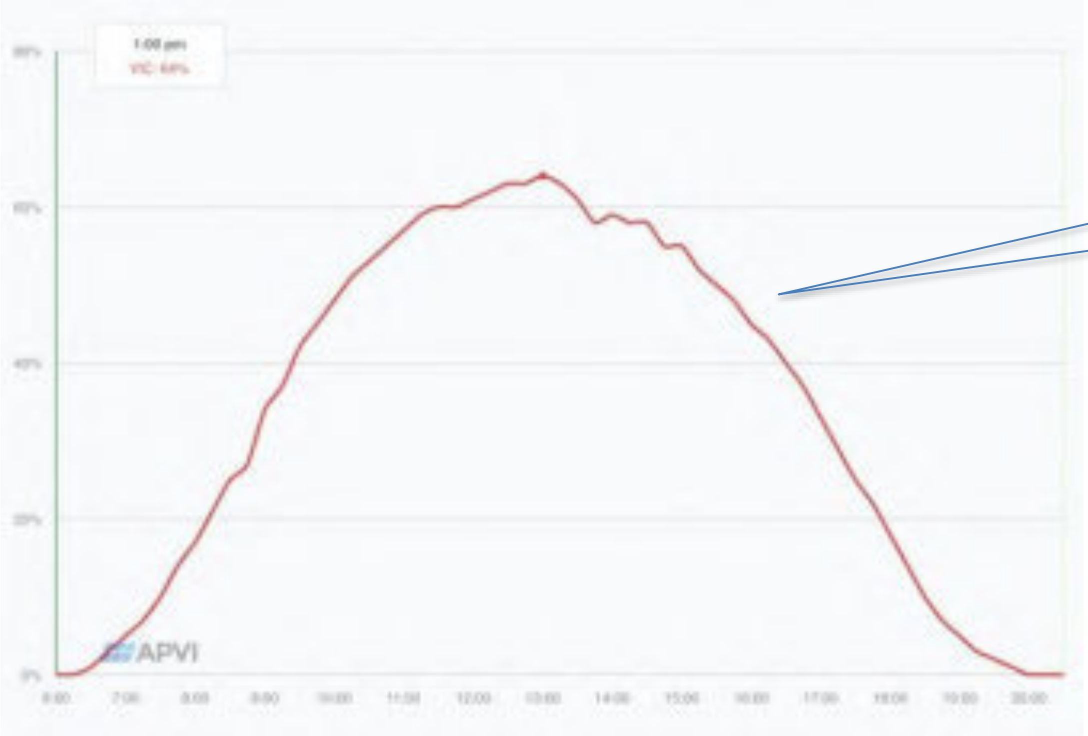
https://anero.id/energy/wind-energy

# ENERGY OUTLOOK

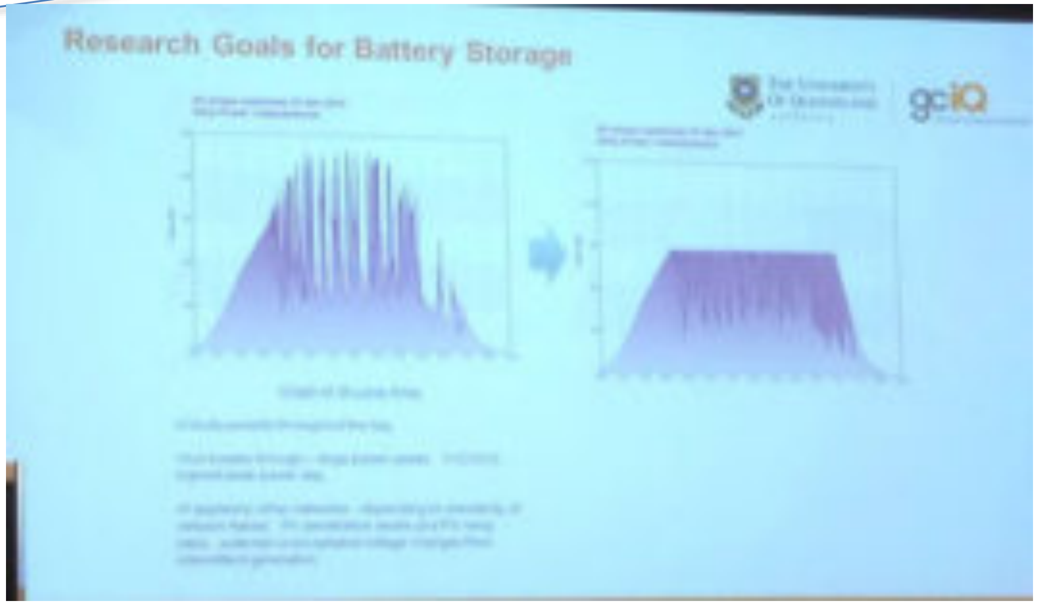
Typical pattern of generation of electricity from solar PV.

Note time of day correlation.

Total output affected by individual clouds, not just persistent overcast weather.




Solar power profile in Victoria on Tuesday 13 November 2018.
Source: http://pv-map.apvi.org.au/live#2018-11-13



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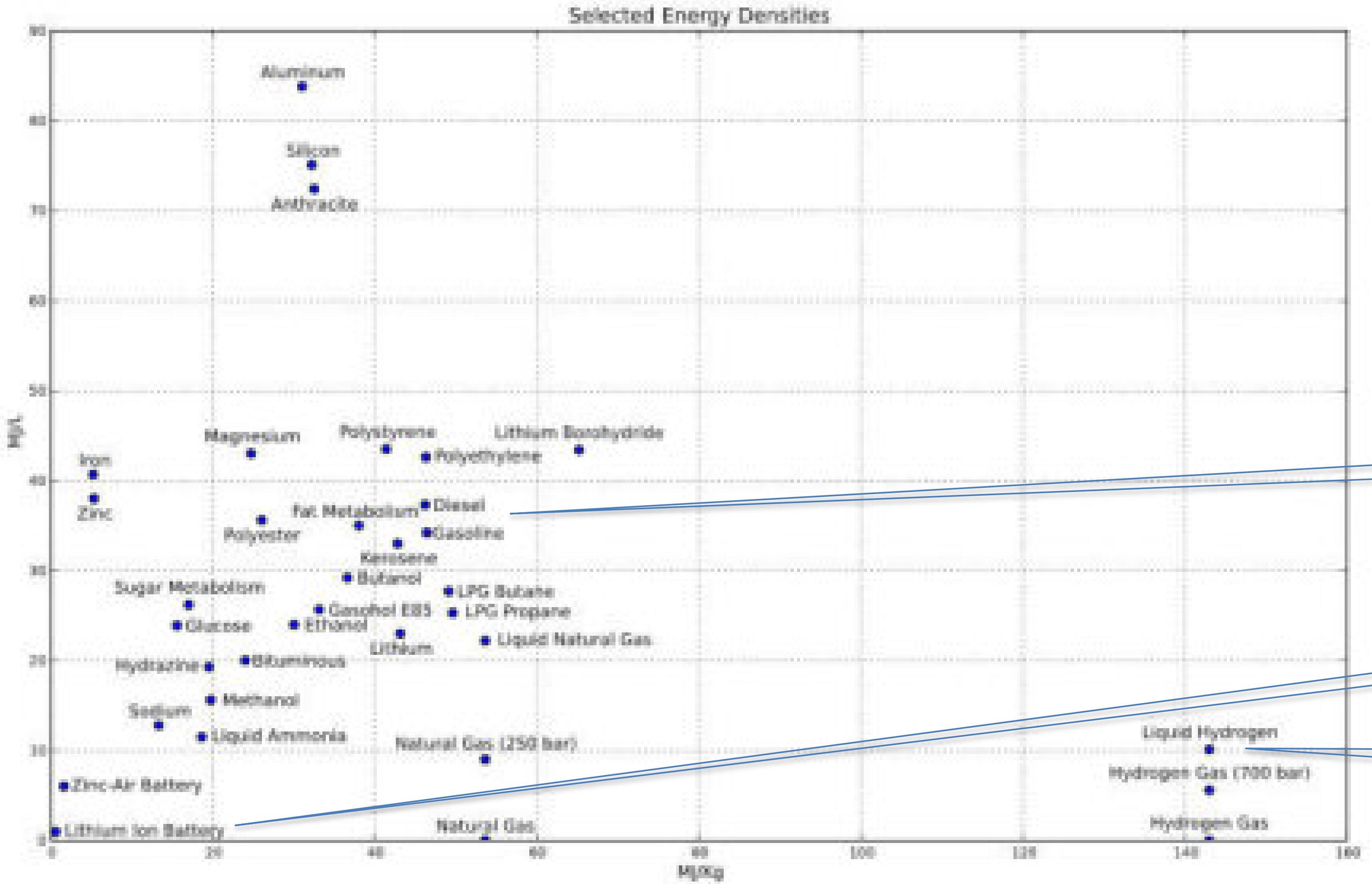



Energy Density of various materials, fuels and batteries

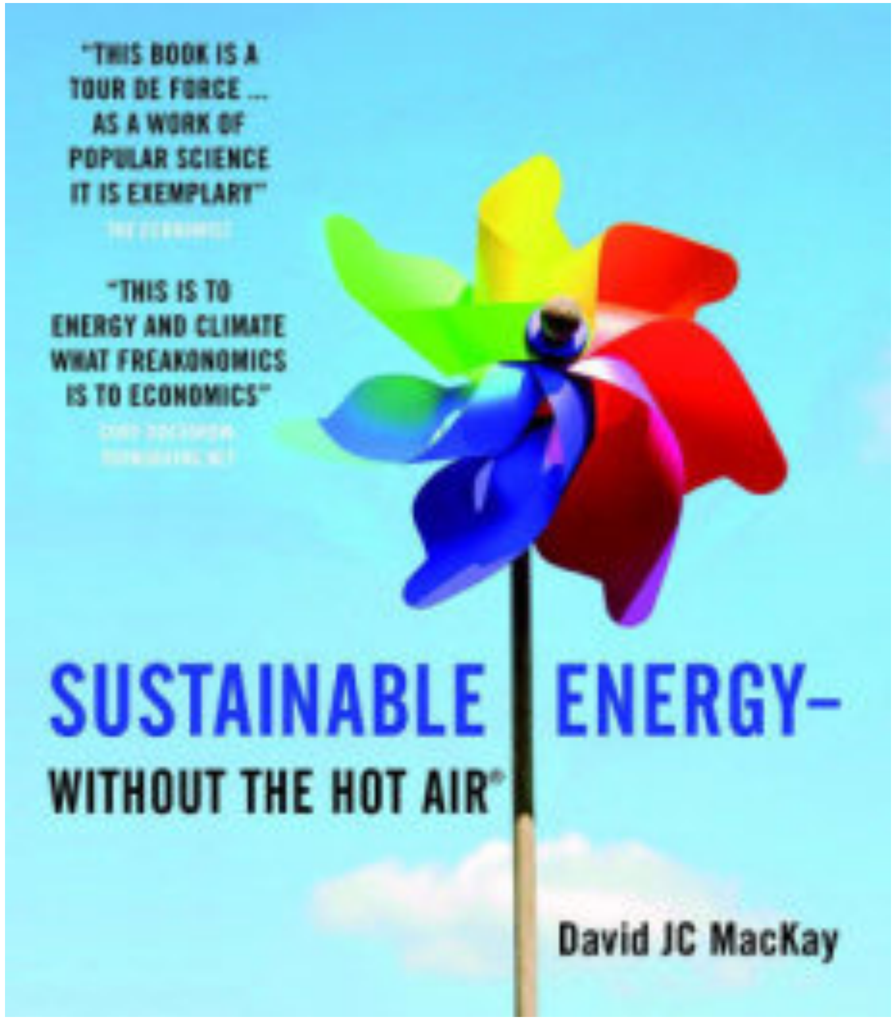
Note low capacity of Lithium Ion battery

Hydrocarbons for transport

Lithium Ion Battery

Liquid Hydrogen

# "JUST THE FACTS"




*David latterly achieved cult status among climate and energy aficionados following the publication of Sustainable Energy: Without the Hot Air (2008), initially self-published using £10,000 of David's own money and offered – as were all his works – simultaneously free for download on his website. Described as a "tour de force" by the Economist magazine and lauded by Bill Gates as "one of the best books on energy that has been written", within two years it had sold 40,000 copies and been downloaded nearly half a million times.*

# RELEVANCE TO TRANSPORT INFRASTRUCTURE


*Diagram from North Queensland Bulk Ports Sustainability Plan 2015+*

WPSP
WORLD PORTS SUSTAINABILITY PROGRAM

*Gladstone Ports Corporation*

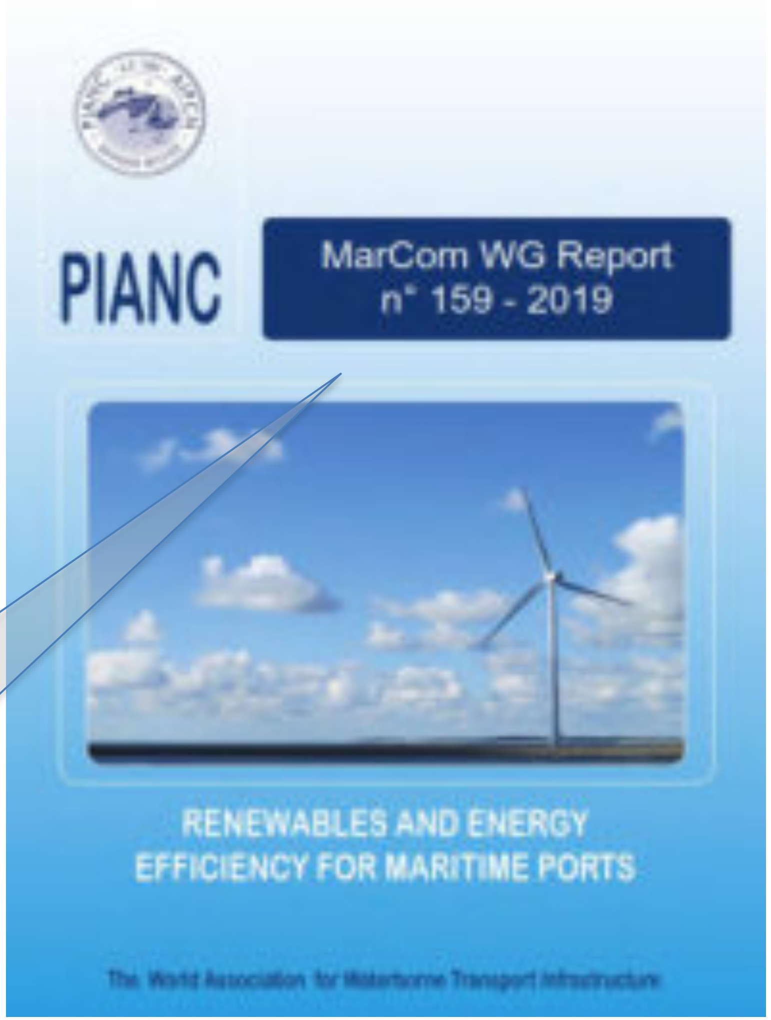
1. *Smart Port operations: driving smart, safe and efficient business operations*
2. *Our environment: supporting science and understanding our environments*
3. *Workplace and people: strength, diversity and resilience with transparency*
4. *Planning a bright future: efficient, responsible and resilient plans*
5. *Port communities: integrating with communities and ongoing learning. The plan will be reviewed each year to ensure NQBP remains abreast of emerging industry trends and new technologies.*

**Ch 2 - Energy Usage**

**Ch 3 - Energy Efficiency**

**Ch 4 - Renewable Energy**

**Ch 5 - Conclusions**



# MARCOM WG REPORT - MAIN ENERGY USAGE AT PORTS

**2 ENERGY IN MARITIME PORTS**

**2.1 How Energy is Used in Maritime Ports**
2.1.1 Energy Consumption and Greenhouse Gas Emissions
2.1.2 Components of Energy Consumption
2.1.2.1 Industrial Activities
2.1.2.2 Containerisation and Container Volume Growth
2.1.2.3 Liquid Bulk
2.1.2.4 Upland Storage
2.1.2.5 Port Operations
2.1.3 Key Drivers of the Energy Transition in Ports

**2.2 Inventory of Energy Consumption Within a Maritime Port – Questionnaire**
2.2.1 Responses Overview
2.2.2 Key Performance Indicators (KPIs)

**2.3 Development of an Energy Masterplan**
2.3.1 Energy Demand Forecast
2.3.2 Electrical Power Systems
2.3.2.1 Transmission Capacity
2.3.2.2 Redundancy
2.3.2.3 Voltage and Frequency Level
2.3.2.4 Local Connection of Renewable Energy Sources and Other Types of Local Power Generation
2.3.2.5 Flexibility
2.3.3 Infrastructure for other Energy Carriers and Utilities
2.3.4 Assessment of Potential of Energy Efficiency
2.3.5 Case Studies
2.3.5.1 Port of Hamburg
2.3.5.2 Port of Livorno
2.3.5.3 Port of Rotterdam – Maasvlakte 2



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# MARCOM WG REPORT - ENERGY EFFICIENCY OPPORTUNITIES

**3.1 Opportunities and Challenges**
3.1.1 Container Terminals
3.1.2 Dry Bulk
3.1.3 Liquid Bulk and Tank Storage
3.1.4 Break Bulk
3.1.5 Waste Treatment Facilities
3.1.6 LNG
3.1.7 Case Study – Port of Felixstowe

**3.2 Energy Storage Systems**
3.2.1 Technology
3.2.1.1 Batteries
3.2.1.2 Super Capacitors
3.2.1.3 Flywheel
3.2.2 Mobile Equipment
3.2.3 Balancing of Renewable Energy
3.2.4 Ess Conclusion

**3.3 Shore-To-Ship Power Supply**
3.3.1 Shore Power Technology
3.3.1.1 Grid Connection
3.3.1.2 Intake Station/Main Distribution System
3.3.1.3 Frequency Conversion
3.3.1.4 Distribution Board Shore Power
3.3.1.5 Shore Power Connection Points
3.3.2 Economic Aspects of Shore Power
3.3.3 Shore Power Feasibility
3.3.4 Alternative Solutions
3.4 Smart Grids in a Port Area
3.4.1 Traditional Grid
3.4.2 Local Power Generation
3.4.3 Smart Grid Technology Application
3.4.5 Advantages of Smart Grid Technology for Ports
3.4.6 Consequences of Smart Grid Technology Application
3.4.7 Future Considerations

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# MARCOM WG REPORT - RENEWABLE ENERGY UPTAKE

**4.1 Solar Energy**
4.1.1 Photovoltaic Energy (PV)
4.1.1.2 Equipment
4.1.1.3 Implementation Options
4.1.1.4 Feasibility Aspects
4.1.2 Solar Heater

**4.2 Wind Energy**
4.2.2 Onshore
4.2.2.1 Operations and Maintenance Planning
4.2.2.2 Grid Integration
4.2.3 Nearshore
4.2.3.1 Design and Planning
4.2.3.2 Grid Integration
4.2.3.3 Decommissioning
4.2.3.4 Operations and Maintenance

**4.3 Ocean Energy**
4.3.1 Tidal Energy Converters (TEC)
4.3.1.1 Device Type
4.3.1.2 Power Take-Off Systems
4.3.1.3 Mooring Solutions
4.3.1.4 Case Study
4.3.2 Wave Energy Converters (WEC)
4.3.2.1 Resource Evaluation
4.3.2.2 Case Studies



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# MAKO AT GLADSTONE PORT – A CASE STUDY

Tidal turbines have been very large, often based on wind turbine designs.
This has limited their application to inshore sites, such as ports.



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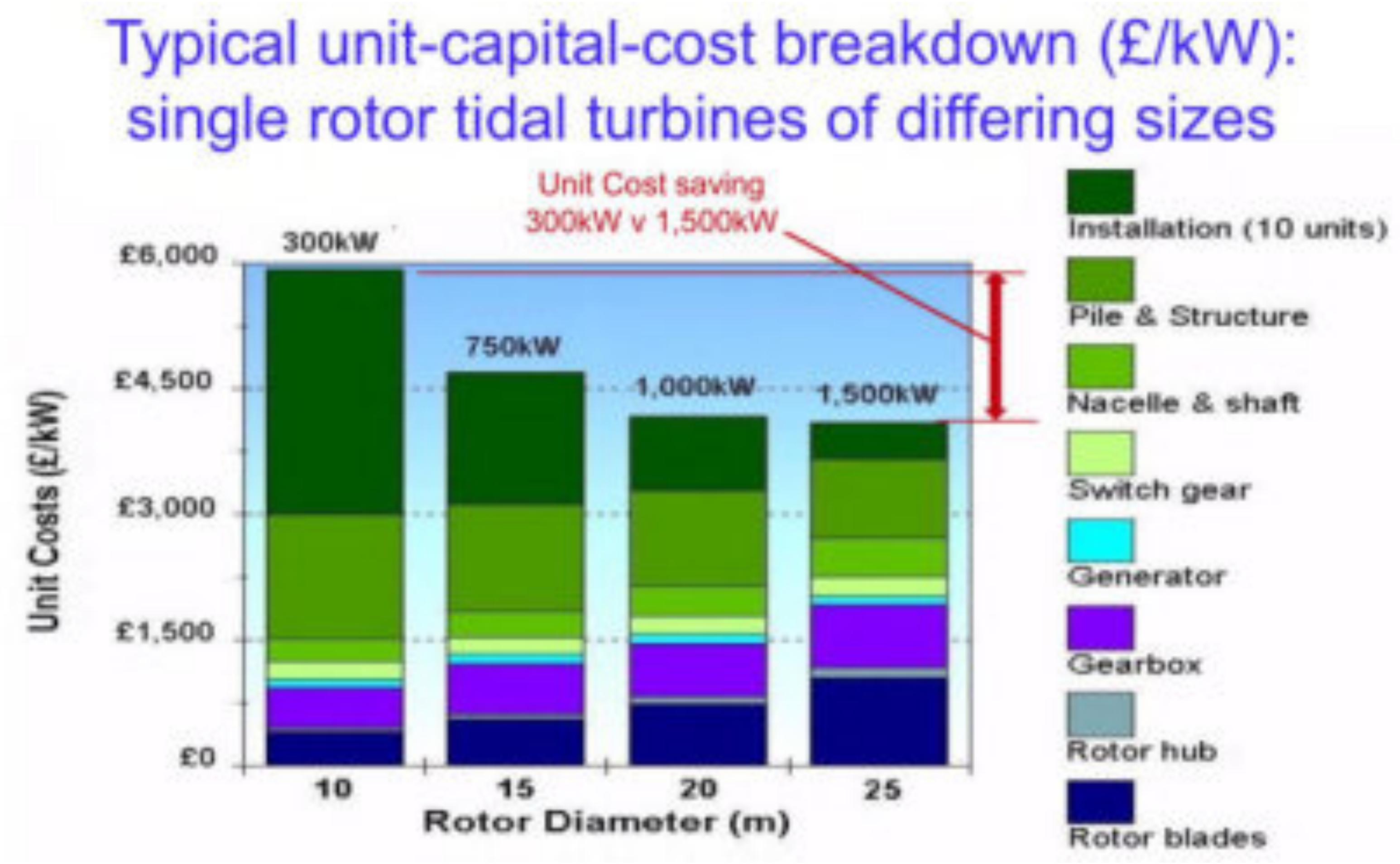
# MAKO – OUR PERSPECTIVE




Fraenkel, "Scaling Up: the only way for tidal turbines to become commercially cost-competitive"
ICOE-2016 (and ITES 2015)

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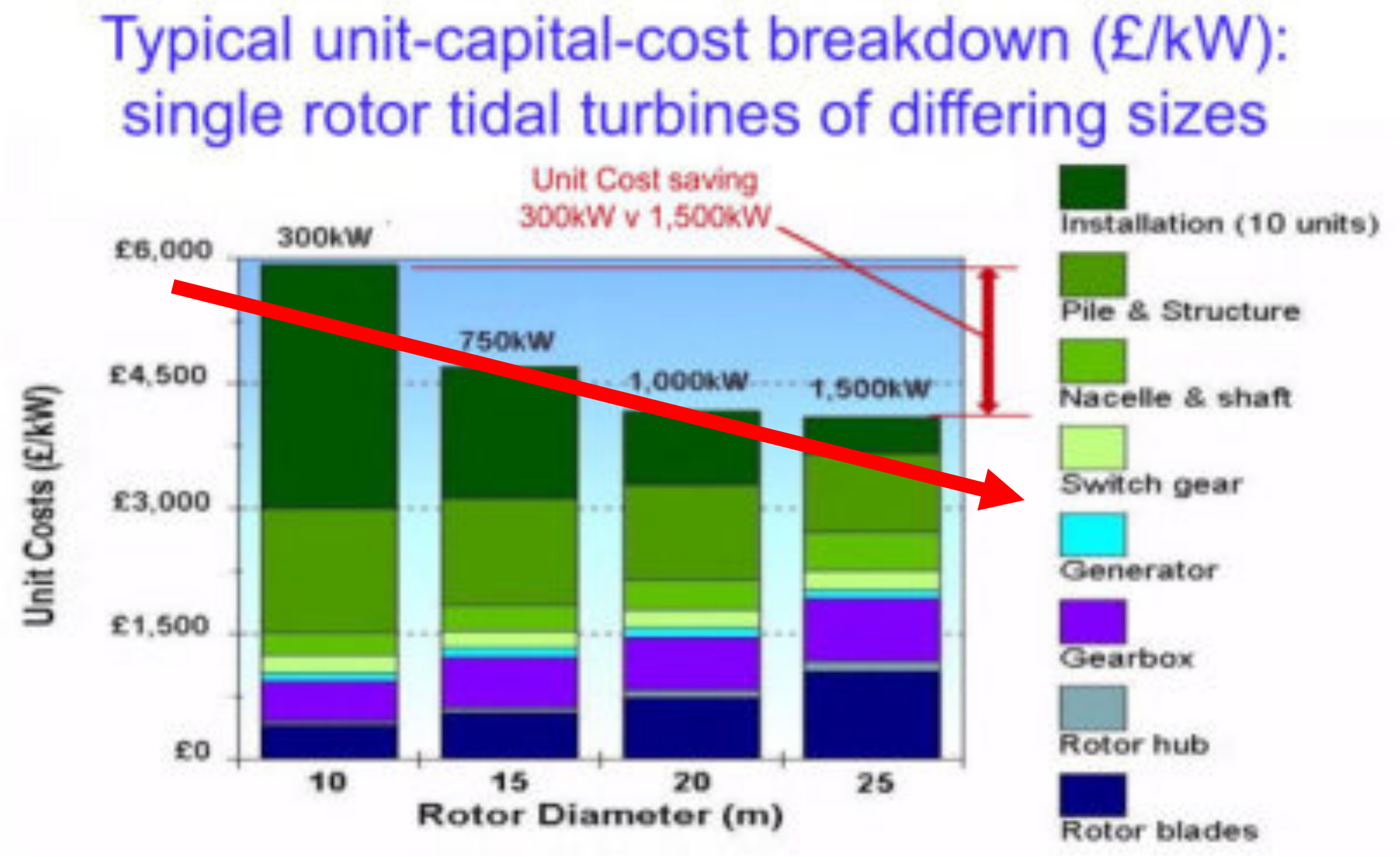


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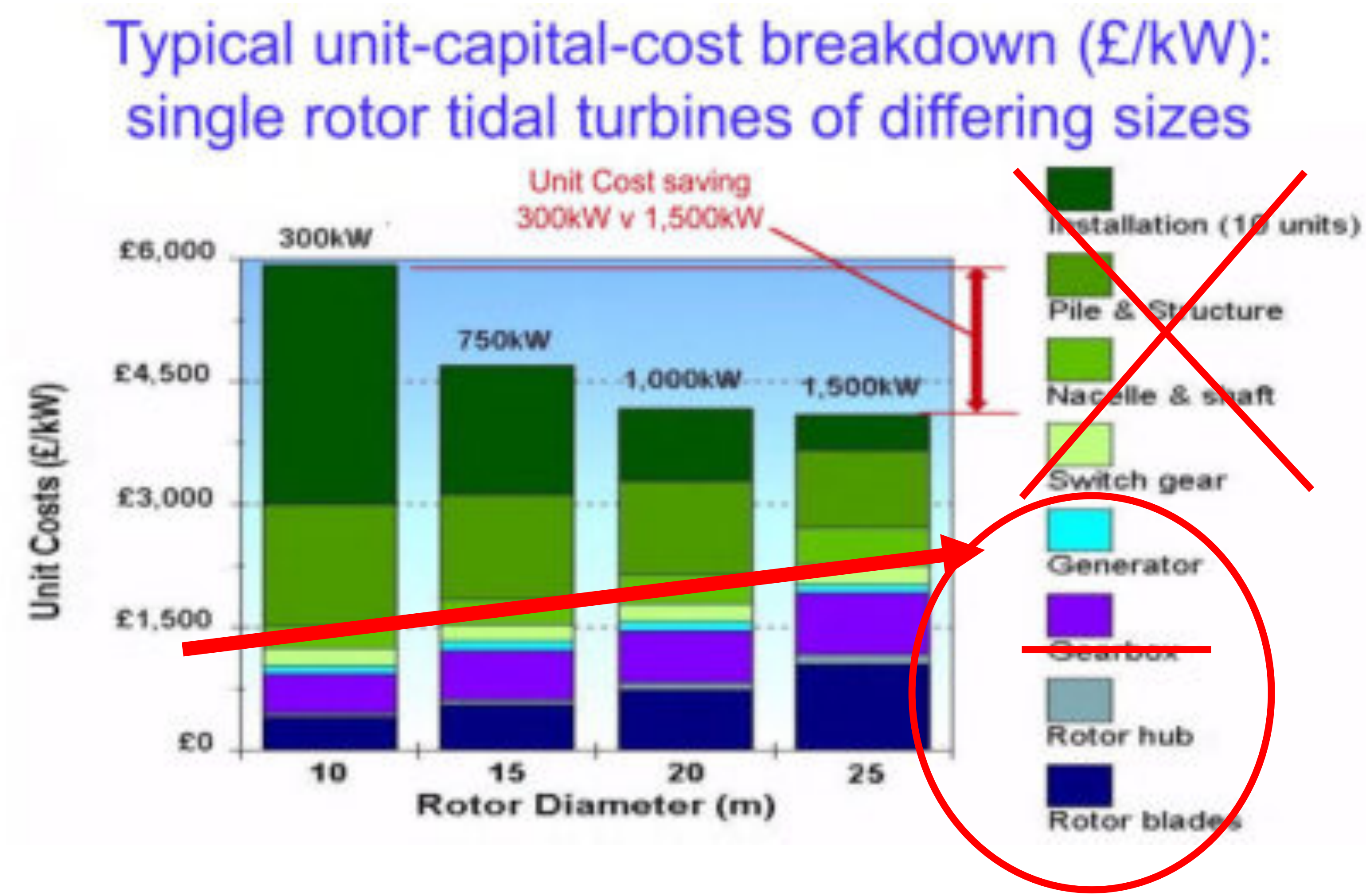


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# MAKO AT GLADSTONE PORT – A CASE STUDY

Scalable turbine technology

Focus on an immediately addressable market


Opportunity

- **Scale:** small turbine unit sizes, ~2m sweep
  Lower cost of production, rapid learning loop
- **Attachment:** pre-existing infrastructure
  Save costs of at-sea deployment, operations and maintenance
- **Resource:** slow to medium velocity range
  More abundant potential sites

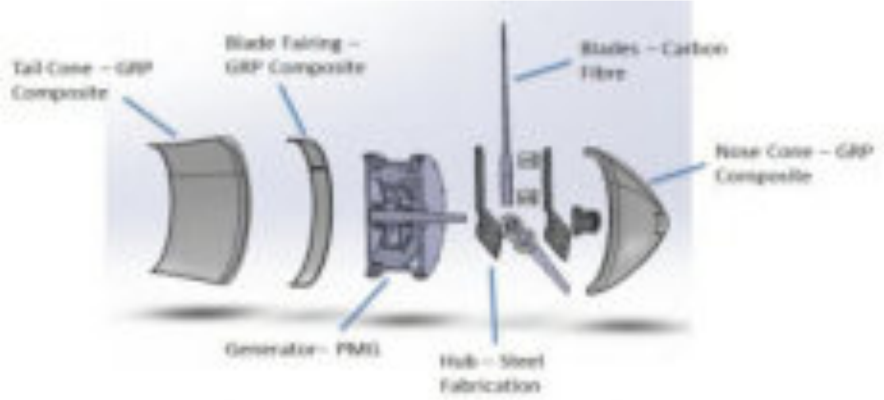
# THE MAKO TIDAL ENERGY SYSTEM

MAKO.7 tidal turbine

- 2m sweep, rated 3 kW @ 1.67 m/s (max < 3m/s)
- 30-100 rpm, direct-drive PMG
- CFD designed, patented, AMC verified

Energy system

- PTO to conditioning to grid compliance
- Integration with storage




Management solution

- On-board autonomous operation
- SCADA remote control via cellular
- Edge-to-cloud link for data analysis



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# SHARED VISION


Partnership with
Gladstone Ports Corporation

- Leading sustainability program
- Formed initial project for 6 month turbine deployment
- Identified multiple candidate sites on wharf
- Settled on Barney Point Wharf end mooring dolphin due to access and reduced marine operations



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# RESOURCE POTENTIAL

Conducted Resource Assessment survey

- Flow sensors for few months
- Semidiurnal tidal cycle
- Peak velocity ~1.5m/s

Investigated structural attachment options

# PATHWAY TO DEPLOYMENT

No template for necessary approvals, unclear process

- Championed by GPC

Process in review:

1. Notify relevant bodies (government departments, utilities, etc)
2. Pre-lodgement of plan to all key parties
3. Submission of plan for review and response (approvals)
4. Marine fauna management plan
5. Tidal works application
6. RPEQ sign-off (professional-engineer) for both mechanical and electrical systems
7. Conduct tidal works (install support structures)
8. Electrical “micro embedded generation connection agreement” from utility: check anti-islanding, power quality and harmonics
9. Qualified utility contractor to do the final electrical connection
10. Turbine attachment and commissioning

Pathway to deployment = zero-order challenge of the ORE industry? Big opportunity to work together

- Recommend “graduated” process requirements, scaled by power output and loads of device

Entities:

- Dept. of Natural Resources, Mines & Energy
- Dept. of State Development, Manufacturing, Infrastructure and Planning
- Great Barrier Reef Marine Park Authority
- Regional Harbour Master
- Engineers Queensland (structural sign-off)
- Ergon Energy (utility)
- RPEQ professionals
- …more…



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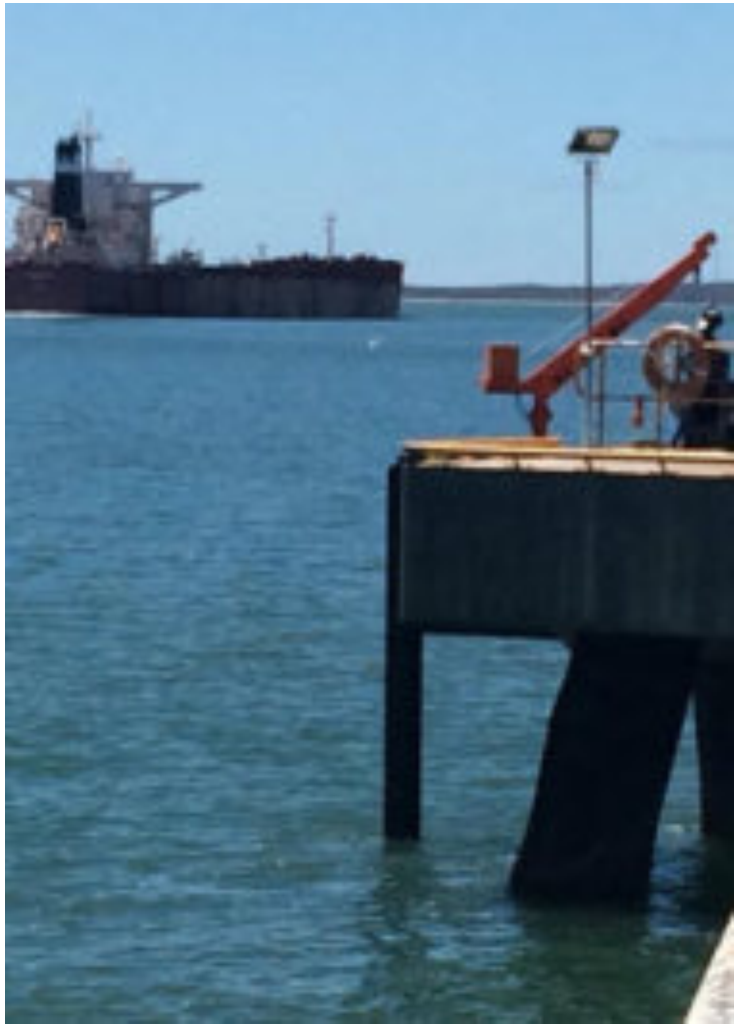
# DEPLOYMENT

- Trolley and rail system to connect the turbine
- I-beam for cable management
- Crane and cable winch to raise and lower the turbine
- Single direction captured in first instance (ebb tide)
- ~2m below low-tide
- MIPEC designed, fabricated and attached to mooring dolphin



# SAFE COMMISSIONING

Launch with go-slow strategy

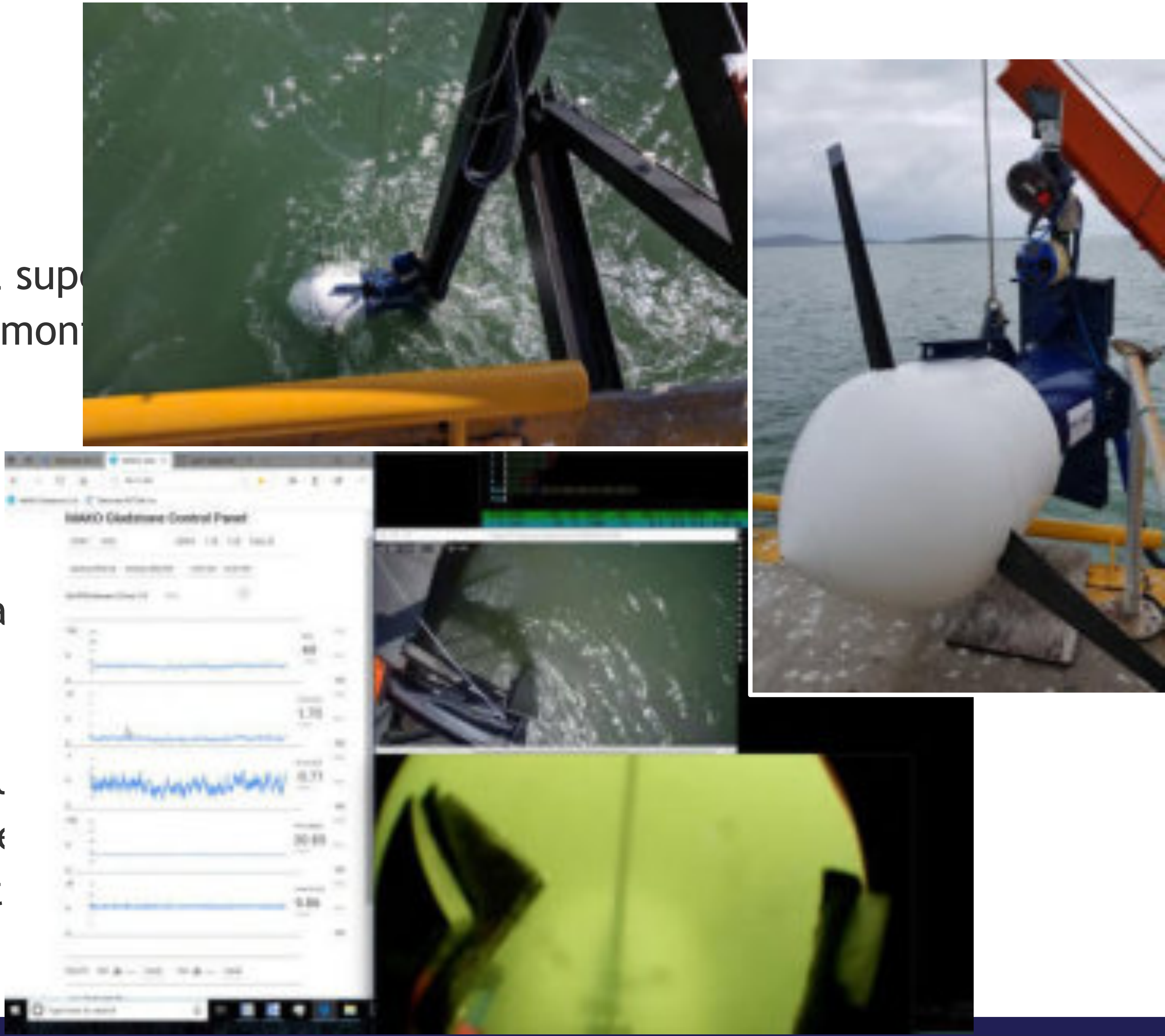
- Operate the turbine under manual sup
- Limit the turbine RPM during first mon

Real-time monitoring and alarms

- Sub-sea and top-side cameras
- 3-axis accelerometer
- Focus on marine life interaction (a

Actions

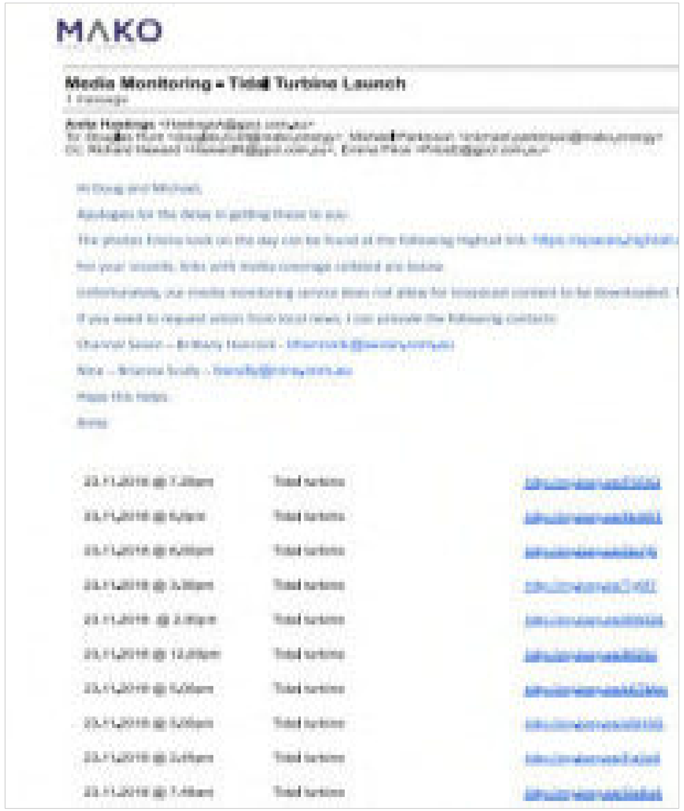
- Alarms trigger brake and stop of tu
- Post-event review (video, data stre
- Crane and winch can remove the t



# MEDIA COVERAGE

Opening of Gladstone Tidal Demonstration Site reached around 1M people via radio, television, newspapers and online.

Favourable publicity for MAKO, GPC  - and importantly the Queensland Government as shareholder.


MAKO

Media Monitoring - Tidal Turbine Launch

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# NEXT STEPS AT GLADSTONE

Finalise commissioning

- Phasing-in automatic control
- Safety limits in-place, manual override when required

Expanding environmental sensor suite

- Real-time/offline analysis for active controls

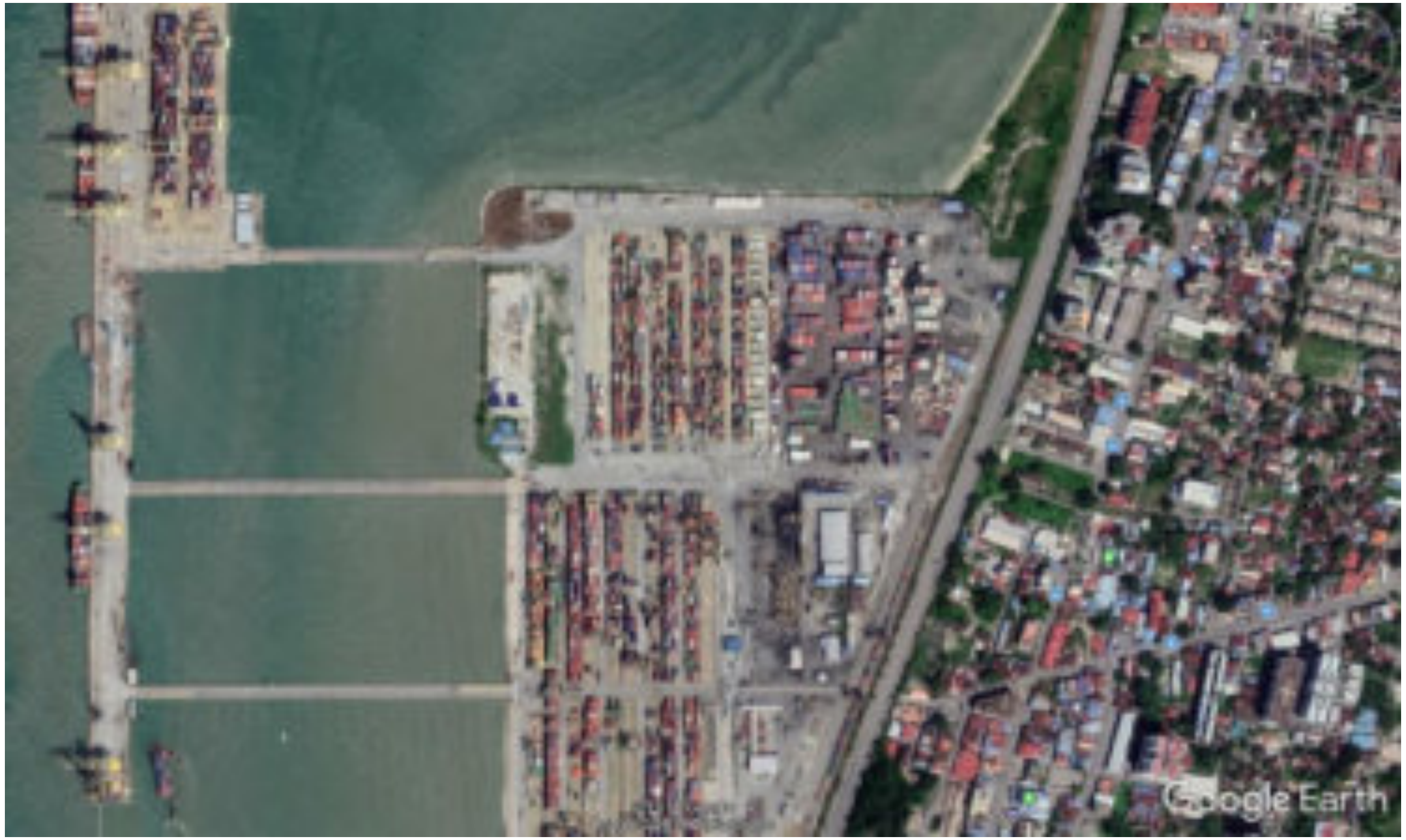
Collect and document

- Continue to gather data (compressed 10 GB/month)
- Ensure all compliance metrics clearly reported

Target bi-direction deployment system for future deployment project

# NEXT STEPS GLOBALLY

Elevated roadway 22km long bridge in North Asia.
*Note wake turbulence from tide flowing past pylons.*




Port in South East Asia.
*Note wake turbulence from tide flowing past pylons in unused seabed area.*



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# TIDAL ENERGY CHECKLIST

- Tidal energy output increases with the cube of velocity
  Minimum velocity of around 1.5m/sec or 3 knots maximum

- Tidal energy output increases with the square of diameter
  Minimum depth of around 6.0 metres at dead low tide

- Costs are minimised if equipment underwater is minimised
  A wharf within around 100m allows power electronics to be on dry land

- Maintenance costs minimised if vehicle access is possible
  Access by truck/utility is much cheaper than by boat

- Distributed generation by tidal energy can reduce CapEx
  In many situations, expensive connection to the grid can be avoided/minimised


*Increasing flow velocity*



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# MAKO'S GLOBAL ROLL-OUT STRATEGY

EET has established demonstration sites in key locations to show the benefits of the MAKO Tidal Turbine System in various large markets.

Initially, EET is focused on large and well-resourced launch customers who have a potential appetite for large number of MAKOs. As warranty experience and supply chain develops, EET will expand in parallel to the more profitable diesel-generator replacement market in off-grid locations.

Pre-IPO funds will allow expansion of business development resources to generate a pipeline of orders, with IPO funding used to fulfil these initial orders and accredit manufacturing and installation partners. Income will be predominantly earned from direct sales of MAKOs, with royalty sales growing as initial manufacturers and installers with local knowledge and contacts take on business development activities themselves.

**Bridge Pylon Deployment**

**Singapore**
Bridge Deployment approved. SEA Demo Site

**Ocean Currents**

**Japan**
Deployment in ocean currents..


**Resource Assessment and Islands**

**Bougainville, PNG**
Tidal Resource Assessment and planning R E Grid

**Canals and Tailraces**

**Eraring, NSW**
Potential to demonstrate for canals and tailraces

**Ports and Harbours**

**Gladstone, QLD**
Installed at Port site. Environmental monitoring

**Income of A$500k in 2018/9. Further $3M of pipeline under discussion. Target A$20M of contracted sales by IPO, with funds raised to fulfil orders**



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# QUESTIONS ??

. . . thank you !