scottish renewables

HYDRO CONFERENCE & EXHIBITION

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Claire Mack

Chief Executive

Scottish Renewables

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The future of hydropower: matching policy ambition to development realities

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Hannah Smith

Senior Policy Manager

Scottish Renewables

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Our Hydro Work: A recap 2018-2019

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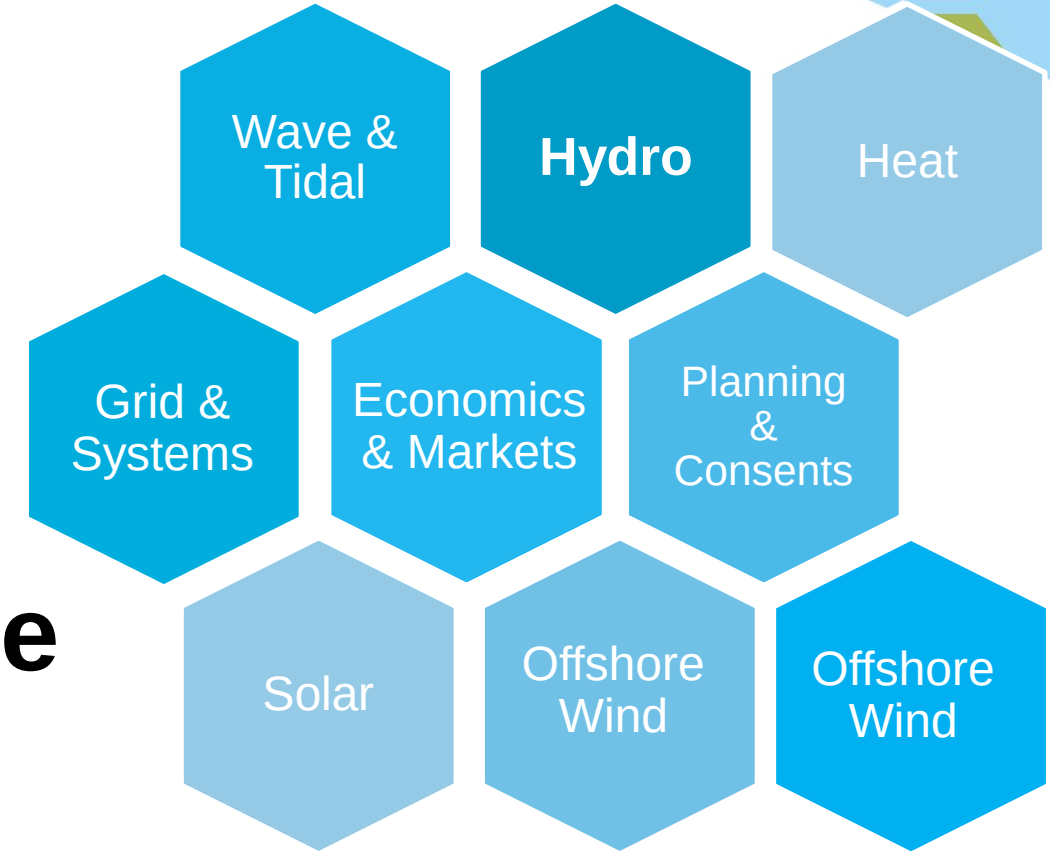
Member Forums: How you can engage with SR



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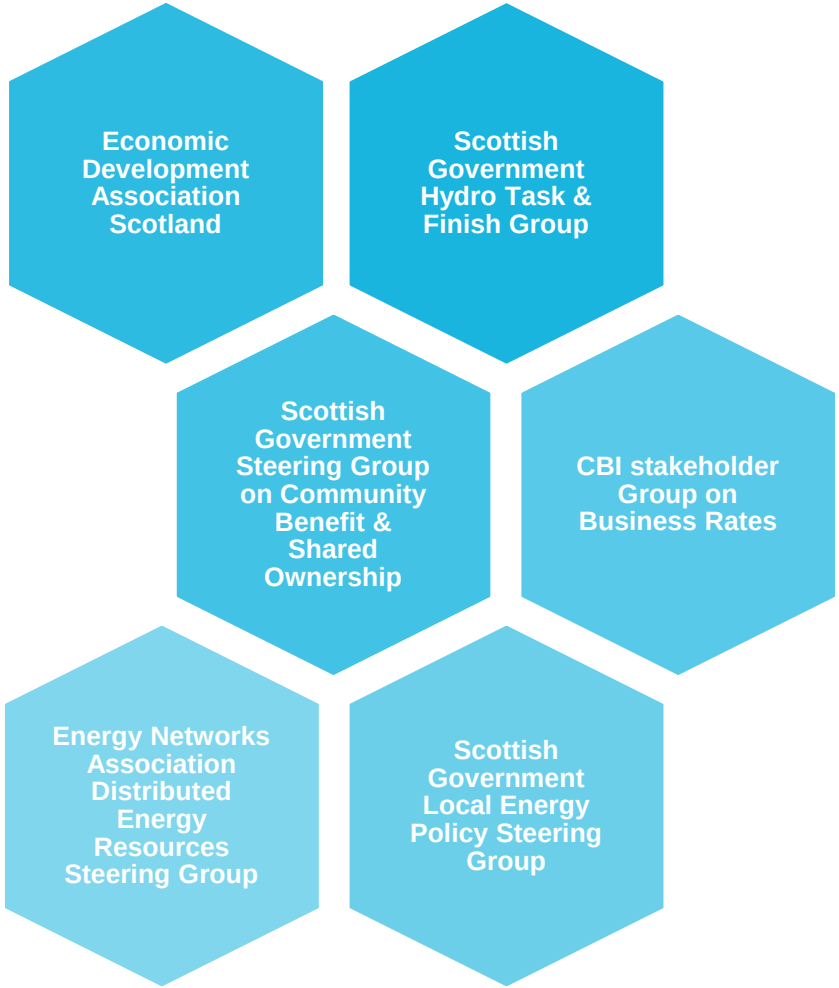

Where SR is representing you

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The Herald

Century-old water turbine turns out to be wheel of fortune for pensioner

Restoring the hydropowered Turgo left rusting in his garden hut has dramatically cut Duncan Stewart's fuel bills, while generating power for the Grid and cash for him, finds **SANDRA DICK**

■ Duncan Stewart with the hydropower turbine, which is generating energy after being installed in 1919.

IT purrs and growls just like the day it was installed a century ago, the colour of the bluebells that flourish in the nearby woods and every bit as "green".

While across the country new hydropower schemes are helping to feed the revolution in renewables and clean energy, in a hut beside a babbling burn on an estate near Dundee, the forerunner of them all is efficiently and calmly still going about its business.

Just as the rest of us might use the garden hut to store the family bikes, a few tools, the lawnmower and maybe a mouldy camping gear, Duncan Stewart throws open the door to his workshop to reveal Scotland's oldest working Turgo water turbine.

Installed in 1919 – just weeks after the first 50hp Turgo was fitted at Invergeldie Lodge, near Crieff – Mr Stewart's personal 8kW hydropower system is not only generating energy to heat and provide hot water for his five-bedroom house in Burnside of Duntrune, there's even enough left over for him to sell on to the National Grid.

As a result, Mr Stewart and his wife Pat not only live virtually energy bill-free thanks to the turbine, but they also derive some tax-free income from it.

"It is remarkable to think that something installed 100 years ago is working so well," said Mr Stewart, 76. "As a result of it, most of our heating is free, it heats our water and powers a log splitter that provides me with logs for my wood burning stove that keeps us warm in winter. It's not just saving us money, it's making money too."

The engineering treasure draws its water from the nearby Fithie Burn, which was dammed by workmen using shovels, horses and carts in the months after the First World War.

However, water-driven power at the site dates back even earlier – to more than 400 years ago, when there was a mill with a water wheel in the area.

The 4ft high, 9ft long turbine was originally installed in a workshop serving Dunstrune Estate, powering a large circular saw and sending electricity to Dunstrune House, nearby Craighill House and Burnside House, the former estate manager's home.

When the Stewarts moved to Burnside House almost 40 years ago, the turbine was still providing electricity to the property – albeit via a quickly dismantled hazardous DC connection – alongside a mains connection.

However, it eventually ground to a halt and was mothballed while the couple opted for more "modern" mains supply electricity and an oil-fired range cooker and boiler.

It lay rusting until Mr Stewart met television presenter and engineer Lieutenant Colonel Dick Strawbridge at an event and happened to mention the turbine lurking in his shed.

"He said, 'get it fixed, it could be your pension'," recalled Mr Stewart.

Inspired, he dusted grime from the rusty turbine's nameplate and discovered it was a Turgo turbine, manufactured by Cumbria-based Gilbert Gilkes & Gordon Ltd. Papers related to its commission and invoices confirmed it had been installed in 1919 – the same year the revolutionary turbine was designed by Eric Crewdson, who had outlined its features while serving in the trenches of the war.

Crewdson conceived the idea of a side-entry impulse turbine capable of running at twice the speed of a Pelton water-wheel turbine, with a higher efficiency across a broad flow range.

Within months of returning from the war, his concept had been developed and the first Turgo turbine installed at a property in Crieff.

However, it is no longer operational – making the Stewarts' refurbished and repainted turbine the oldest operational example in Scotland.

The refurbishment was carried out by the original manufacturers, while Mr Stewart set about removing a build-up of silt from the burn.

He added: "The turbine's governor alone, which controls the flow of water and is a beautiful piece of engineering, must have weighed half a tonne – the new one only weighs around half a pound. Now it all works beautifully."

The savings – and earnings – have been significant. Hydropower is used to heat the property's water and radiators, enabling the Stewarts to reduce oil consumption, as well as powering the log splitter to feed the stove.

"I now use about 1,500 to 2,000 litres of oil when a house this size would normally require 5,000 litres," Mr Stewart added, "while I get paid for whatever energy is generated regardless of how much actually goes to the Grid.

"It's now part of our life."

The only downside, he adds, is if a dry spell hits and the local farmers opt to use additional local water to irrigate their crops, leaving an insufficient flow to power the system.

■ **The Turgo, above, after years lying idle in a hut on Dunrune Estate before it was renovated by Gilbert Gilkes & Gordon Ltd.**

Hydropower has recently surged in popularity, with dozens of community-run schemes now either in operation or in the planning stages.

Hannah Smith, senior policy manager at Scottish Renewables, said: "Hydropower is one of Scotland's great unsung heroes, using our notorious wet weather to provide 15 per cent of Scotland's gross electricity demand while reducing the carbon emissions which cause climate change.

"Mr and Mrs Stewart's turbine is one of Scotland's oldest, and the fact it is still in service in its 100th year demonstrates how hydro delivers subsidy-free power long after support provided by government has ceased."

She added that the Scottish Renewables Hydro Conference, in Perth on May 9, is set to explore further ways to ensure hydropower technology's role in the future energy landscape, particularly in wake of the closure of the Feed-in Tariff scheme earlier this month.

300+ VIEWS

Sun

POWER ON TAP

Duncan and Pat Stewart generate leccy after restoring a 100-year-old water turbine in Burnside of Duntrune, Angus.

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Economics & Markets | Planning | Grid & Energy Systems

Small-scale & Community Support

- Built a broad coalition
- Feed-in Tariff Closure & Call for Evidence on the Future of Small-Scale
- Smart Export Guarantee
- SG Local Energy Systems Steering Group

Scottish Government

- Scottish National Investment Bank
- Publicly Owned Energy Company
- Scottish Infrastructure Commission
- Business Rates

UK Government

- Capacity Market
- Energy White Paper

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Planning Bill, NPF & SPP

- Shaping the Bill
- Stage 3 expected before summer recess
- NPF/SPP to follow bill

Shared Ownership

- SG Steering Group
- New Planning chapter clarifying SG view that a material consideration in planning is a question of law not policy

Landscape

- Joint SNH/ SR Landscape Capacity/ Sensitivity Studies seminar
- SR policy paper

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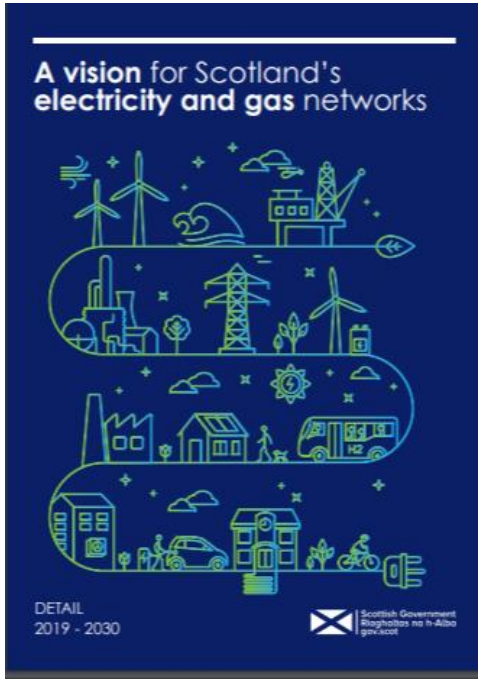
Economics & Markets | Planning | Grid & Energy Systems



Efforts focussed on:

£££ - mitigating costs from charging reform

Understanding new DSO opportunities

Outages

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Thank you

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Sara Thiam

Regional Director

Institution of Civil Engineers

Infrastructure Investment

Sara Thiam – Director Scotland

Who we are


Pre-19
Student
Graduate
Technician
Associate
Member
Fellow
All members

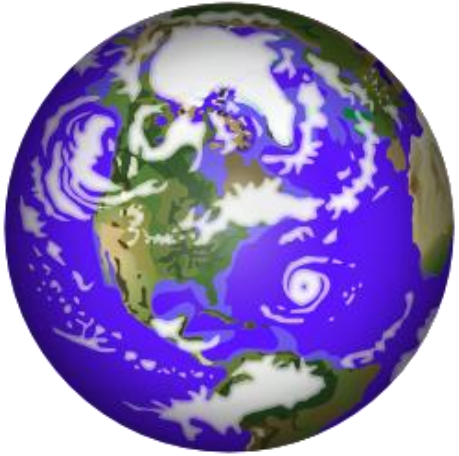
What we do

Membership

Shape the
Big Issues

Lifelong learning

Infrastructure Investment Drivers



Who pays?

Sector	Powers devolved or reserved	Ownership	Scottish Delivery bodies	How is it funded?	Where can they borrow from?
Road	Devolved powers	Public	Transport Scotland (trunk roads)/local authorities (non-trunk roads)	Tax	Scottish Government/ Private PPP
Rail	Scottish Government - internal services. UK government - cross-border services	Public	Transport Scotland/Scotrail Alliance	User charges/tax 44%/56%[17]	Recent transition to public budgets/ regulated asset base
Major Airports Rural airports[18]	Devolved powers, with some minor exceptions Devolved responsibility	Private Public	Transport Scotland	User charges Tickets/tax (26m)[19]	Private corporate Scottish Government
Major and Trust Ports Local authority ports	Devolved powers, with some minor exceptions	Private Public	Local authorities	User charges Tax	Private corporate Scottish Government
Energy	Reserved powers[20]	Private		User charges	Private/part regulated
Communications	Reserved powers	Private		User charges	Private/part regulated
Water/Waste Water	Devolved powers	Public	Scottish Water	User charges	Scottish Government
Flooding	Devolved powers	Public	Local authorities	Tax	Scottish Government
Waste	Devolved	Public and Private	Local authorities	Tax User charges	Scottish Government/ Private PPP Private corporate

City Region Deals

Strategic approach to improving regional economies

- Glasgow £1.13 billion (20 years)
- Aberdeen £169 million (10 years)
- Inverness £315 million (10 years)
- Stirling and Clackmannanshire £214million (10-15 years)
- Edinburgh and South East Scotland £1.3 billion (15 years)
- Tay Cities Region Deal £300 million + regional partners contribution (10-15 years)
- Ayrshire £251.5 million (10-15 years)

What we said

- Independent Commission focusing on needs
- Declare asset planning and maintenance a National Infrastructure Priority
- Work together to address problems associated with transactional industry contract models and fairer risk allocation in delivering public infrastructure projects

What else we said

- **Roads**: multi-year funding, how replacements for VED and fuel duty could fund asset maintenance, benefits to regulation?
- **Energy**: Decarbonise heat, work together to achieve maximum value and resilience from existing energy infrastructure. Explore legislative mechanisms to enable storage technologies to access the market.
- **Water**: Increase expenditure on asset maintenance critical for maintaining service. Advance use of data and analytics to support maximum efficiency delivery, **Rail**: Improve efficiency in delivery and maintenance

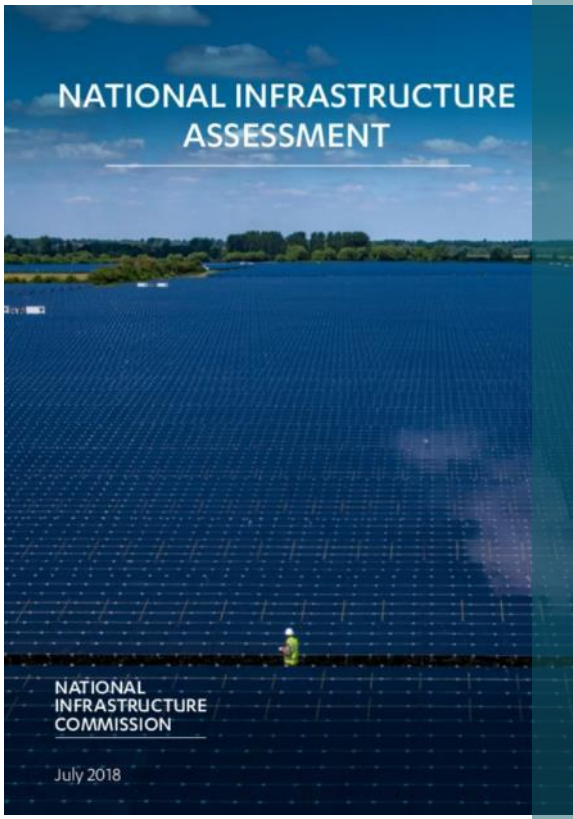
National Infrastructure Mission

- Increased annual investment of 1% of GDP (£1.5 billion) higher per year by 2025/26 than in 2019/20

Providing the infrastructure society needs

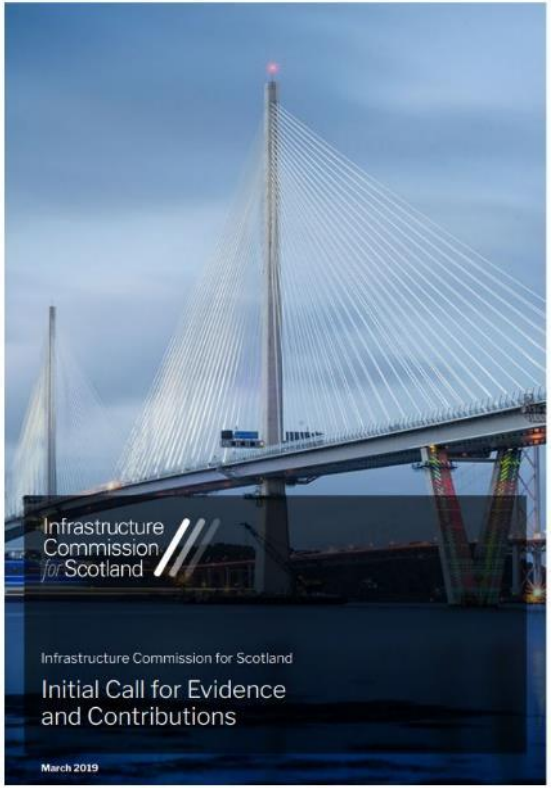
National Infrastructure Strategy (Autumn)

- Full fibre broadband to all homes and businesses by 2033
- 50% of electricity by renewables by 2030
- 100% of new car and van sales electric by 2030. Get charging infrastructure in place
- Transport £43b Devolution to city leaders and Metro Mayors



Scotland objectives

- Sustainable, inclusive economic growth **across** Scotland
- Manage transition to a low carbon economy
- Support delivery of high quality public services
- Increase industry competitiveness and tackle inequality
- Enhance societal living conditions
- Align with the National Planning Framework



ICfS Remit – What and how?

Provide independent, informed advice on:

- Vision ambition and priorities for Strategy for Infrastructure including key 5 and 30 year investments
- Guiding principles to support a coherent Scot Gov Infrastructure Investment Plan
- Delivery of Infrastructure in Scotland

Will report on:

- Infrastructure **ambition and priorities** by the end of 2019
- Delivery options by July 2020

How?

Independent of Scottish Government.

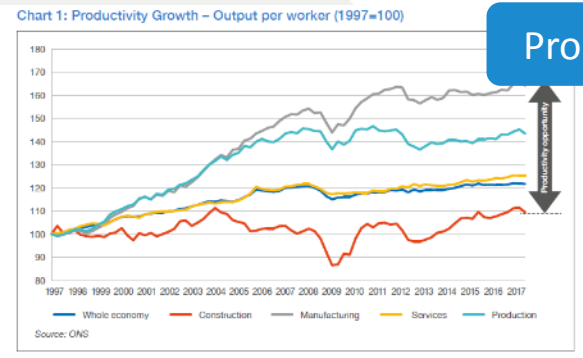
Works in a which is:

- Engaging and widely consultative across all of Scotland and civic society
- Credible, objective and evidence-based
- Outward looking, forward thinking and innovative

Project 13

A better approach to delivering high performance infrastructure

Why we need a new approach



Productivity

Source: McKinsey&Company, “The construction productivity imperative” By S Changali, A Mohammad and M van Nieuwland, July 2015

Unsustainable Industry

Source: Construction Leadership Council, “The Farmer Review – Modernise or Die” By M. Farmer 2016

Digital Transformation

What is Project 13?

- An industry-led movement to improve the way high performance infrastructure is delivered.
- Moving from transactional business models to collaborative business models.
- Being adopted on some of the UK's largest projects and bringing together skills and technologies in a collaborative environment
- Building a sustainable future for the construction industry, creating a more highly skilled workforce and creating infrastructure that represents better value for all.

Institution of
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105 West George Street
Glasgow
G2 1QL

ice.org.uk/scotland

Ben Smith

Contracts Manager, Commercial

National Grid ESO

The Changing Electricity System

Ben Smith –
Contracts Manager,
NGESO

nationalgridESO

The role of ESO

- We balance supply and demand of electricity across GB in real time to ensure it is delivered where it is needed
- We plan for future system requirements to ensure we have the tools needed to balance the system
- We maintain the codes that govern the operation of the electricity system
- We manage charges for using the electricity transmission system

How is the Electricity system changing

Decentralisation

- Behind the meter generation
- Transmission/Distribution interaction
- Consumer Power

Decarbonisation

- Non-synchronous renewable generation
- Emission targets
- Closure of large coal station

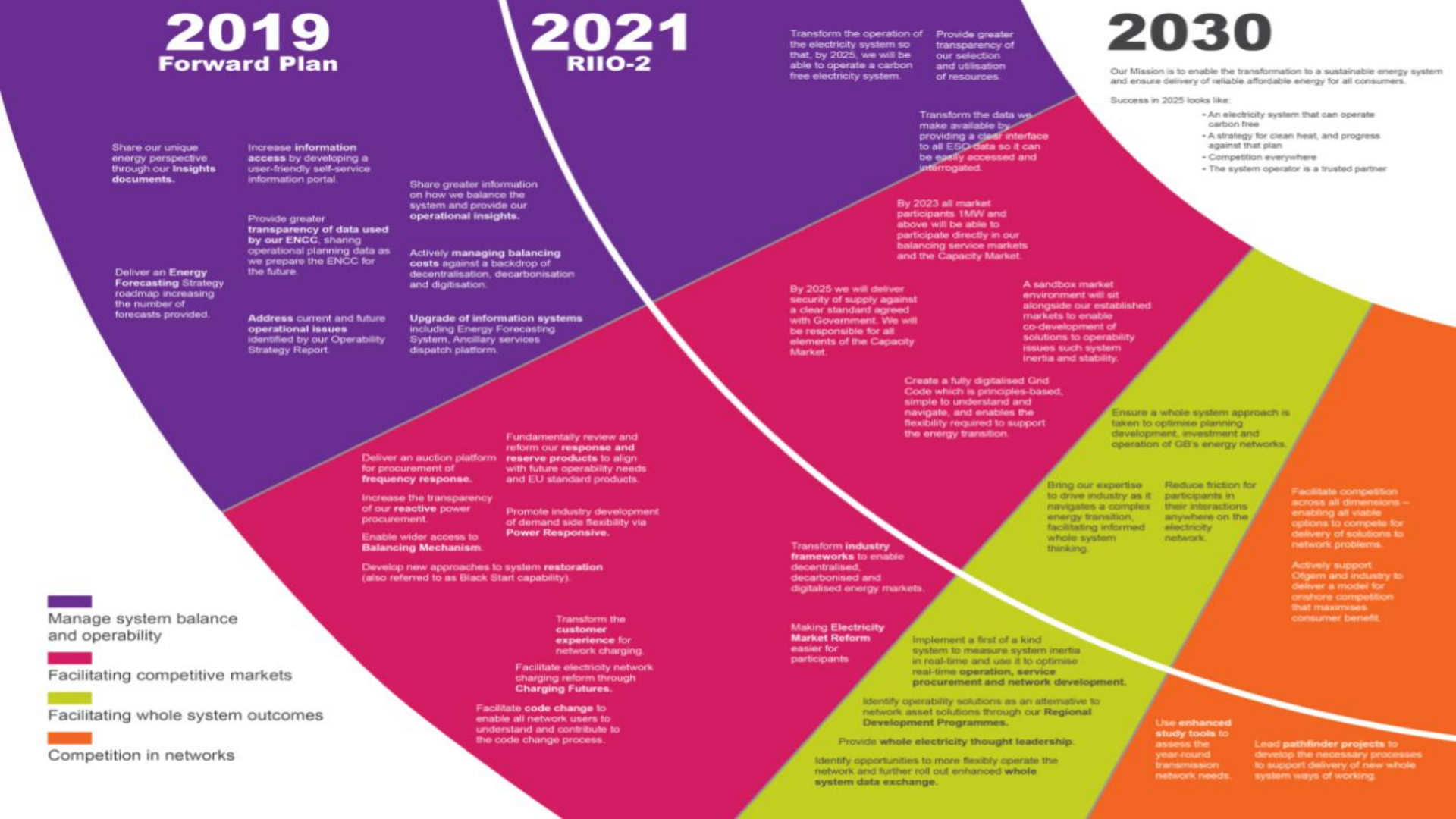
Digitisation

- Electric Vehicles
- Smart Appliances

What does this mean for the ESO?

- **Fewer synchronous generators to manage the system**
  - Declining short circuit levels (SCL), inertia and dynamic voltage support
- **Greater interaction with DNOs**
  - Forecasting demand and managing locational constraints
- **New technologies with varying characteristics**
  - Understanding their capability and how use them
- **Review of balancing services so they are fit for purpose**
  - Reform what we currently buy, consider new services and markets
- **Ability to operate a zero carbon electricity system by 2025**

What is on the system is changing, so is how we operate it.


2019
Forward Plan
2021
RIIO-2
2030
Our Mission is to enable the transformation to a sustainable energy system and ensure delivery of reliable affordable energy for all consumers.
Success in 2025 looks like:
• An electricity system that can operate carbon free
• A strategy for clean heat, and progress against that plan
• Competition everywhere
• The system operator is a trusted partner
Share our unique energy perspective through our **Insights documents**.
Increase **information access** by developing a user-friendly self-service information portal.
Provide greater **transparency of data used by our ENCC**, sharing operational planning data as we prepare the ENCC for the future.
Deliver an **Energy Forecasting** Strategy roadmap increasing the number of forecasts provided.
Address current and future **operational issues** identified by our Operability Strategy Report.
Share greater information on how we balance the system and provide our **operational insights.**
Actively **managing balancing costs** against a backdrop of decentralisation, decarbonisation and digitisation.
Upgrade of information systems including Energy Forecasting System, Ancillary services dispatch platform.
Transform the operation of the electricity system so that, by 2025, we will be able to operate a carbon free electricity system.
Provide greater transparency of our selection and utilisation of resources.
Transform the data we make available by providing a clear interface to all ESO data so it can be easily accessed and interrogated.
By 2023 all market participants 1MW and above will be able to participate directly in our balancing service markets and the Capacity Market.
By 2025 we will deliver security of supply against a clear standard agreed with Government. We will be responsible for all elements of the Capacity Market.
A sandbox market environment will sit alongside our established markets to enable co-development of solutions to operability issues such system inertia and stability.
Create a fully digitalised Grid Code which is principles-based, simple to understand and navigate, and enables the flexibility required to support the energy transition.
Ensure a whole system approach is taken to optimise planning development, investment and operation of GB's energy networks.
Deliver an auction platform for procurement of **frequency response.**
Fundamentally review and reform our **response and reserve products** to align with future operability needs and EU standard products.
Increase the transparency of our **reactive** power procurement.
Promote industry development of demand side flexibility via **Power Responsive.**
Enable wider access to **Balancing Mechanism**.
Develop new approaches to system **restoration** (also referred to as Black Start capability).
Bring our expertise to drive industry as it navigates a complex energy transition, facilitating informed whole system thinking.
Reduce friction for participants in their interactions anywhere on the electricity network.
Facilitate competition across all dimensions – enabling all viable options to compete for delivery of solutions to network problems.
Actively support Ofgem and industry to deliver a model for onshore competition that maximises consumer benefit.
Transform **industry frameworks** to enable decentralised, decarbonised and digitalised energy markets.
Transform the **customer experience** for network charging.
Making **Electricity Market Reform** easier for participants.
Facilitate electricity network charging reform through **Charging Futures.**
Implement a first of a kind system to measure system inertia in real-time and use it to optimise real-time **operation, service procurement and network development.**
Facilitate **code change** to enable all network users to understand and contribute to the code change process.
Identify operability solutions as an alternative to network asset solutions through our **Regional Development Programmes.**
Provide **whole electricity thought leadership**.
Identify opportunities to more flexibly operate the network and further roll out enhanced **whole system data exchange.**
Use **enhanced study tools** to assess the year-round transmission network needs.
Lead **pathfinder projects** to develop the necessary processes to support delivery of new whole system ways of working.
Manage system balance and operability
Facilitating competitive markets
Facilitating whole system outcomes
Competition in networks

What does this mean for projects?

- **Clearer signals for system requirements**
  - Pathfinder projects for SCL launching in Summer 2019
- **New market opportunities – what and how we buy services**
  - Possible tenders for Black Start in Scotland
  - Constraint management to manage power flows across boundaries

We need to work collaboratively across all sectors to create the future energy systems to be able to deliver the vast change required

Dr Edward McCarthy
Lecturer in Composites Design & Testing
The University of Edinburgh

Composites Group
University of Edinburgh:
Introduction to Composites and their Use in Marine Blades

Institute of Materials and Processing

School of Engineering

The University of Edinburgh

Dr. Edward McCarthy
Prof. Conchúr Ó Bradaigh
Dr. Parvez Alam
Dr. Dipa Roy

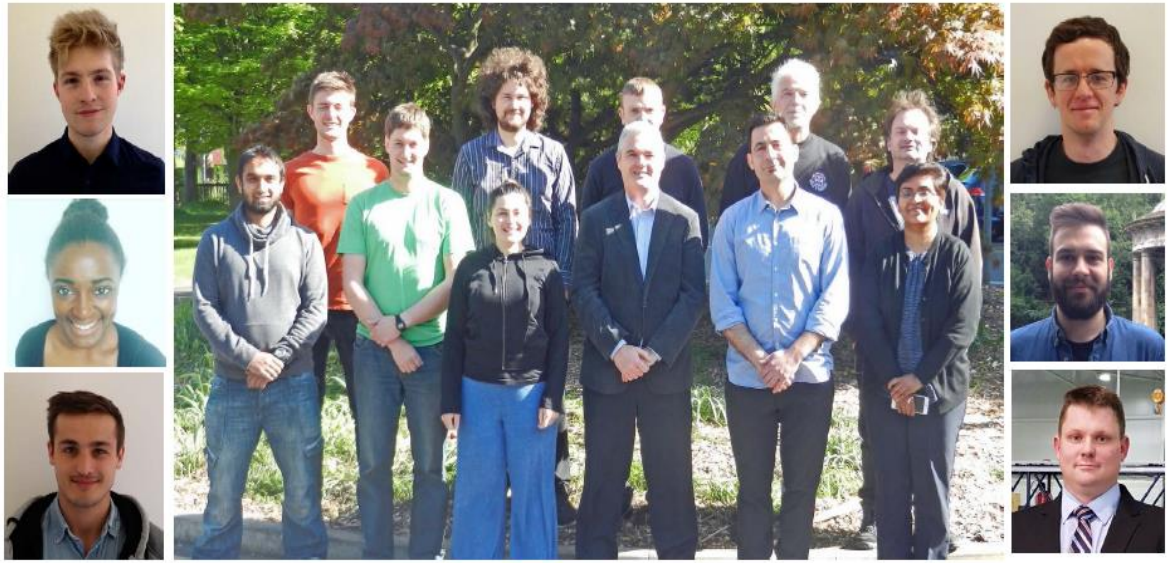
THE UNIVERSITY of EDINBURGH
School of Engineering

Part 1: Edinburgh Composites Group and Introduction to Composites

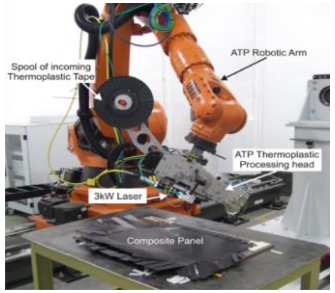
Composites Group at University of Edinburgh

Academics

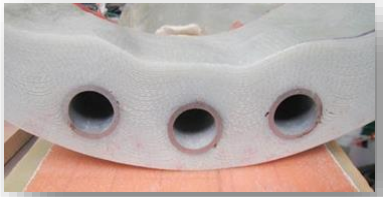
- **Prof. Conchúr Ó Brádaigh,** Chair of Materials Engineering.
- **Dr. Parvez Alam,** Senior Lecturer in Materials Modelling.
- **Dr. Edward McCarthy,** Lecturer in Composites Design & Testing.
- **Dr. Dipa Roy,** Senior Lecturer in Composites Processing.



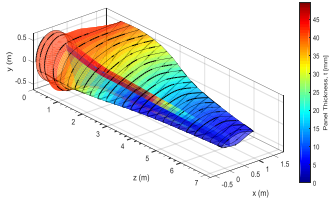
Current Composites Activity at University of Edinburgh



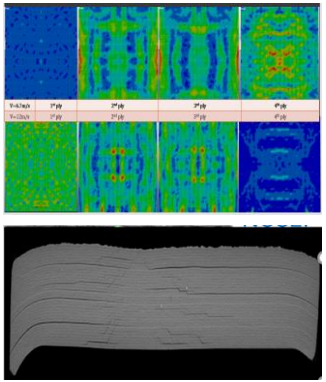
Laser Tape Placement for Faster Processing



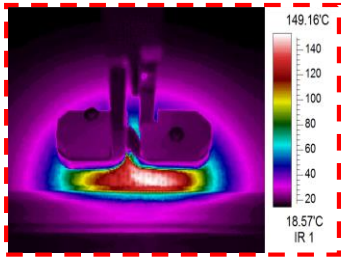
Wind/Tidal Blade manufacture using Advanced Powder Epoxy Composites



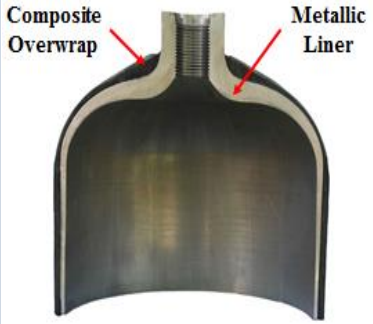
Stress Analysis/Design of Blades



Modelling of Impact Damage



Thermoplastic Composites.



Composite-Wrapped Pressure Vessels

Composites Group at University of Edinburgh

What are composites?

- **Structures** that contain resins reinforced with arrays of fibres arranged in definite geometries.
- ***Nanocomposites*** are resins with dispersed particles that do not form a macro-structure, i.e., are dispersed in a random manner, i.e., carbon nanotubes, clays, inorganic salts.

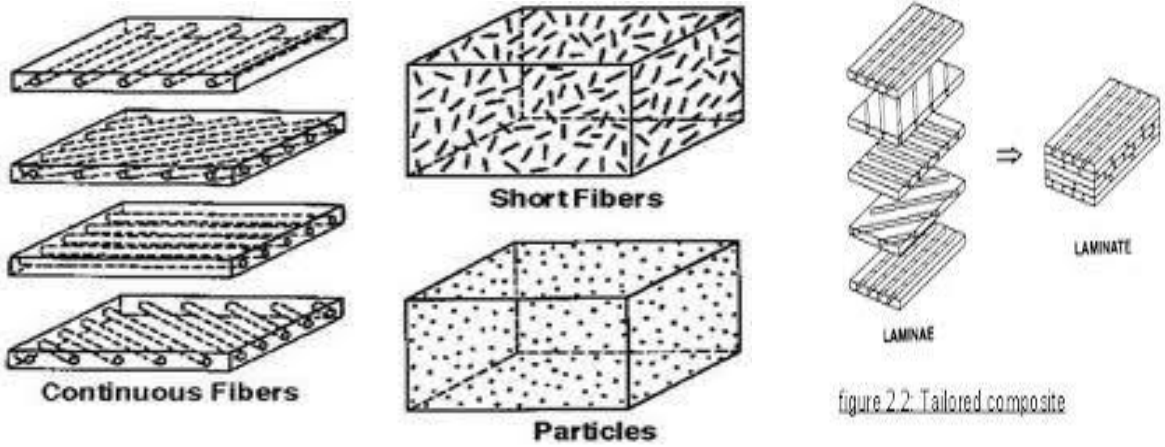
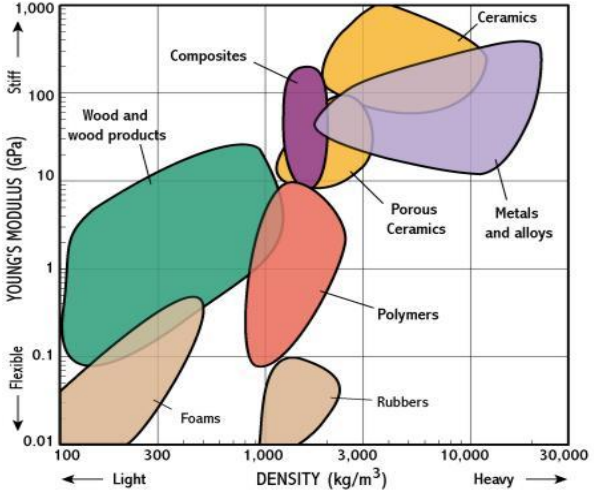
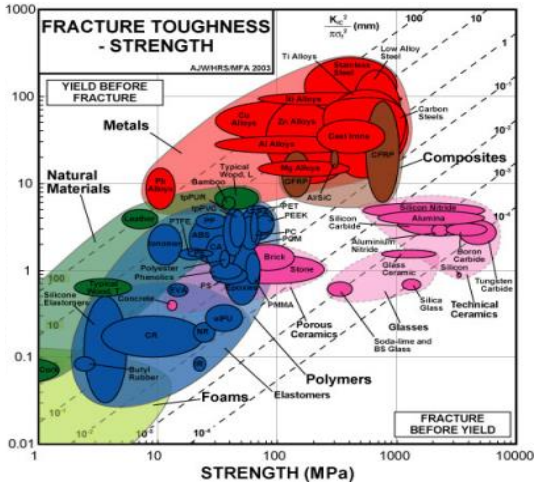


figure 2.2: Tailored composite

Composites Group at University of Edinburgh

How do composite properties compare?





- CFRP composites occupy a competitive property space: lower density than metals, but with comparable stiffness (Modulus).
- Fracture toughness and strength also competitive (although stainless steel still retains higher fracture toughness).

UK Opportunity for Composites*

*2016 UK Composites Strategy, Composites Leadership Forum

Part 2: Design of Composite Power Blades – (Tidal)

Why Composites in Blades?

World's Largest Wind Turbine Blade - 88.4m long for 8MW Offshore Turbine, now outdone by their 107 m blade for a 12 MW! (Haliade-X, General Electric)

Fabricated in Glass Fibre/Epoxy.

Manufactured by Vacuum-Assisted Resin Infusion in 3-4 parts which are adhesively bonded.

LM Windpower 2016 – designed for 180 m rotor diameter turbine, Cherbourg

- Wind blades are about to get longer > 100 m for 12 MW !
- Increasing length drives increased power harvest.
- Composites: improved fatigue life and lower self-weight.
- Tidal blades – shorter, higher root loadings, **riskier!**

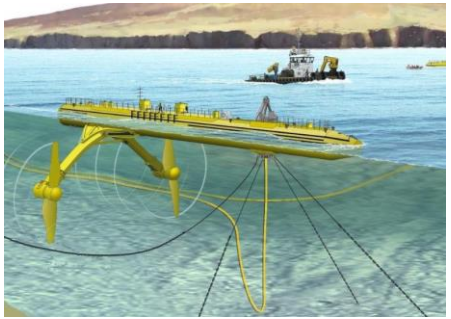
C. Floreani, University of Edinburgh

I. Tidal Turbine Design

- Turbines can be located near the surface, in the middle and at the bottom of the water column.
- Turbines can float or have ground foundations.
- Rotors can have 2, 3 or more blades.

Atlantis Resources Ltd

SeaGen - MCT

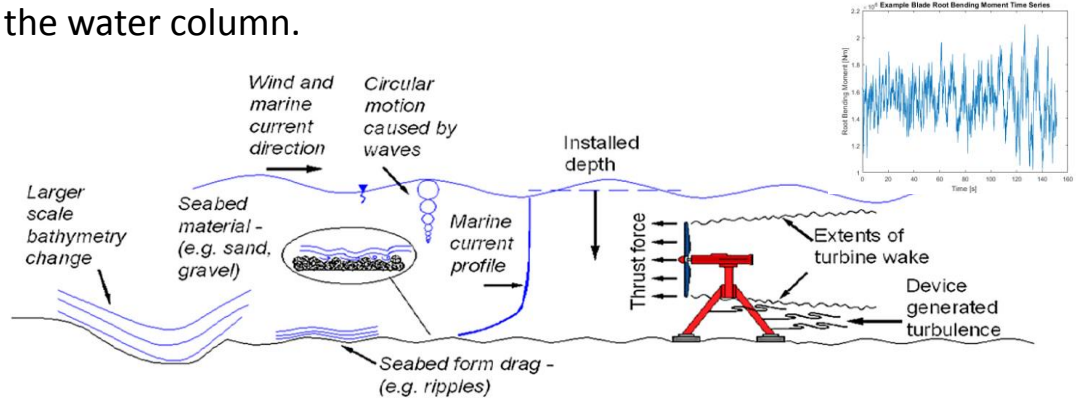


SR2000 - ScotRenewables

C. Floreani, University of Edinburgh

II. Loads on a Tidal Turbine Blade

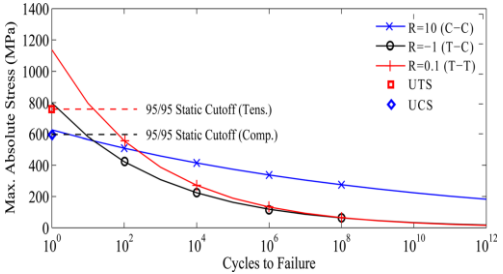
- Loads are very complex and site specific.
- Surface waves, turbulence, tower shadow and an uneven inflow velocity create high frequency cyclic loads.
- Ebb and Flood Tides create low frequency loads.
- Dominating loads depend on site, turbine design and position in the water column.

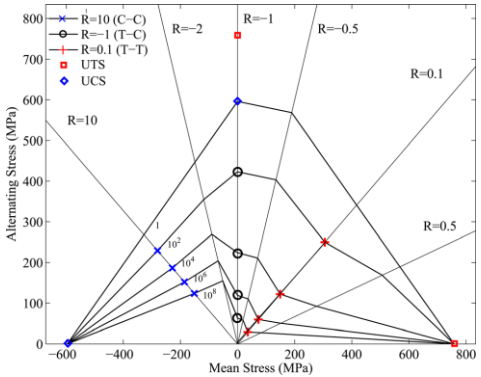


Myers, L. E., & Bahaj, A. S. (2012). An experimental investigation simulating flow effects in first generation marine current energy converter arrays. Renewable Energy, 37(1), 28–36.

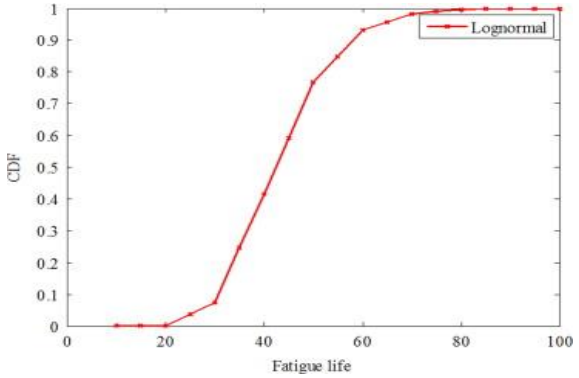
C. Floreani, University of Edinburgh

III. Fatigue Analysis





Fossum, P., Frøyd, L., & Dahlhaug, O. G. (2013). Design and fatigue performance of large utility-scale wind turbine blades. Journal of Solar Energy Engineering, 135(3), 31019.



Probability of Failure with Years of Service

Li, H., Hu, Z., Chandrashekhara, K., Du, X., & Mishra, R. (2014). Reliability-based fatigue life investigation for a medium-scale composite hydrokinetic turbine blade. *Ocean Engineering*, *89*, 230–242

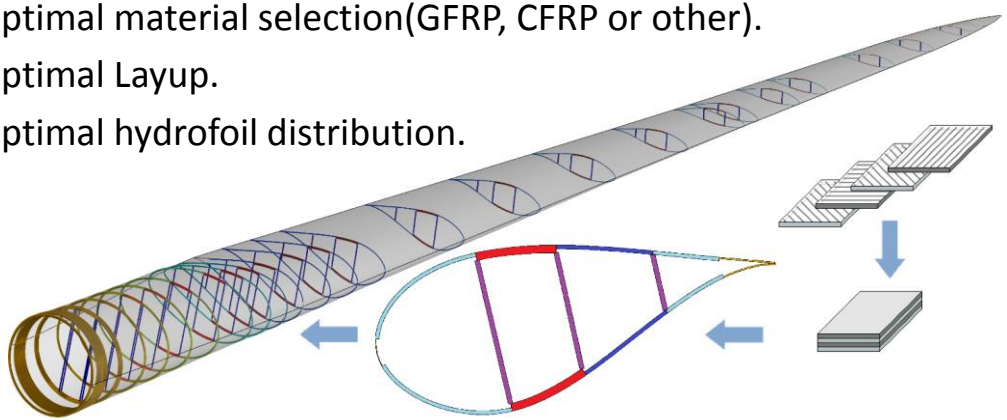
- Analysis of ***material*** fatigue data generates reliability curves, but these can be very approximate.
- Need ***structural*** fatigue data.

C. Floreani, University of Edinburgh

IV. Blade Optimisation

Use Genetic Algorithms and Neural Networks to optimise power production while minimising weight and keeping the strain under a reference value. This will give the following parameters:

- Optimal shear web location and design.
- Optimal material selection(GFRP, CFRP or other).
- Optimal Layup.
- Optimal hydrofoil distribution.



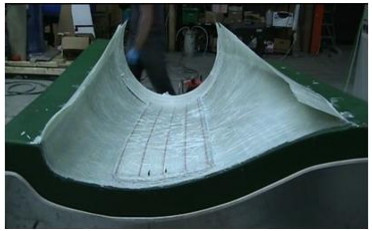
Co-Blade Software

Part 3: Novel Manufacturing of Wind (And Tidal) Blades

Tidal Blade Hub Manufacture

1. Initial Placement of Composite Sheets

Shear web



Bottom Skin

Top Skin

Surface coat being applied.

Shear web pre-form being placed in position

Top skin pre-form being placed on top of shear web

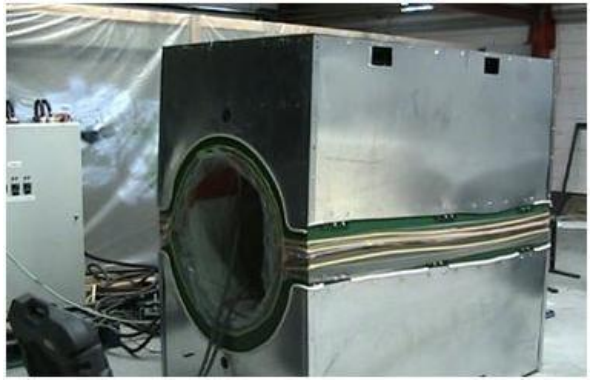
Flanagan, T. et al., "Smart Affordable Composite Blades for Tidal Energy", Proceedings of *EWTEC 2015 – 11th European Wave and Tidal Energy Conference*, Nantes, France, September 2015.

Tidal Blade Hub Manufacture

2. Final Assembly and Tool Cure

As all the sections are now net shape they fit together for final processing

All sections in position

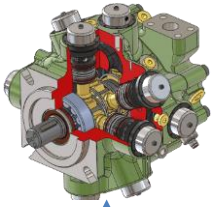


Mould closed, vacuum bag placed inside the lay-up, vacuum applied and heated to 180°C.

Flanagan, T. et al., "Smart Affordable Composite Blades for Tidal Energy", Proceedings of *EWTEC 2015 – 11th European Wave and Tidal Energy Conference*, Nantes, France, September 2015.

Part 4: FASTBLADE:
Novel Fatigue Testing of Tidal Blades

FASTBLADE (Fatigue testing)



HYDRAULIC POWER PACK

ARTEMIS IP DD®

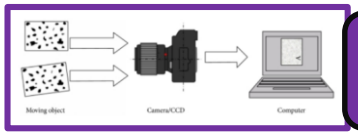
SAFETY, CONTROL & OPERATION

TIDAL TURBINE BLADE SPECIMEN

12 m long

HYDRAULIC RAMS

REACTION FRAME



DATA ACQUISTION & MONITORING

1MN Fatigue Load

3MN Static Load

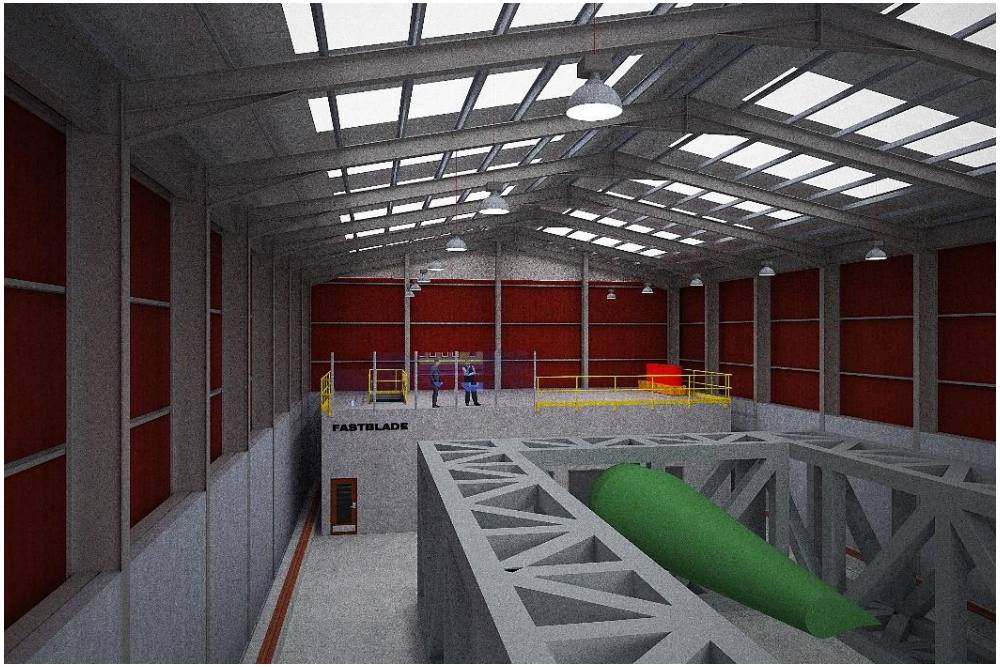
5MNm Fatigue Moment

15MNm Static Moment

J. Steynor, University of Edinburgh

FASTBLADE Visualisation

THE UNIVERSITY of EDINBURGH
School of Engineering



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J. Steynor, University of Edinburgh

FASTBLADE Project Partners

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Engineering and Physical Sciences Research Council

Scottish Enterprise

Fife COUNCIL

CATAPULT
Offshore Renewable Energy

DNV·GL

ORBITAL
MARINE POWER

SIMEC ATLANTIS ENERGY

MacTaggart Scott
Innovators since 1898

SUZLON

University of Southampton

OÉ Gaillimh
NUI Galway

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CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

SUMMARY

- Composites are being increasingly used in aerospace, automotive, structural and oil and gas sectors.
- They are light but strong, corrosion resistant, and enable more sophisticated design shapes to be realised.
- They will be essential in effective tidal blades.
- The Composites Group has strong links to composites materials suppliers, manufacturing companies and wind and tidal OEMs and are active across Design, Manufacture, Testing and Analysis.
- FASTBLADE due for commissioning in May 2020.
- Currently seeking manufacturing and test partners for collaborative development (e.g. AMCF).

Questions?
Interested in working with us?

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FASTBLADE
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Lecturer in Composites Design & Testing,
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Beyond the Feed-in Tariff: development challenges and opportunities in a new financial landscape

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Rob Forrest

CEO

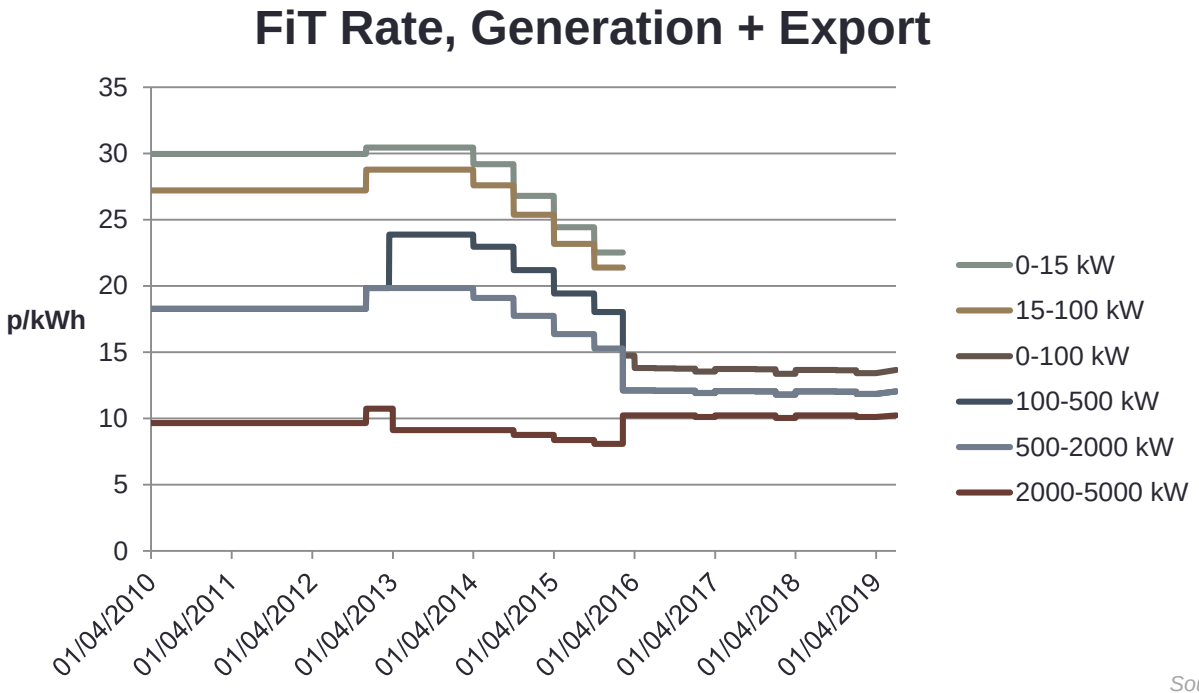
GreenPower

Robert Forrest
CEO

GreenPower – a brief introduction

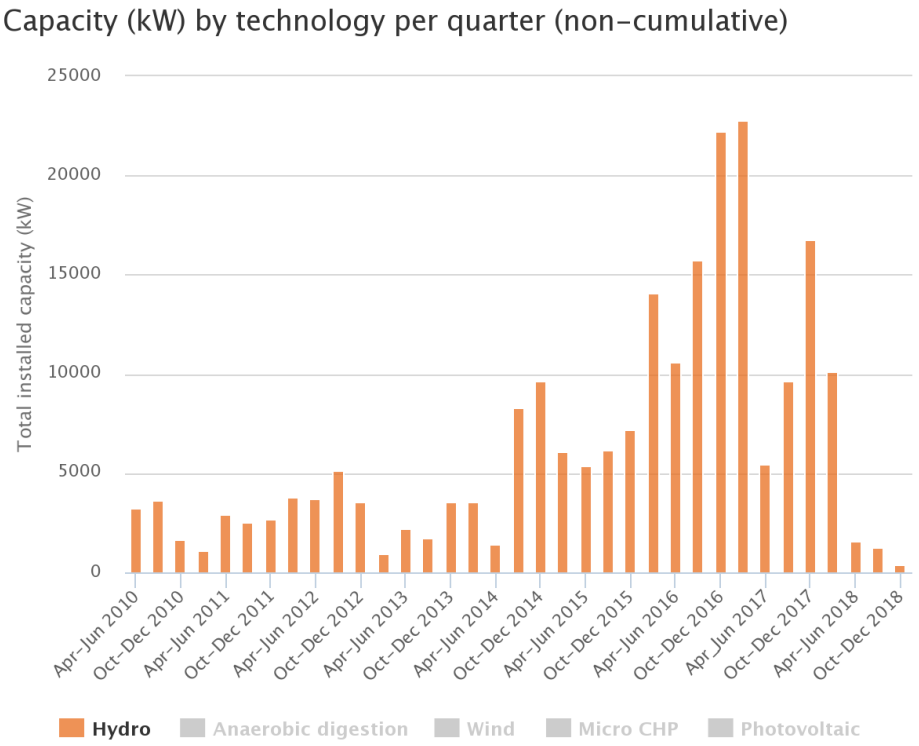
- Founded 2000
- Privately Owned
- JVs and Co-Investment at Project Level
- Develop, Build, Own & Operate
- On-shore Wind, Hydro and Solar

FiT Historical Perspective



Source: Ofgem, Real Terms, 2019

FiT Historical Perspective



Source: Ofgem, 2019

Carie Hydro

- South Side, Loch Rannoch
- 500kW, Twin Jet Pelton, 163m Head, 4 intakes
- Pre-Accredited Dec 2013
- Commissioned Oct 2015
- Capacity Factor 39%
- Constructed on time and under budget

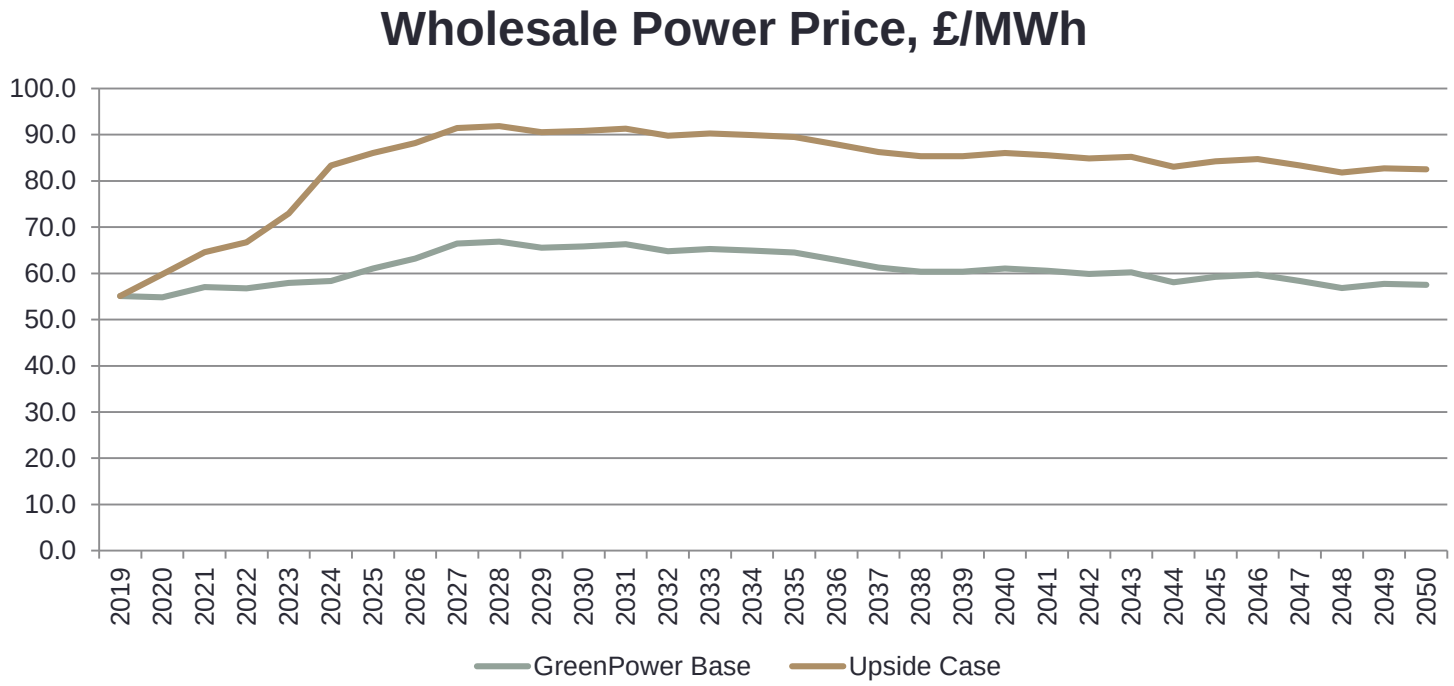
Green Power

FiT Economics

- Capital Cost £3.3m
- Economic Life 40 years
- Unlevered
- Generation + Export Tariffs
- No Embedded Benefits
- Yield 1,700 MWh
- Equity IRR, post-tax 8.7%

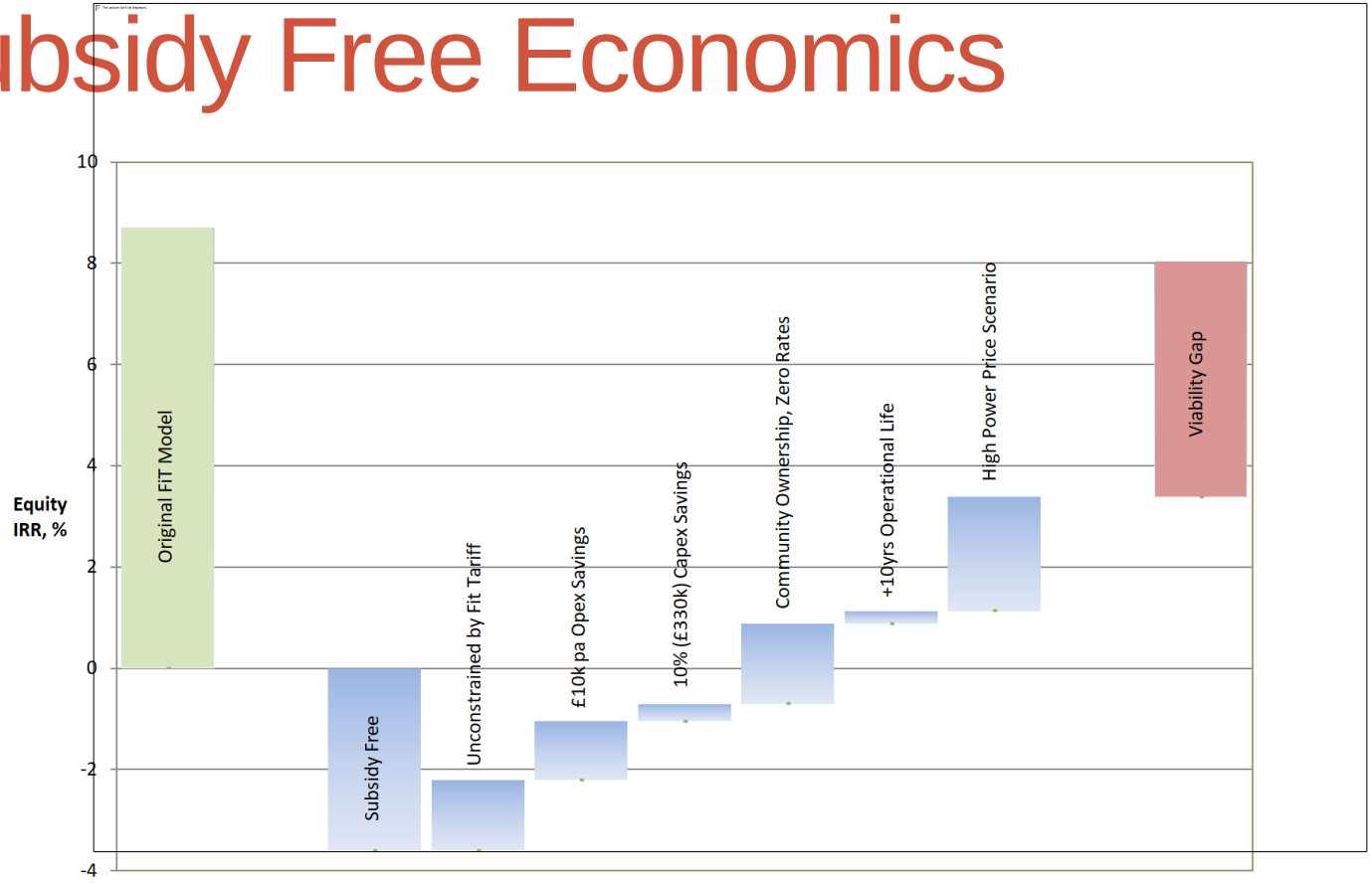
Model Assumptions – actual operational results differ

Future Power Prices



GreenPower, real terms April 2019, indicative only

Subsidy Free Economics



Key Risks & Opportunities

- Business Rates
- Grid Charging
- Loss of embedded benefits
- Downside on wholesale power prices – global trends, UK fracking
- Interest rate rise
- Locational restrictions
- Regulatory burdens
- Construction industry inflation > RPI

- DSO ancillary services
- Passive storage
- Portfolio aggregation
- Optimise schemes to resource, not artificial tariff levels
- New power trading models, aggregation, virtual power plants
- Private wire offtakes
- Smart Export Guarantee
- Unprecedented public awareness and levels of support

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Innovation & Technology

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Scottish Renewables Hydro Conference 2019: The impact of EU R&D funding
A 20 year perspective

Gregor Hogg
Consultant, Ricardo Energy & Environment

www.ricardo.com

EU FP R&D funding

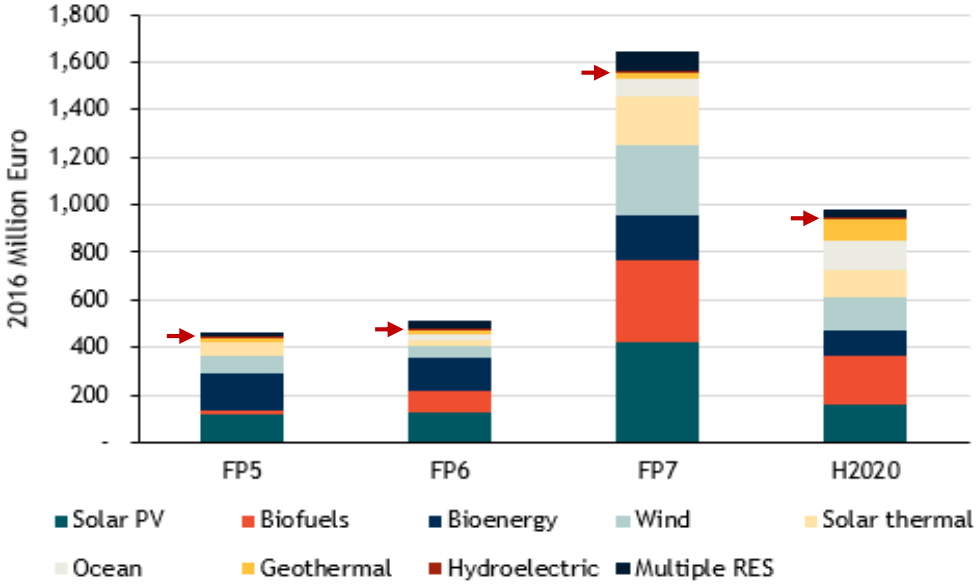
- Most funding provided under FP7
- Most projects under FP5

	Hydropower		Hydropower and Other RES	
Framework programme	EU funding (M EUR)	No. projects	EU funding (M EUR)	No. projects
FP5	4.91	8	5.11	2
FP6	4.15	4	0.00	0
FP7	12.09	5	1.82	1
H2020	3.06	4	0.00	0
Total EU funding	**24.22**	**21**	**6.93**	**3**

Source: Cordis, 2018
Funding converted to 2016 Euros

EU FP R&D funding

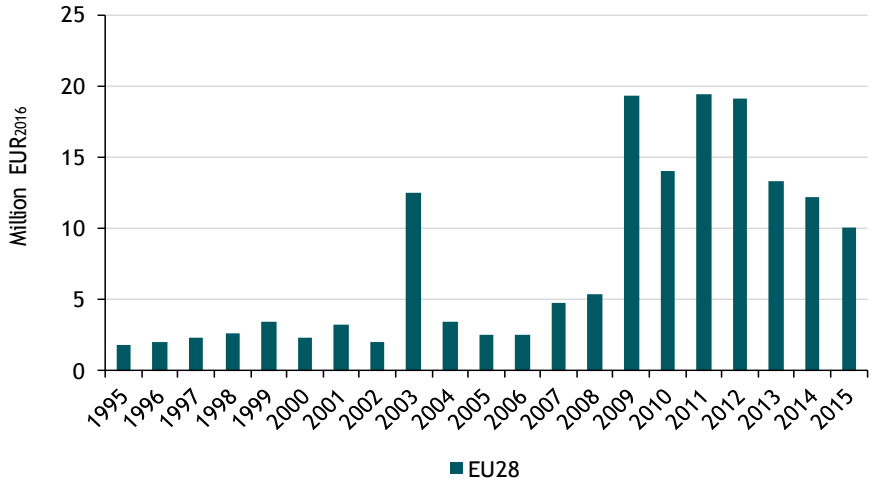
- Modest share: hydropower received 0.7% of total €3.6 billion



Source: Cordis, 2018
H2020 not for full funding period

Funding at Member State level

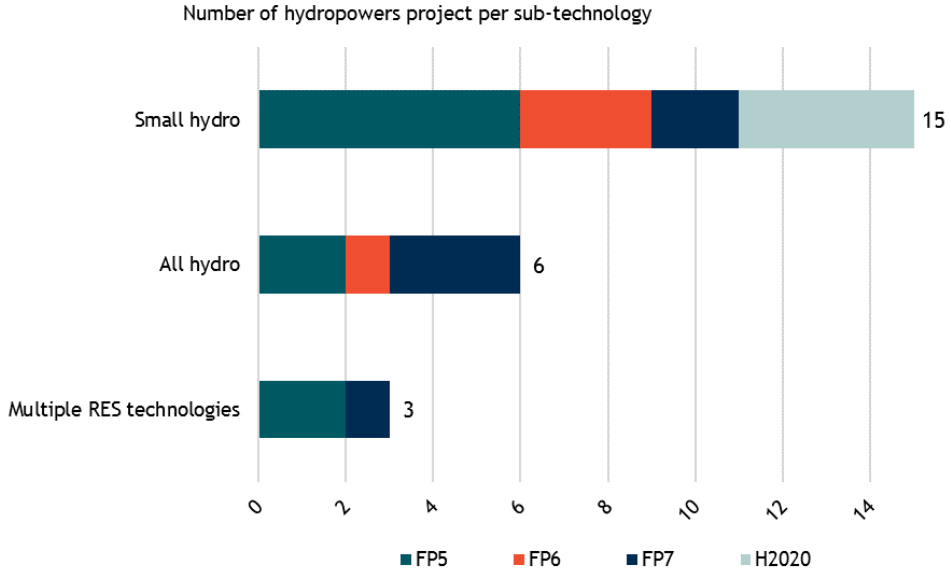
- Increased MS funding from 2009 onwards
- Highest R&D budgets in Finland, Poland and Austria
- Very modest share of national R&D RE budgets (below 2%)



Source: IEA/OECD, 2018

Funding per technology scale

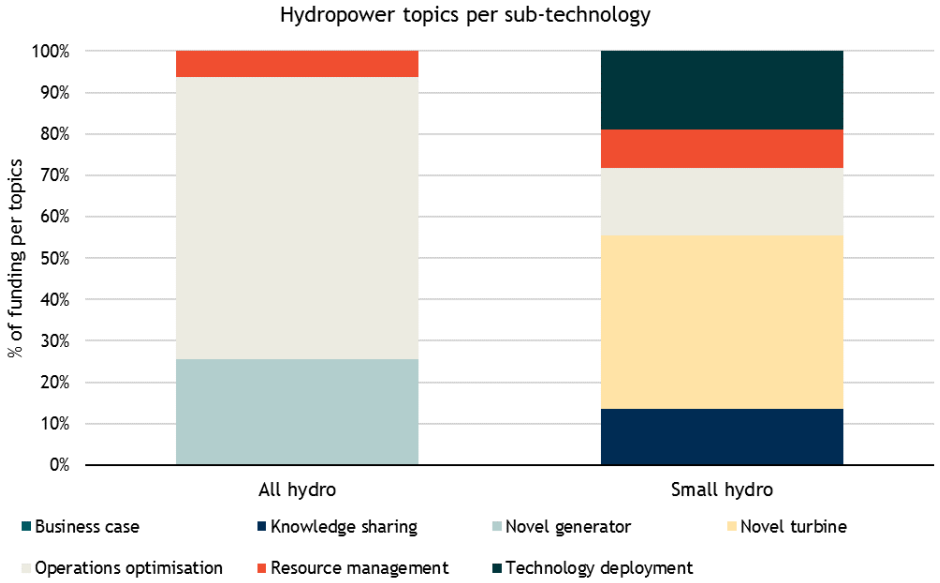
- Funding focussed on Small Hydropower where the largest number of potential sites for new installations are



Source: Cordis, 2018

Funding per technology scale

- New technology development across all scales received most funding



Source: Cordis, 2018

Technology improvements

- **Technological advancements for SHP**: potential to open up new sites that were not technically or economically viable before (e.g. Hydrokinetic, River-Power, Hydroaction)
- Improving the **operational performance** of the existing installed capacity (e.g. Hyperbole)
- Improving the s**ystems and processes used for improving the design** of new and existing hydropower technologies (e.g. Cavismonitor)

Market activity and creation

- Large hydropower: most potential utilised. Opportunities in **optimisation and refurbishment activities.** Ongoing export activities.
- Industrial activities mostly focus on SHP: **increasing industry turnover and jobs creation** and still has untapped potential.
- The EU plays a leading role in SHP, **exporting its technologies** all over the world

Social & environmental impacts

- Installed capacity grew from 106 GW in 1995 to 130 GW in 2017
- Hydropower now provides **10 % of gross final electricity consumption** in the EU
- Substantial industry turnover (€8 billion in 2016 excl. production of electricity)
- Jobs in the hydropower sector ~107,000
- Positive trade balance with the rest of the world (€560M exports - €160M imports)

Conclusions

- **Hydropower plays a significant role in the EU economy**, providing renewable electricity, jobs, industry turnover and exports
- EU R&D funding has contributed to the **development of new SHP technologies and designs in Europe**, which enable the exploitation of sites that were previously not viable
- EU holds a **leading position for SHP**, and has significant exports to the rest of the world
- EU R&D funding led to new modelling tools and improved operation of large hydro, as well as knowledge sharing tools **to create new opportunities for existing plants**

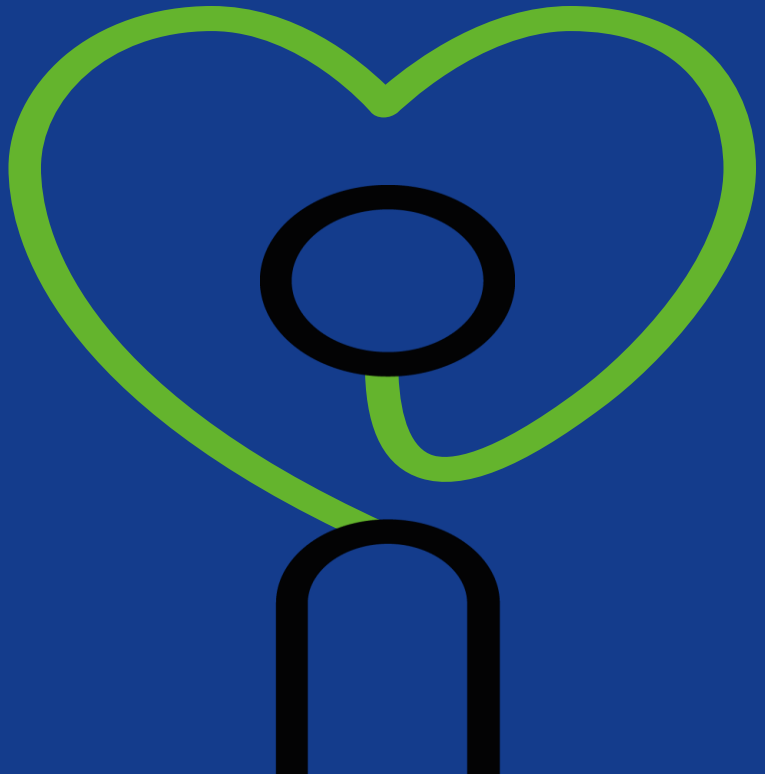
Roisin Mc Cormack

Project Coordinator and Business Development Manager
DesignPro Renewables

Nicola Percival

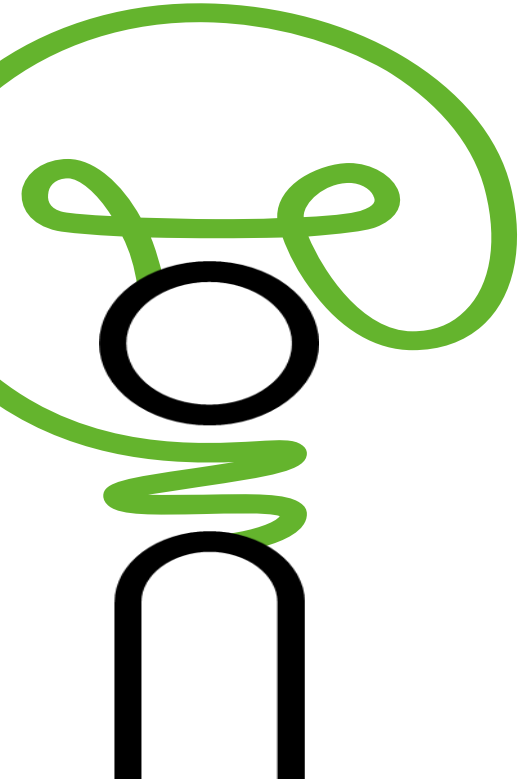
Policy & Regulations Manager

innogy Renewables UK



Regulatory reforms - what could happen and when?

innogy SE · Nicola Percival · May 2019



1

What and why?

2

Targeted Charging Review

3

Electricity Network Access Project

Grid – what is going on?

- There are two ongoing fundamental reviews being managed by Ofgem:
  - **The Targeted Charging Review (TCR)**
  - **The Electricity Network Access Project (ENAP)**
  - **Effectively part 1 and part 2.**
- Both are classed as '**Significant Code Reviews**' (SCRs). An SCR is a tool for Ofgem to initiate wide ranging and holistic change, often to multiple Codes.
- Industry have been **supportive of network charging reform in principle**, as the Codes were written decades ago for a system dominated by large, thermal plant. A **review to make the Codes suitable for a low carbon system** with high flexibility and lots of renewables is what was called for.

Grid – why is it happening?

innogy

The Targeted Charging Review (TCR)

Objectives:

- consider **reform of residual charging arrangements** for both **generation and demand**, to ensure it meets the interests of current and future consumers;
- keep the other **'embedded benefits'** that may distort investment or dispatch decisions **under review**.

Principles-based assessment of options based on: **fairness**, **reducing distortion** and **practicality and proportionality**.

The Electricity Network Access Project (ENAP)

Objective: to ensure electricity networks are **used efficiently and flexibly**, reflecting **users' needs** and allowing **consumers to benefit from new technologies and services** while **avoiding unnecessary costs** on energy bills in general.

Targeted Charging Review (TCR)

Ofgem's minded-to position:

Residual charges – all paid by demand customers, either via fixed charges or agreed capacity-based charges.

CMP264/265 already implemented, no proposed changes to that.

Transmission Generation Residual **(TGR) – set to £0/kW, subject to compliance with the EU 'cap'.** This is currently negative, so is a loss of revenue for generators who pay G-TNUoS.

Remove BSUoS embedded benefits **("partial reform")**

Possibly also charge embedded generators <100MW (EGs) BSUoS **("full reform").**

Launch a '**Task Force**' to look at whether BSUoS – which is currently 100% cost recovery – could have a forward-looking element to it.

Live CUSC Mod regarding BSUoS (**CMP308**).

Therefore a number of outcomes are possible…

Targeted Charging Review (TCR)

Frontier/LCP impact assessment commissioned by Ofgem:

- Uses National Grid FES scenarios "Steady Progression" and "Community Renewables",
- Identifies benefit-shift from generators to consumers if proposal implemented,
- **Assumes no response to the proposed reforms from "non-CM" generators.**

Scottish Renewables' and RenewableUK's joint response to the December 2018 consultation provided evidence to the contrary.

Publicly available report by Oxera demonstrates:

- Possible response from renewable generators to TGR/BSUoS proposals,
- offers some sensitivities and potential resultant impacts on consumers and carbon targets.

Electricity Network Access Project (ENAP)

Included in the SCR – Ofgem-led

> Review of the definition and choice of transmission and distribution access rights
> Wide-ranging review of Distribution Use of System (DUoS) network charges
> Review of distribution connection charging boundary
> Focussed review of Transmission Network Use of System (TNUoS) charges

- Early stages, little is known for certain
- Challenge Group meets monthly
- Working papers expected in June 2019

Areas led by industry outside the SCR

Review of balancing services charges (BSUoS)

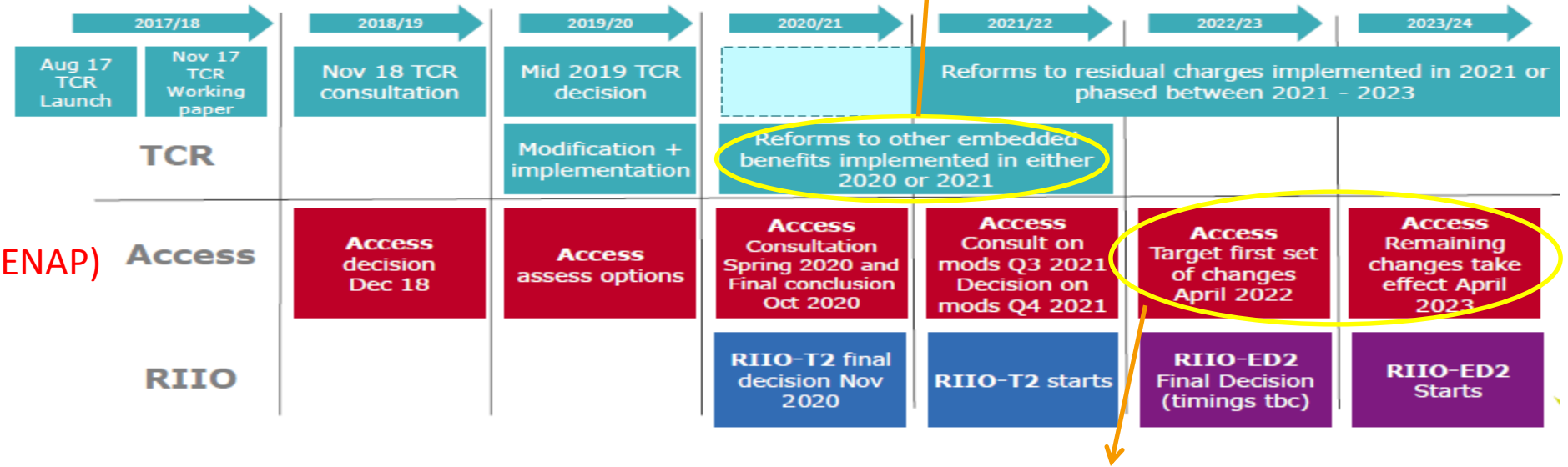
> Access right allocation

Excluded from the SCR and wider industry review

> Introducing fixed duration long-term access rights
> Introducing geographically exclusive local access rights which do not allow access to the rest of the system
> Wider changes to transmission network charges
> The transmission connection charging boundary

Ofgem's proposed timelines

Affects both Transmission & Distribution connected



Likely to affect mostly Distribution connected

Thank you!

Oxera report available here:
https://www.oxera.com/publications/ofgem-targeted-charging-review-impact-assessment/

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Chief Executive, Intelligent Land Investments

Tom Pendrey
Project Manager, Buccleuch

Sean Kelly
Project Manager, Generation Development, SSE

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Hydro’s place in local energy systems

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Logan Black

Renewable Energy Consultant

Locogen

Scottish Renewables Conference & Exhibition 2019
09 May 2019

Local Energy Systems

By Logan Black CEng MEI – Renewable Energy Consultant, Locogen

Contents

- Company overview
- Definition of Local Energy System
- Example projects
  - Private Wire
  - Virtual Private Wire
  - Local Energy Market
  - Expectations for developers
- Summary

Locogen Group

- Established in 2009
- Head office in Edinburgh
- We develop, build and operate low carbon distributed energy technology projects:
  - Commercial renewable power;
  - Embedded electricity & heat generating technologies; and
  - Local energy systems and transport.

Our client

- Range of clients:
  - Industrial, commercial & agricultural;
  - Investors & lenders;
  - Public sector; and
  - Community groups.

Definition of Local Energy System

- A Local Energy System (LES) utilises energy that is generated within a local area

- This is typically done to maximise the value of the project

- The value could be
  - Economic
  - Social
  - Environmental

Example 1: Private wire/behind the meter

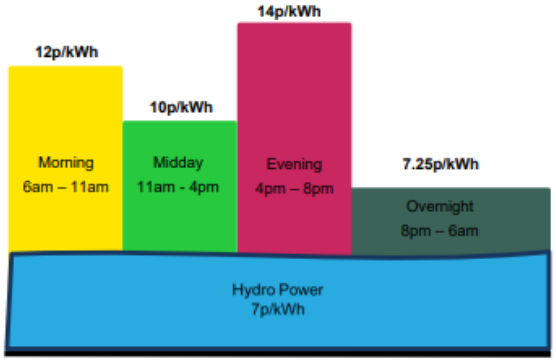
30kW Solar PV

- Community group looking to take advantage of available opportunities
- Private wire to local business (95% self consumption)
- Sale price of 10p/kWh
- Potential returns of 9.1% over 20 years
- Opportunities for existing assets

Example 2: Virtual Private Wire

Bethesda Hydropower

- Community group partnered with Co-operative Energy
- Smart metering system recording demand from 100 houses and generation from hydro
- Community can buy power from hydro plant at 7p/kWh when it is generating
- Community receives low cost energy
- Hydro project receives higher PPA

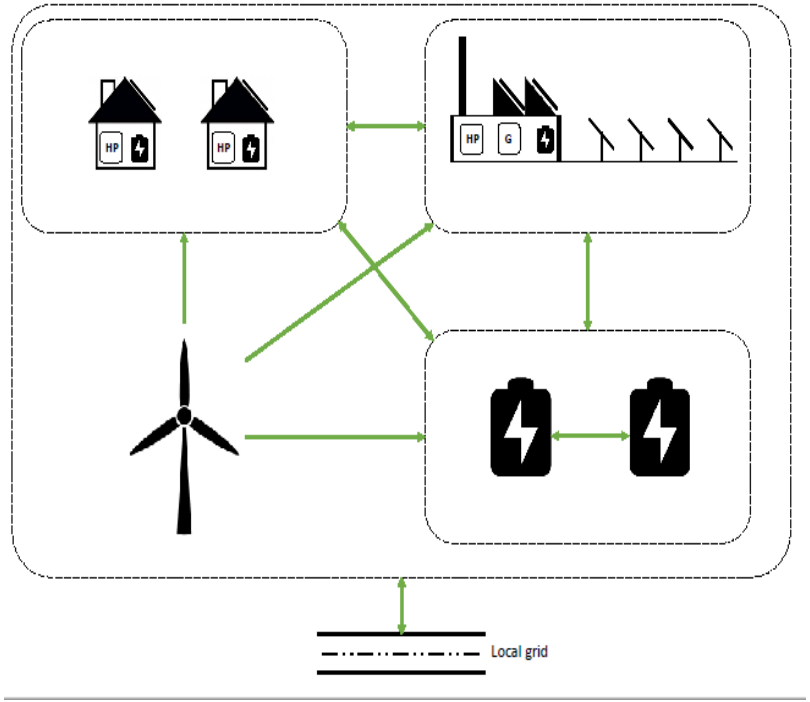


Example 3: Local Energy Market

Cloud ZuoS

- Local Energy Market

- Aims to:
  - Balance supply and demand locally through trading
  - Offer better value to consumers and generators
  - Offers services to DNOs/DSOs



Expectation for developers – what is realistic

Benefits

- Higher price than a conventional PPA (sale price can vary on customer 7-10p/kWh)
- Better returns
- Strong community support

Considerations

- More complex to set up
- More stakeholders
- Impact on existing revenues
- Limited in who can be supplied
- Long term agreements are needed

Summary

- Lots of innovative ways of developing projects
- Risk/reward is key to understand
- Opportunities to review marginal projects

Thank you

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James Buchan

Energy Systems Specialist

Local Energy Scotland

Hydro's Place in Local Energy Systems

LOCAL ENERGY SCOTLAND

Scottish Renewables Hydro Conference & Exhibition: Perth Concert Hall, 9th May 2019

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About us

LOCAL ENERGY SCOTLAND

THE SCOTTISH GOVERNMENT'S → COMMUNITY AND RENEWABLE ENERGY SCHEME (CARES) → IS DELIVERED BY: LOCAL ENERGY SCOTLAND

This consortium is between

CHANGEWORKS

energy agency

energy saving trust

SCARF

wisegroup

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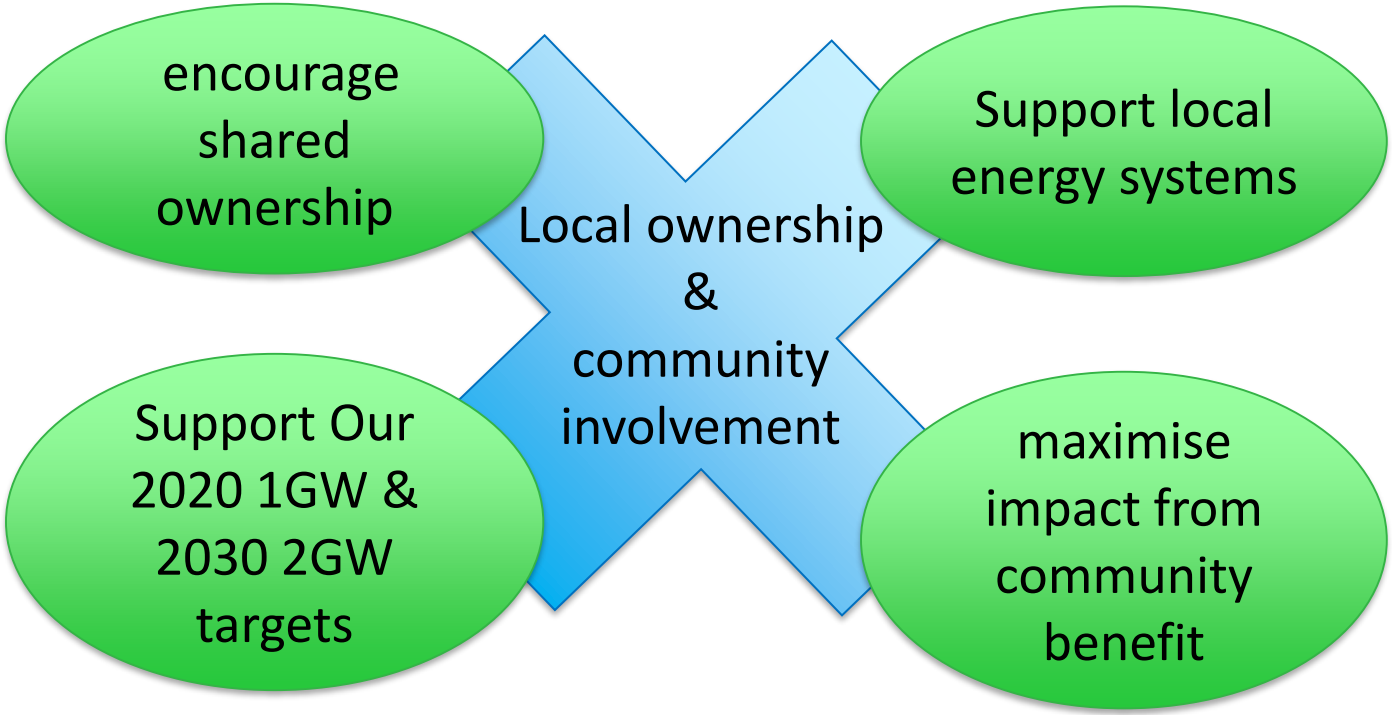
Objectives

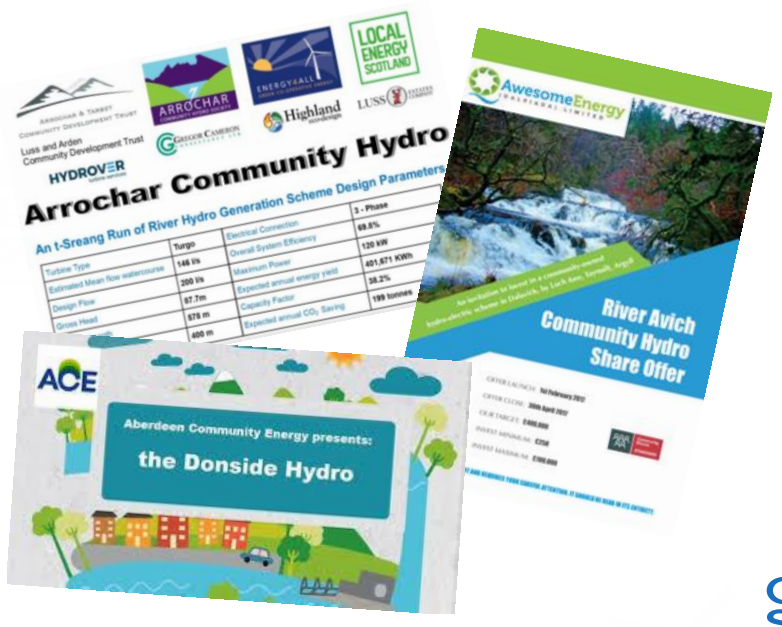
Local Energy Scotland aims to



Project Success

We have supported over 100 hydro projects at various stages of development..

CARES Hydro Projects			
Type	Projects	Value Offered (£)	Size (MW)
Loans	45	2,265,000	12.2
Grants	49	1,925,000	
IIF Grants	10	314,000	
TOTAL	104	4,504,000	12.2



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Local Energy Systems

LOCAL ENERGY SCOTLAND

The Scottish Energy Strategy sets out a whole-system (heat, transport and electricity) approach as a core principle of the future of energy in Scotland.

CARES is designed to support this approach and to develop innovative and integrated local energy systems.

We've developed several resources to help take forward locally owned energy system projects, including for example:

- A step-by-step guide to developing a project combining solar PV, battery storage and electric vehicle charging, based on a project we funded at Comrie Croft.
- A toolkit module focused on innovative energy systems, featuring case studies from the Local Energy Challenge Fund.
- Project summaries from our Innovation and Infrastructure Fund and Local Energy Challenge Fund awards.

Local Energy Systems – Where can hydro play a role?

LOCAL ENERGY SCOTLAND

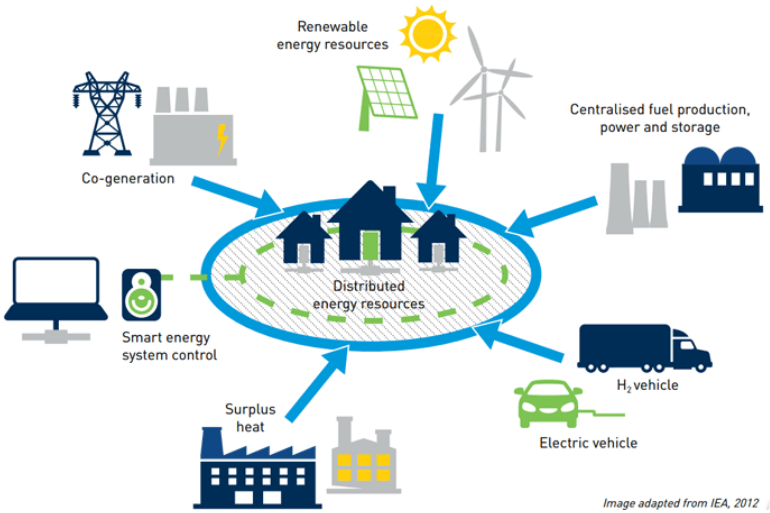
Potential Opportunities

Hydro to Heat?

Hydro to Transport?

Plan new housing developments next to Hydro resources?

Relocation of load – industrial activity to hydro locations?



Post FIT Local supply options could become more attractive for project economic viability.

Hydro schemes deliver constant power so no need to store energy if grid connected, however the advent of Time of Use Tariffs may incentivise storage options such as battery storage to allow timed release at peak demand.

Pumped Hydro storage already plays role both as both storage and baseline generation and management of demand peaks.

Local Energy Systems – Project examples

Knoydart Battery Demonstration Project

Funded by the Local Energy Challenge Fund - feasibility study carried out to develop suitable energy storage solution for community. StorTera designed the first SLIQ single liquid flow battery demonstrator and control solution to store hydro-generated energy and provide back-up power when required.

Subsequently, Knoydart Renewables ordered a small-scale battery which was installed in April 2017. The 8kW/30kWh SLIQ flow battery was designed, built and installed in a purpose built enclosure to stabilise power supply to main office building of Knoydart Renewables.

Functions of system

1. Store hydro generated energy during off-peak hours
2. Sense frequency variations and inject power into grid to stabilise the Knoydart grid (Frequency response)
3. Time shift hydro-generated power
4. Work as power back up system during a grid failure
5. Automatically collect data for future system improvements

Results to date

1. Battery helped keep diesel generator shut-off at night during hydro pipe failure in April 2017 and during 3 other consecutive grid failure events in 2017.
2. Battery powers the system at night during normal operations avoiding use of diesel generator
3. More than 820kWh exported in October 2017
4. Successful frequency response/stabilisation and backup functionality

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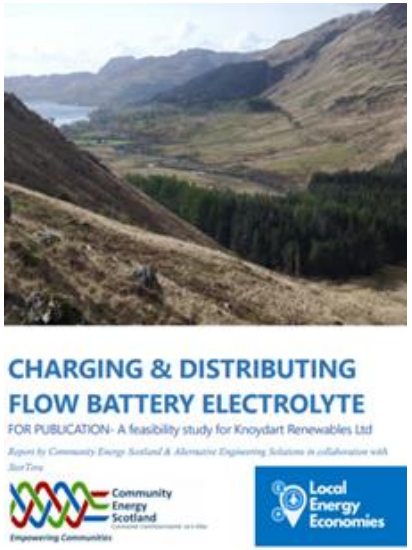
Local Energy Systems – Project examples

Knoydart Renewables Ltd - charging and distribution of electrolyte

Project to assess the technical and operational feasibility of using surplus available electrical capacity of the Knoydart Renewables Ltd (KR Ltd) hydro system (280kW) to supply electricity to a larger market; by means of charging and distributing electrolyte from large flow batteries.

Feasibility study builds upon prior supported work involving the successful trial installation of StorTera's unique SLIQ flow battery, to assess its potential to provide backup power for properties on the Knoydart micro-grid.

This would be carried out by modifying existing flow battery technology to enable movement of electrolyte charged in Knoydart by the hydro system to locations of electrical demand off national grid in the surrounding areas. These demand locations would receive the electrolyte into a smaller battery suitable for their needs located on site and connected to their electrical supply.



Local Energy Systems – Project examples

Abernethy Trust - Ardgour Outdoor Centre Hydro Power Utilisation Project (HYPUP)

The Abernethy Trust was established in 1971 and runs 4 outdoor centres in Scotland. At their Ardgour Centre they were successful in developing an 89kW run of river hydro scheme. This project has grid connection, and at the time of IIF application was 10% of generation was used at the centre and 90% exported to the grid. Abernethy Trust wanted to use as much of this locally at their site for space and hot water heating which would reduce oil and grid electricity usage.

The project was comprised of the following:
-alteration of space and hot water heating system at the centre.
- design, purchase and installation of a bespoke thermal store with immersion heaters (estimated 2000 litre tank) and their integration with additional 420 litre DHW storage
- connection and integration of EMMA controls

As a result, this project allows the centre to benefit from the hydro and uses a thermal store. If there is no demand then electricity is sent to the grid. This means the centre is benefiting from using less oil and electricity from the grid by using locally, and also making an income from selling electricity to the grid.

Local Energy Systems – Project examples

LOCAL ENERGY SCOTLAND

Lochaber Aluminium Smelter – Hydro to Industry

Based at Fort William in the Scottish Highlands, the smelting facilities are powered by two neighbouring hydro-electric stations and a complex of on-site bio-diesel units, owned and managed by Liberty's sister company SIMEC. This combination of renewable energy sources makes the site one of the greenest metal production plants in the country.

Lochaber's new AC generators are 3 phase synchronous machines which use a Francis Turbine as opposed to a pelton bucket/wheel system to turn the kinetic energy of water into mechanical energy.

The Fort William smelter produces amongst the greenest aluminium in the world – emitting up to five times less CO2 than that produced by coal-fired stations, which forms the majority of the world's aluminium supply.

Lochaber Power Station houses five 20MVA Generators giving an installed capacity of 100MVA making it one of the biggest continuous Hydro Power Stations in Britain. Each generator rotates at 600 revolutions per minute (RPM) and will annually generate on average 14MW of power at 11,000 Volts.

CONTACT US

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Kenny Taylor

Policy & Advice – Sustainable Development
Scottish Natural Heritage

View presentation here

Catherine Falconer

Major Connections Manager
Scottish & Southern Electricity Networks

Local Energy Systems: the Networks Angle

Hydro Conference 2019

Catherine Falconer
Commercial Contracts

Scottish & Southern Electricity Networks

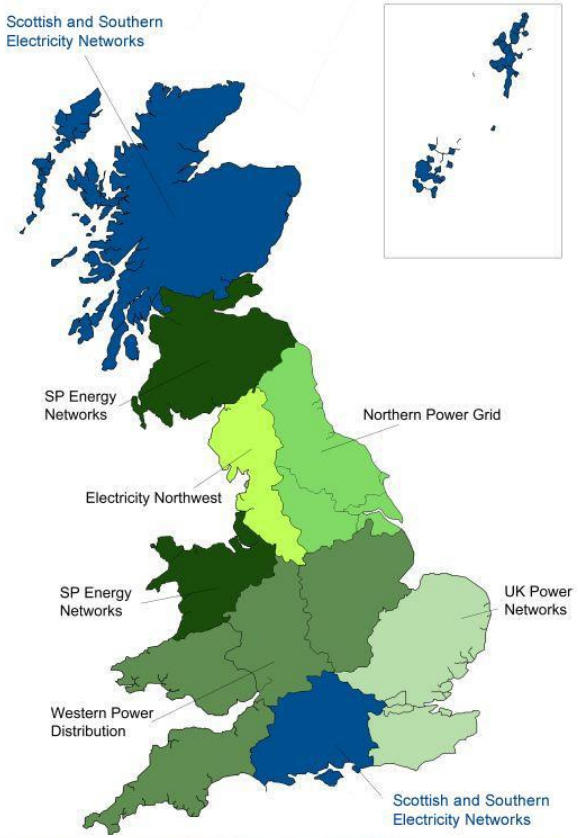
Who we are and what we do

Scottish & Southern Electricity Networks

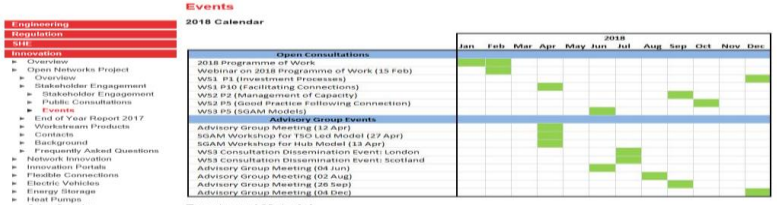
- Scottish Hydro Electric Power Distribution (SHEPD)
- Southern Electric Power Distribution (SEPD)
- Scottish Hydro Electric Transmission (SHE Transmission)

Our first priority is to provide a safe and reliable supply of electricity to our communities in Scotland and England.

This priority is reflected in our values which guide how we behave as we work together now and in the future.



There's a lot going on.....



Ofgem - Electricity Network Access and Forward-Looking Charging Review :

- https://www.ofgem.gov.uk/publications-and-updates/electricity-network-access-and-forward-looking-charging-review-significant-code-review-launch-and-wider-decision

ENA Open Networks Project:

- http://www.energynetworks.org/electricity/futures/open-networks-project/

Requirements for Generators (RfG) / EREC G98 and G99 (Replacement to G83 and G59):

- http://www.energynetworks.org/electricity/engineering/distributed-generation/engineering-recommendation-g59.html

SSEN Wedsite: Events and dedicated resources:

- **Events Page – view historic events, request an event, register to be kept informed:** www.ssepd.co.uk/stakeholderevent/basicsearch/
- **More on EV including a guide and webpage:** www.ssen.co.uk/Connections/EVconnections/
- **More on G98 and G99 including links, FAQs, and a dedicated email**: www.ssen.co.uk/G99G98Requirements/

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Decarbonisation -The network journey

The network DNO to DSO journey

- Flexible Connections - Using the network more efficiently and more locally
- Decarbonisation of Transport
- Connections capable of entering the new marketplace

Getting ready for the Pricing Signals which will drive this.

Scottish & Southern Electricity Networks

Flexible Connections

Initial Trial has connected 85 Generators/153MW "Early"

- Standard Application – from 16th April 2018
- Options for Flexible Connections
  - Full ANM, 3rd Party ANM
  - Export Limiting and Timed Export Limiting
  - Short Term or Permanent

- Visit our website: https://www.ssen.co.uk/AlternativeGenerationConnections/
- Contact the Active Solutions Team at FlexibleConnections@sse.com

Scottish & Southern Electricity Networks

Offsetting New Generation against New Demand

Conventional Approach

- New generation may trigger works, costs and delays to a project

An alternative local energy approach - Connect without triggering these works

- Where **new generation** is connected with **new demand** and
- It can be demonstrated that the generation is offset by the new demand
  - For G83 PVs this could be the utilisation of a battery or hot water connection
  - For Larger this could be through suitable control systems

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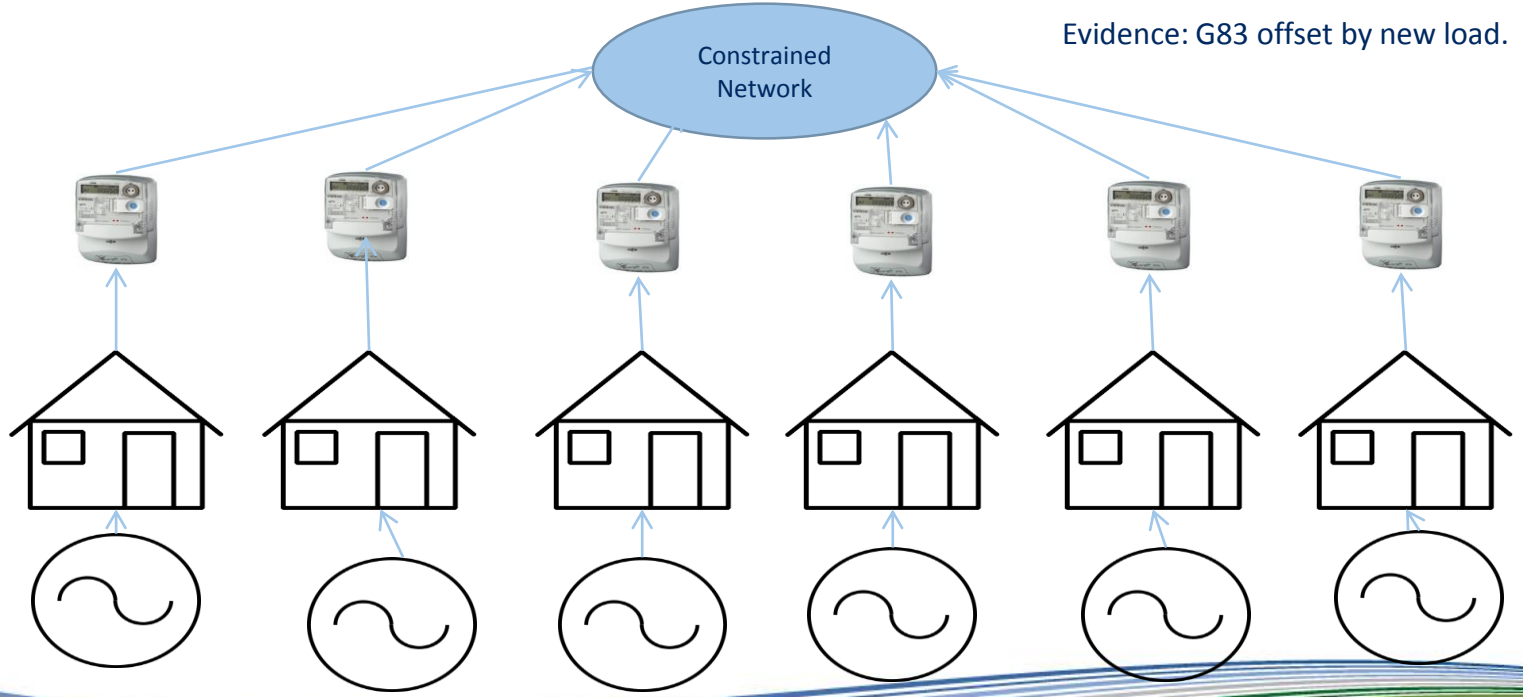
A Real Example: Orkney New Housing



Evidence: G83 offset by new load.

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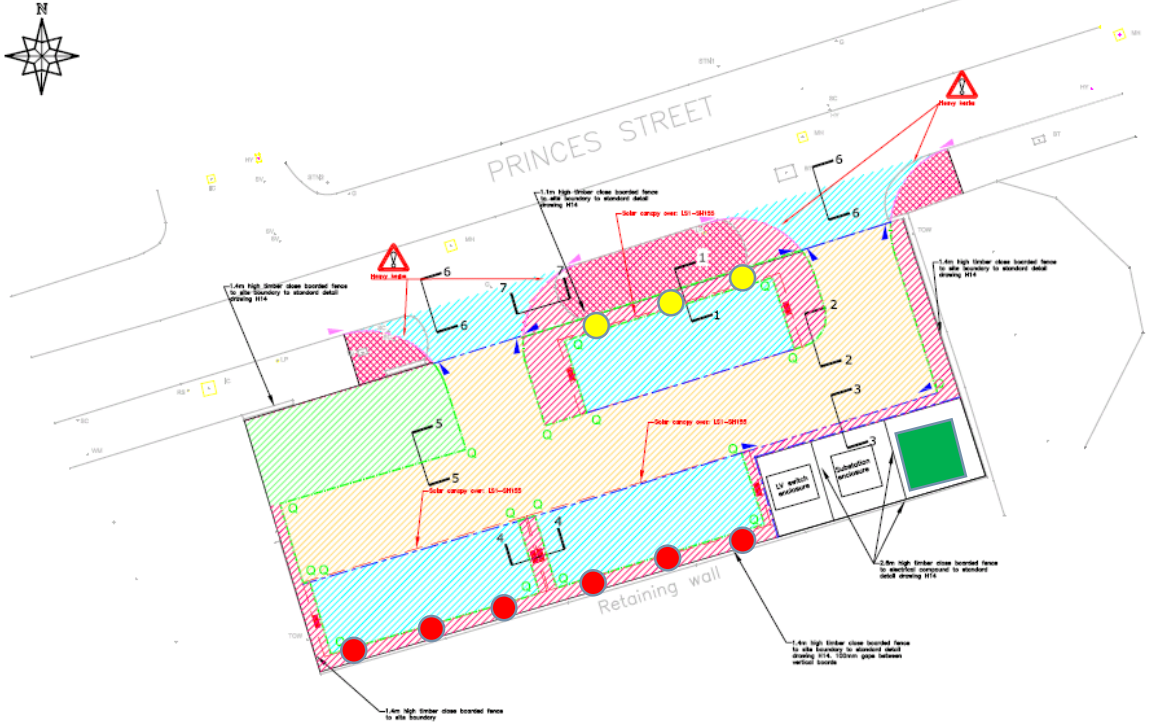
Decarbonisation of Transport – alongside Generation



Dundee EV HUB

- 3 x 22kW car chargers
- 6 x 50kW Rapid car chargers
- 3 x 6 bay solar PV canopies (36kW)
- 60kW (90kWh) Energy storage unit

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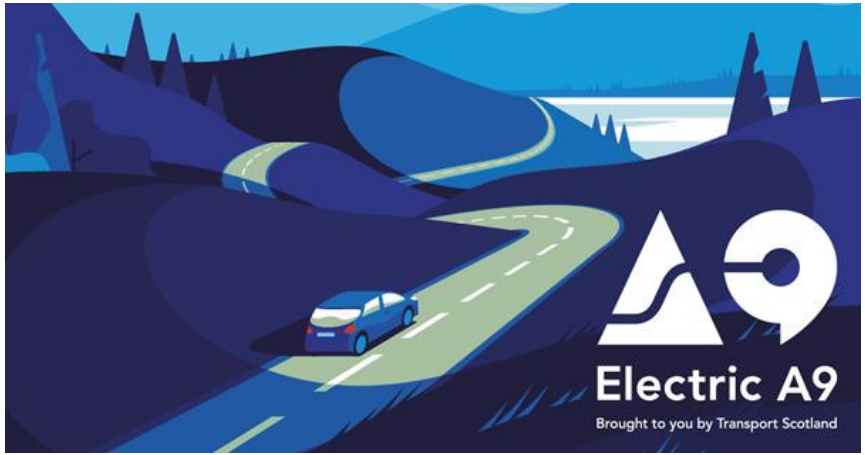
The Electric A9 – another Real example



At 273 miles (439 km), the A9 is the longest road in Scotland.

The Electric A9 will expand and reinforce Scotland's existing EV charge place infrastructure.

- Run along the entire route of the A9.
- Multiple EV charge place hubs along the route
- To provide EV charging for long distance journeys, local charging for businesses and residents, and charging at your destination.

The Electric A9 EV charge place hubs will be located along the route of the A9 within local communities; between Falkirk Stadium in the south to Scrabster Harbour in the north. Each hub facility will provide multiple charge points and access to associated amenities.

SSEN have so far issued budget estimates for 18 sites along the route.

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Ready for the changes – Generation Connections

EREC G98 and G99 (replacement for G59 and G83) - to **harmonise the technical and market rules**

to provide a sustainable, secure and competitive electricity market

Applies to all new Generation projects not yet commissioned

…Significantly more work for DNOs and Generators

- New Application Form and register of manufacturers equipment
- More evidence of compliance during design
- Additional Commissioning witnessing

Effect on Connected Generators – Loss of Mains (LOM) changes coming.

.....Those useful links and contacts again

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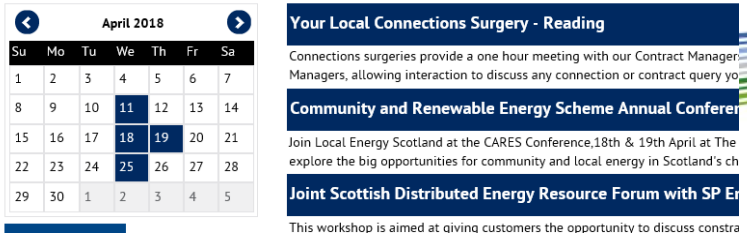

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Scottish Renewables

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