Battery Storage and Planning Policy

14th November

Jon Buick – Climate Change Projects Officer

merton

Overview

- How can battery storage help tackle peaks in demand?
- The case for inclusion in planning policy
- Future work - energy projects at Merton

South Australia

Elon Musk's big battery for South Australia already half complete

Tesla boss said the project is a great example of how to replace fossil fuels with renewables

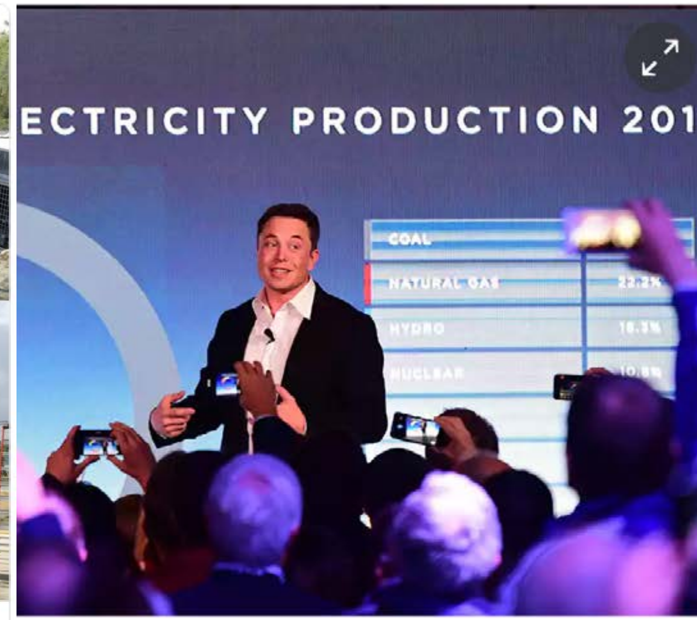
- Elon Musk: SpaceX can colonise Mars and build moon base

Tesla @Tesla

Hospital del Niño is first of many solar+storage projects going live. Grateful to support the recovery of Puerto Rico with @ricardorossello

3:00 PM - Oct 24, 2017

1,301 15,308 41,469



n at the Tesla Powerpack launch event at in Adelaide. Photograph: Mark

TESLA

POWERWALL

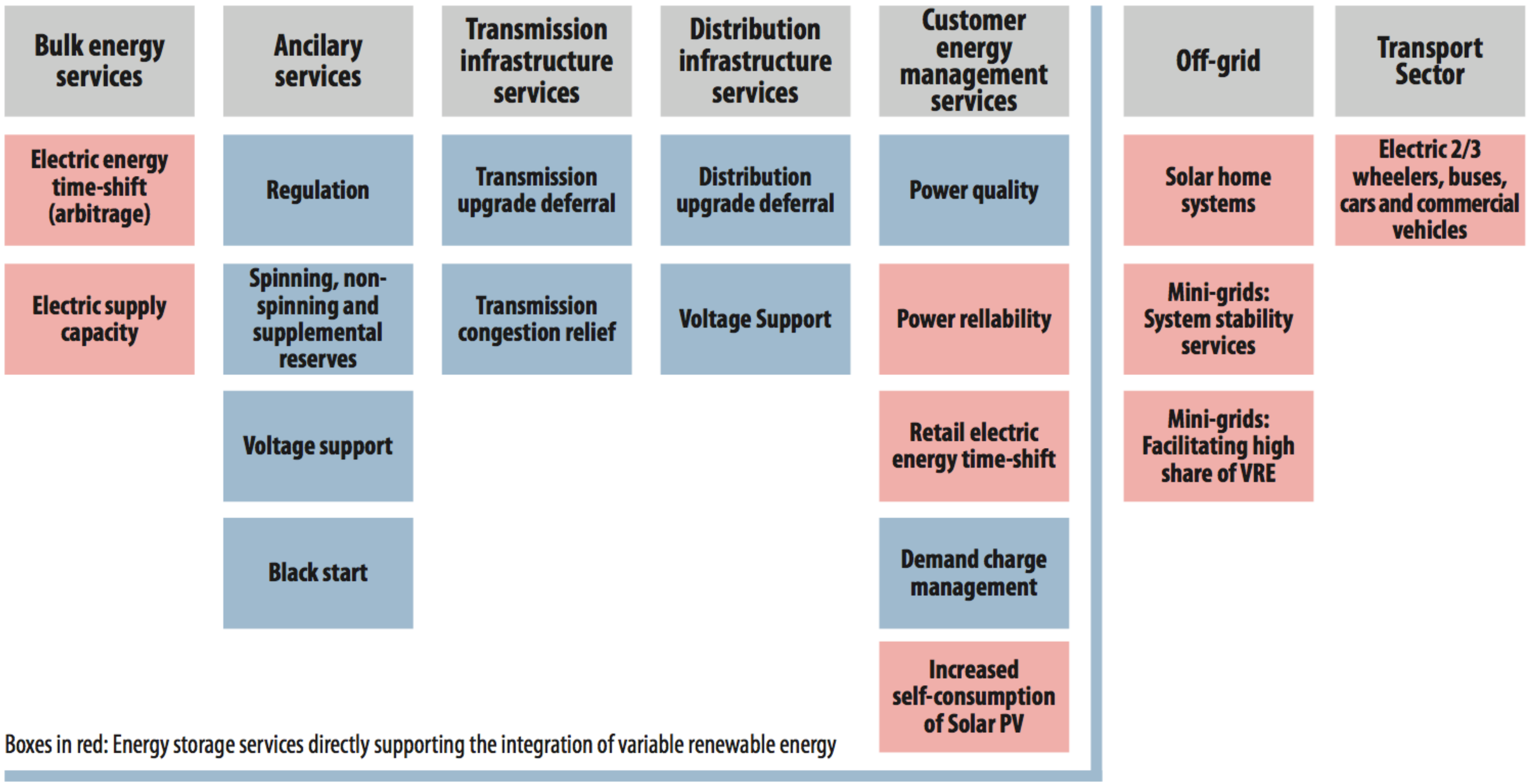
CERTIFIED INSTALLER

Battery storage and the clean energy transition

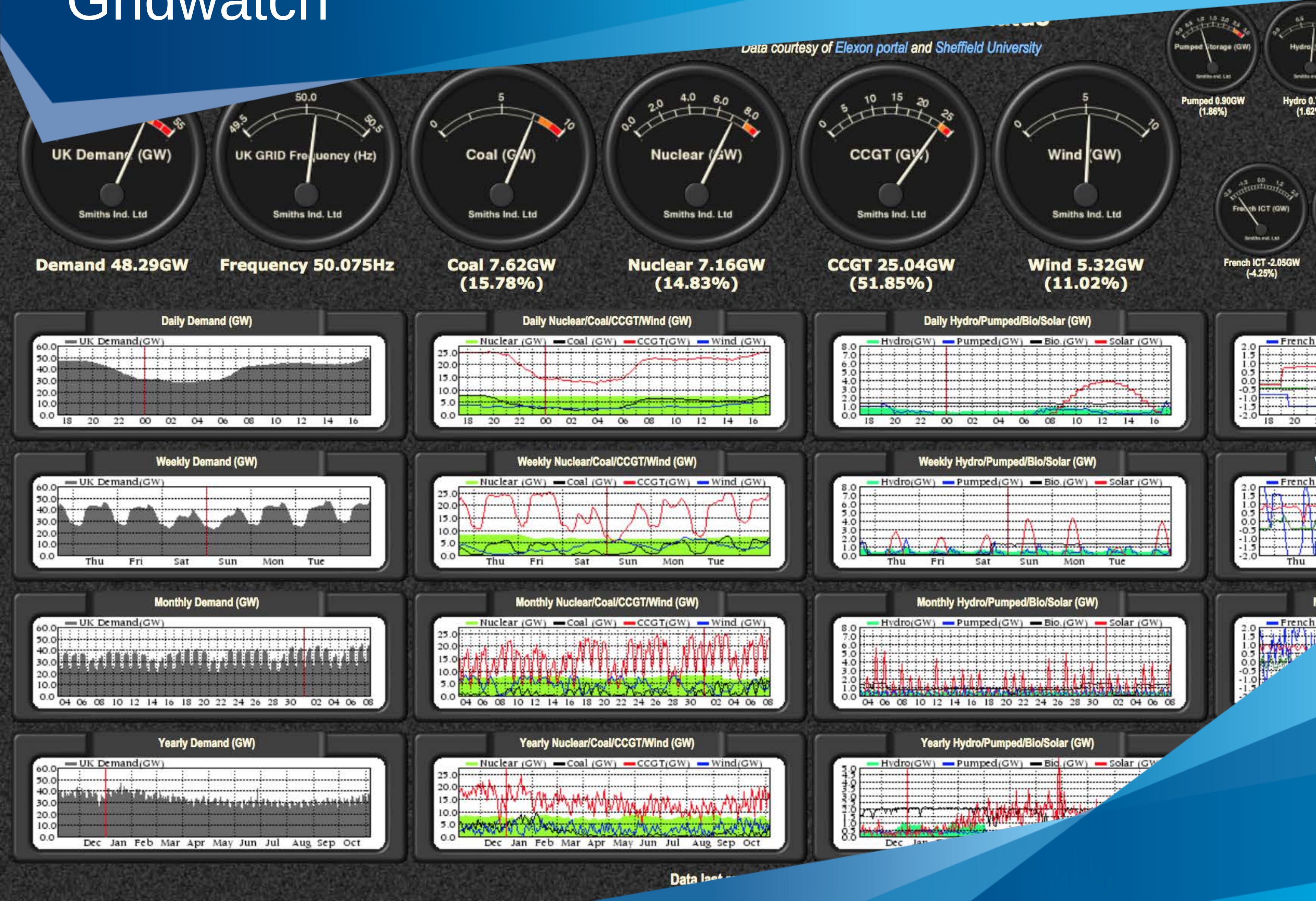
	Today	2020s	2030s
Off-grid & isolated grids	Solar home systems, mini grids, islands	Increased deployment, very high-100% VRE shares	Very high-100% VRE shares even on large islands
Grid services	High power low energy applications (e.g. frequency response)	Increasingly economic for higher energy applications (e.g. firm capacity)	Economic for high power and energy service provision
VRE integration	Small role, for RE capacity firming and short duration time-shift	Large capacity firming role, time - shift within the day	Providing firm capacity and VRE time-shift up to intra-day
Self-consumption	In high retail price/low rooftop PV cost locations with right regulatory support	Economic in markets with competitive rooftop PV costs & moderate retail prices	Economic for most rooftop PV systems to be coupled with some battery storage
Electromobility	Competitive costs for 2/3 wheelers, some EV offerings/markets. Modest V2G potential	EVs economic for passenger vehicles, increasingly for light commercial. Growing V2G potential	Highly competitive EVs, public transport & light commercial. Large V2G potential

Functions of battery storage

Figure ES1: The range of services that can be provided by electricity storage

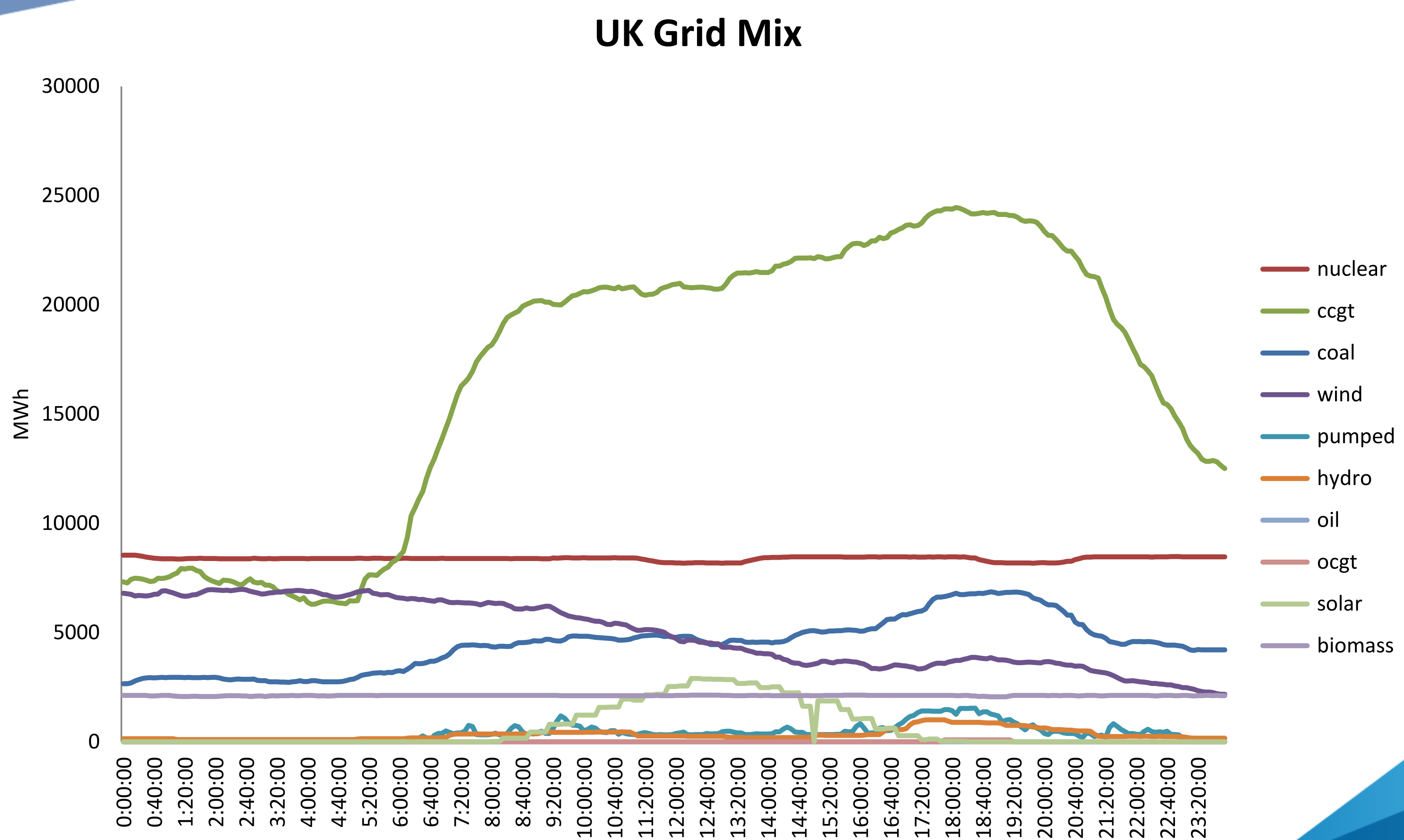


Gridwatch

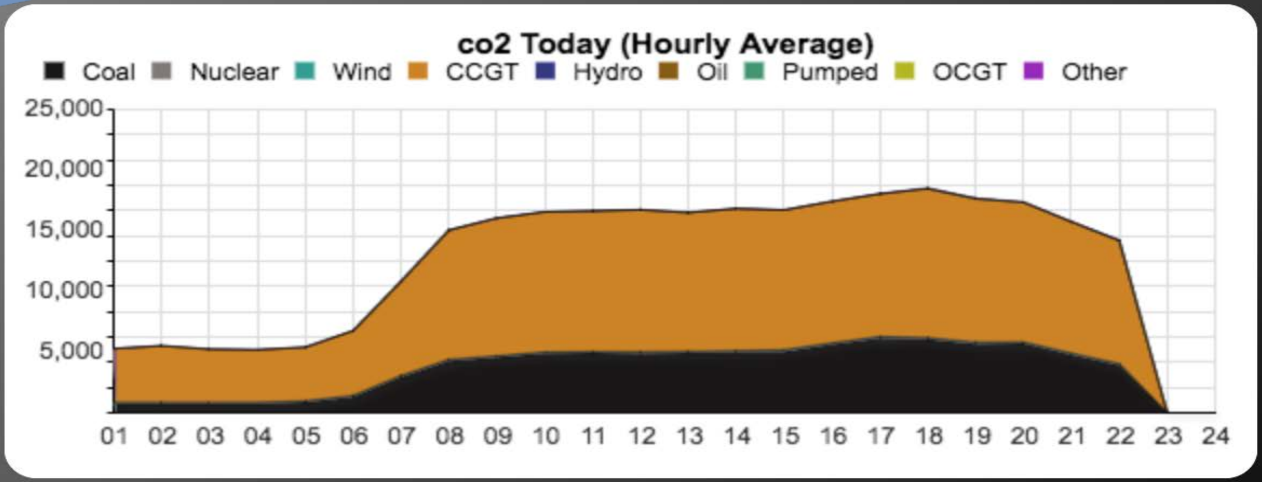


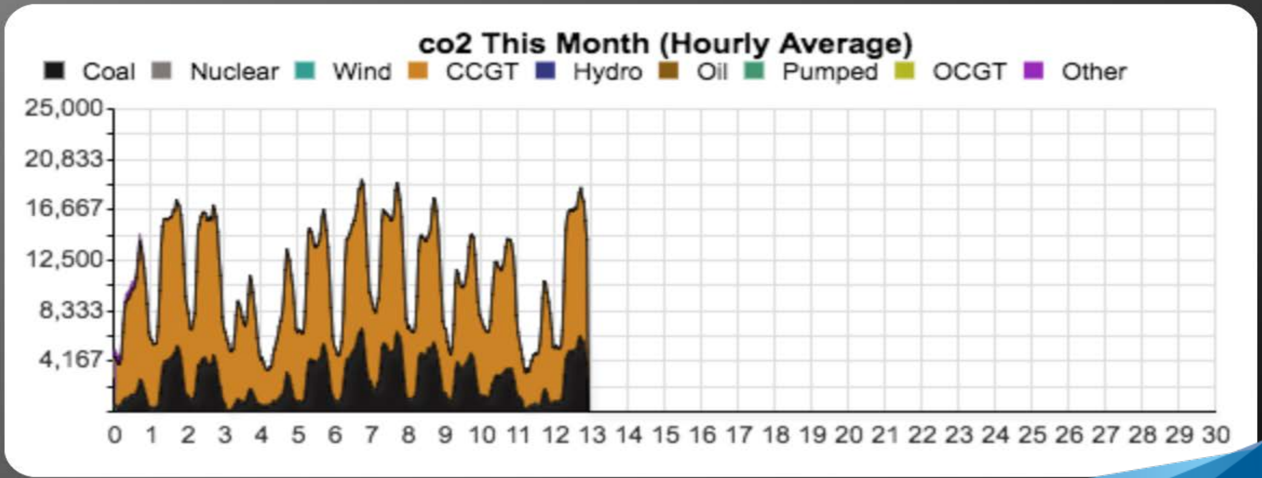
Data courtesy of Elexon portal and Sheffield University
UK Demand (GW)
UK GRID Frequency (Hz)
Coal (GW)
Nuclear (GW)
CCGT (GW)
Wind (GW)
Smiths Ind. Ltd
Demand 48.29GW
Frequency 50.075Hz
Coal 7.62GW (15.78%)
Nuclear 7.16GW (14.83%)
CCGT 25.04GW (51.85%)
Wind 5.32GW (11.02%)
Pumped 0.90GW (1.86%)
French ICT -2.05GW (-4.25%)
Daily Demand (GW)
Daily Nuclear/Coal/CCGT/Wind (GW)
Daily Hydro/Pumped/Bio/Solar (GW)
Weekly Demand (GW)
Weekly Nuclear/Coal/CCGT/Wind (GW)
Weekly Hydro/Pumped/Bio/Solar (GW)
Monthly Demand (GW)
Monthly Nuclear/Coal/CCGT/Wind (GW)
Monthly Hydro/Pumped/Bio/Solar (GW)
Yearly Demand (GW)
Yearly Nuclear/Coal/CCGT/Wind (GW)
Yearly Hydro/Pumped/Bio/Solar (GW)

The UK energy mix

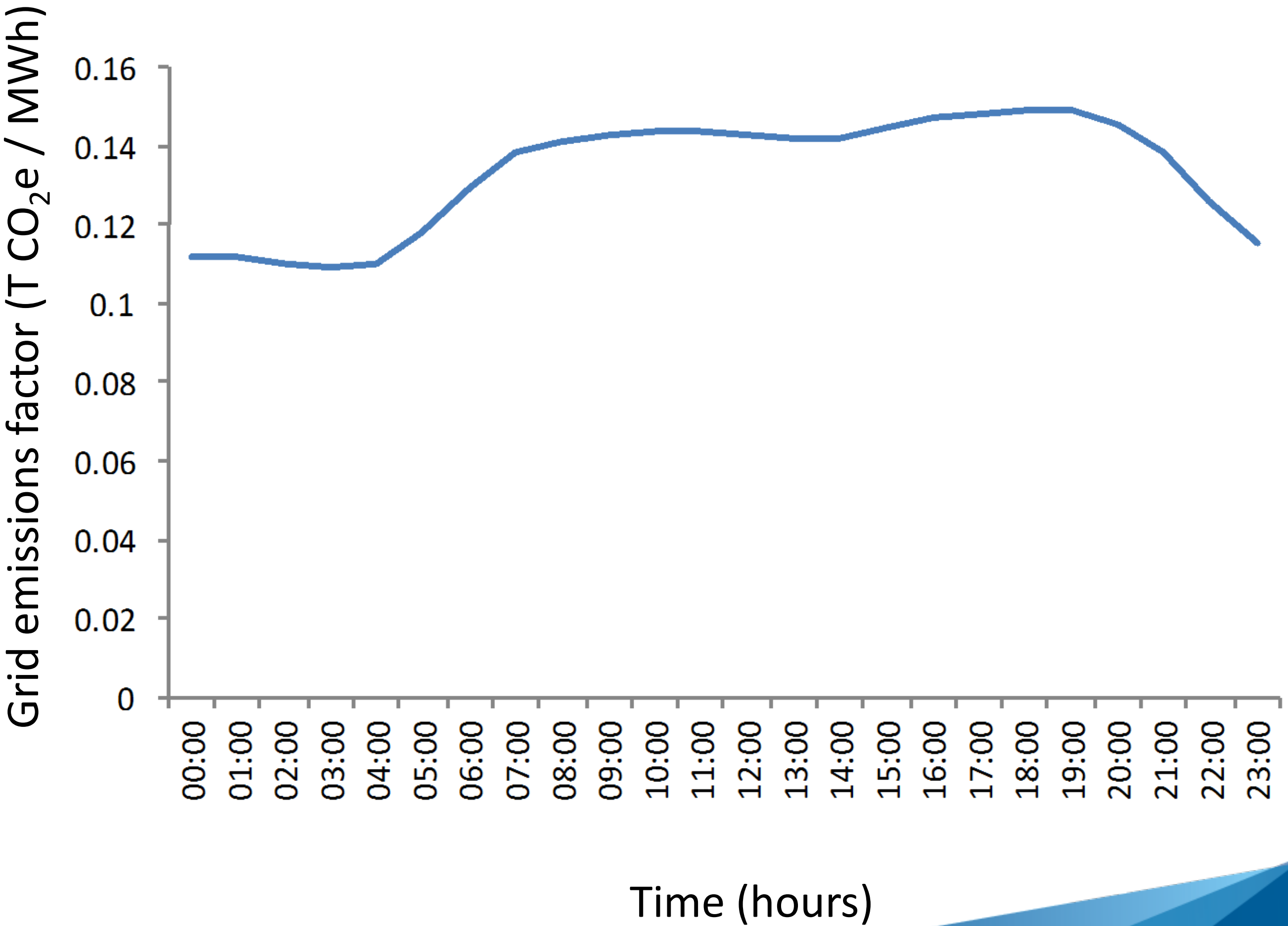


UK Grid emissions

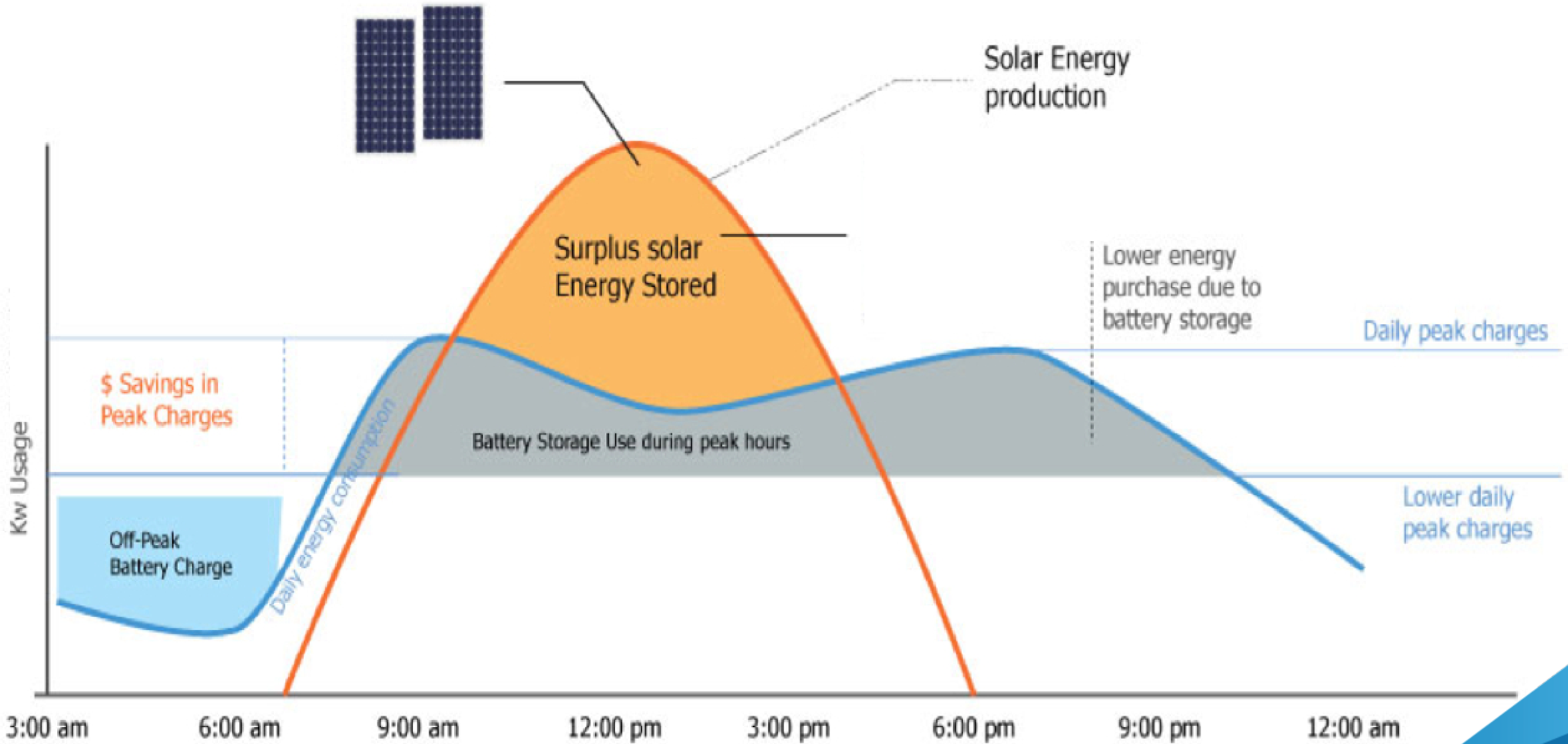


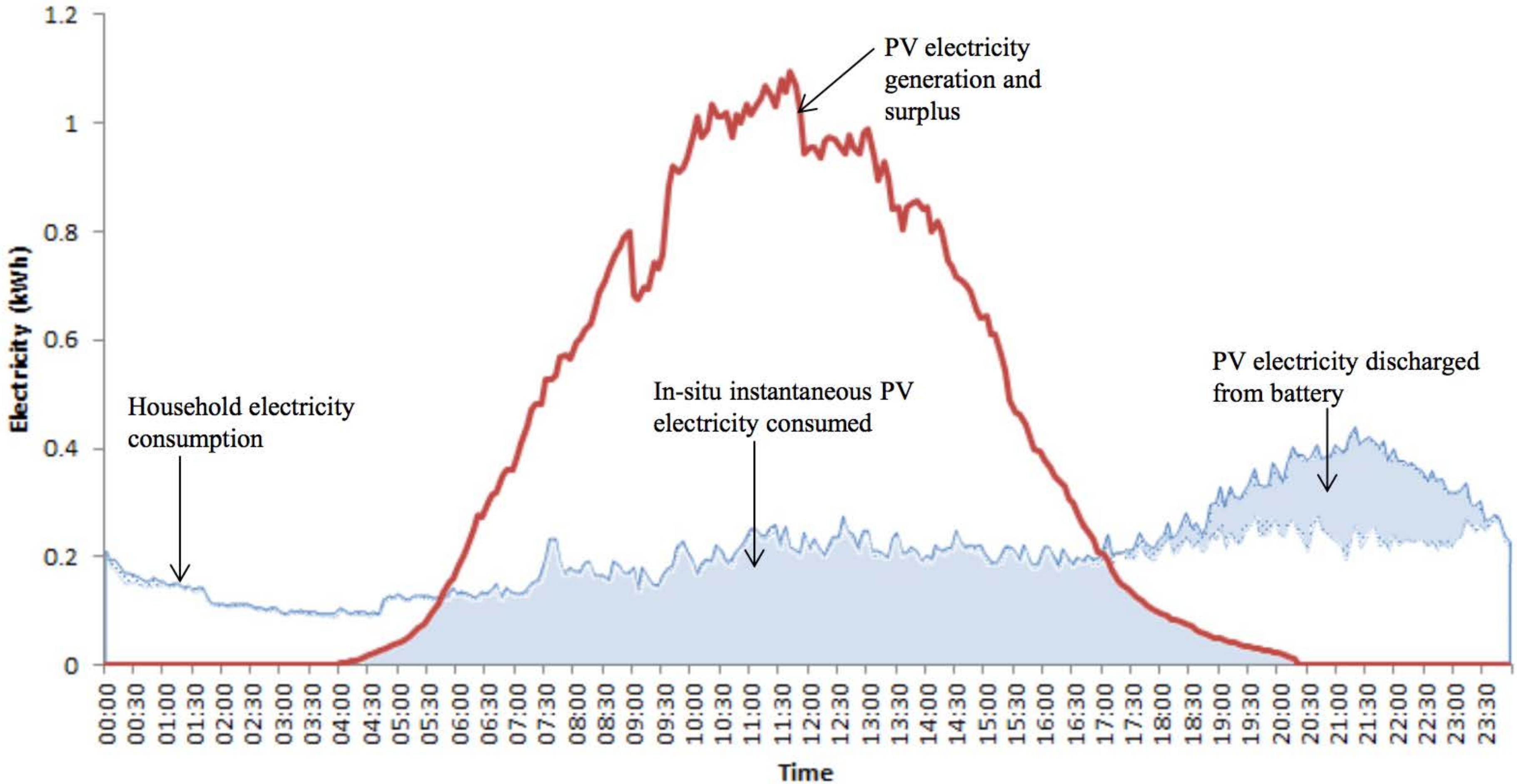


Grid emissions factor



Time shift + PV storage



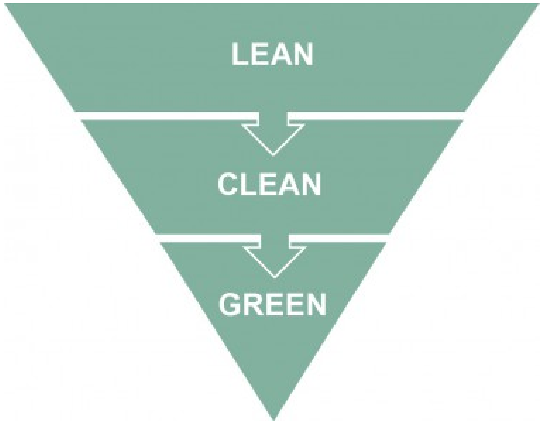


PV Size (kWp)	Average daily generation (kWh)				
	1.5	2.0	2.5	3.0	3.5
Summer	4.1	6.6	8.2	8.7	12.0
Winter	1.6	3.7	4.1	4.8	5.3

PROJECT ERIC
re-energising communities

London Plan Policies

- Policy 5.2 Minimising carbon dioxide emissions
  - Energy hierarchy:
    1. Be lean: use less energy
    2. Be clean: supply energy efficiently
    3. Be green: use renewable energy



- Policy 5.4A Electricity and gas supply
- Policy 5.5 Decentralised energy networks
- Policy 5.7 Renewable energy
- Policy 5.8 Innovative energy technologies

EP E6 Environmental protection

f) All domestic solar PV should be considered in conjunction with on-site battery storage.

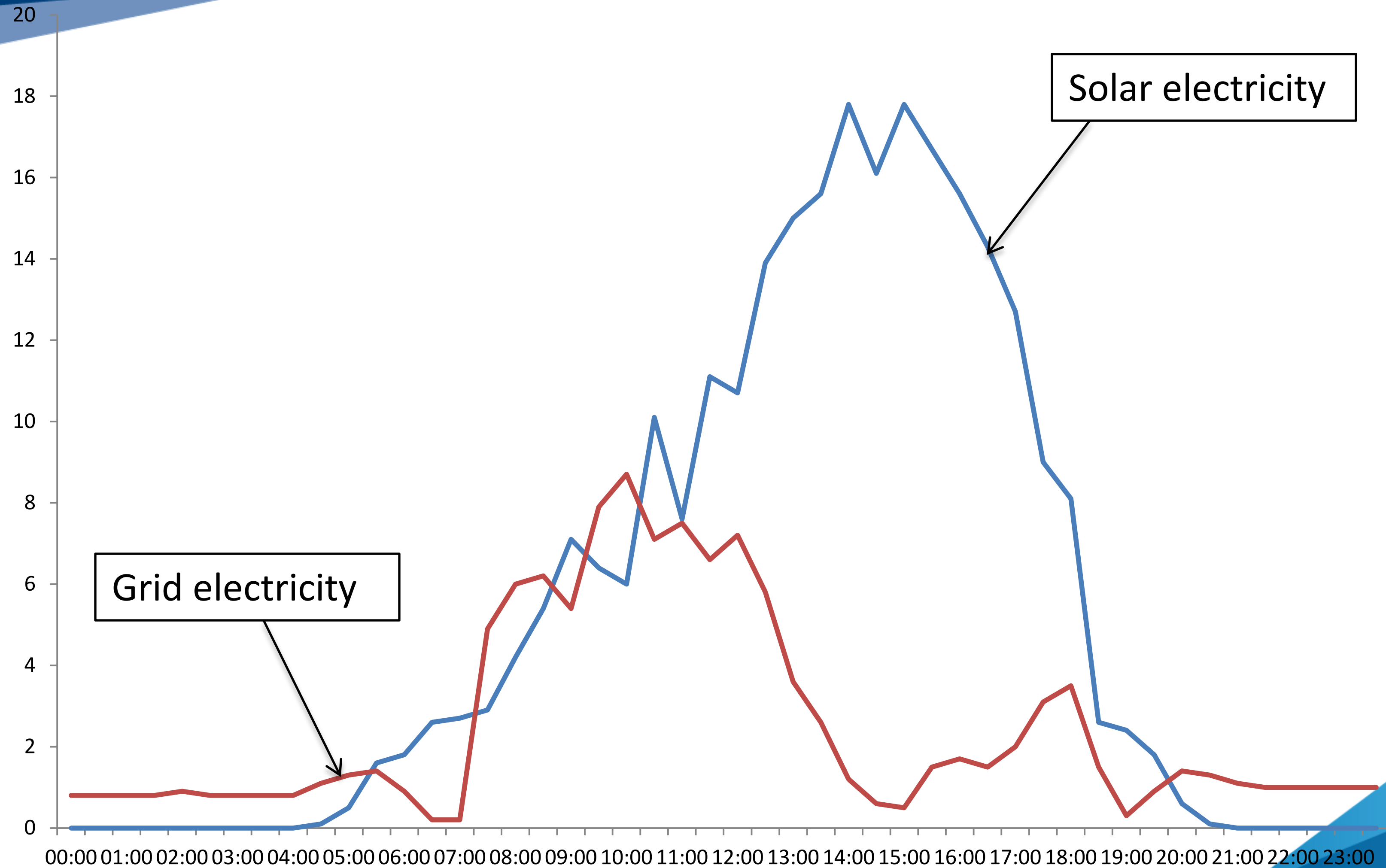
The supporting text provides:

- That Battery Storage is considered to be a “Be Clean” technology based on the efficiency of supply
- A methodology for calculating the CO_2 based on SAP

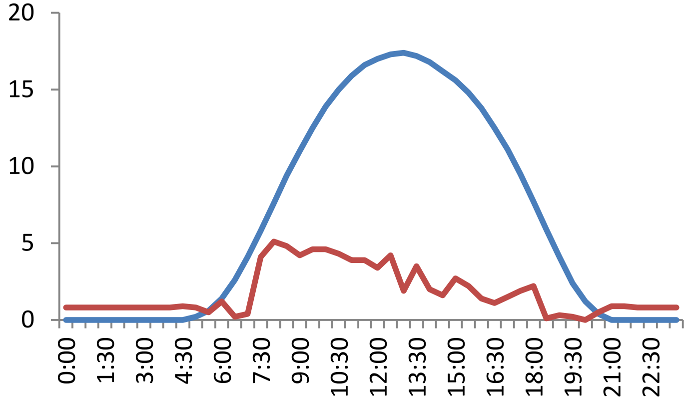
kWh/year = kWp x S x ZPV x 0.2 (Carbon savings from battery storage)

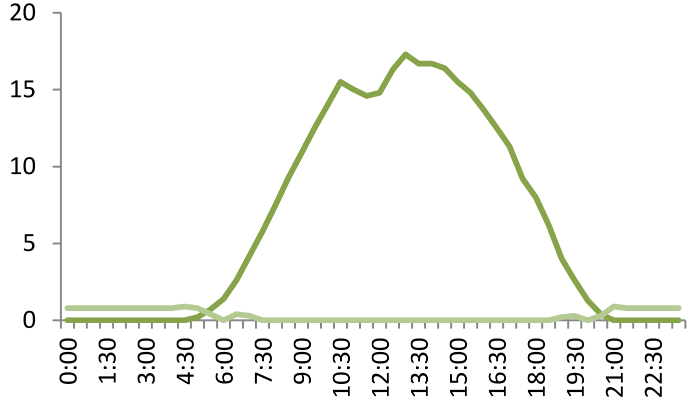
kWp – Kilowatt Peak (Size of PV System)
S – Annual Solar Radiation kWh/m2 (See SAP)
ZPV – Overshading Factor (See SAP)

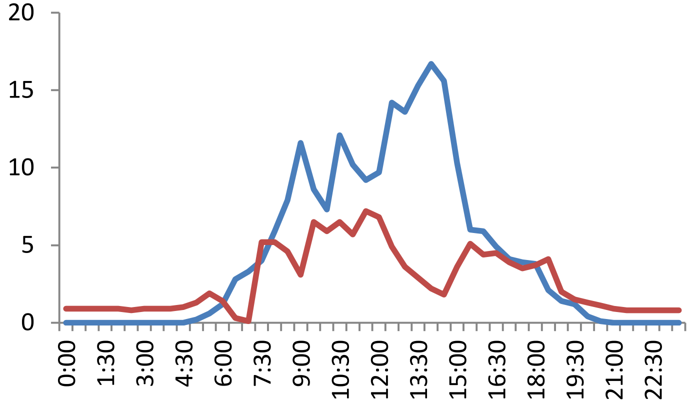
Electricity profile – William Morris Primary School

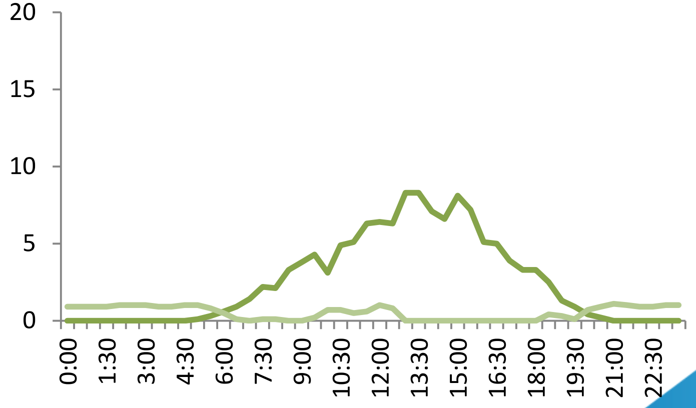


Battery storage potential for non-domestic sites?









Conclusions

- Batteries can reduce peak time energy demand and reduce carbon emissions through:
    - Increasing self consumption of energy from PV
    - Time-shifting for low carbon production at night, offsetting gas at peak times
- The introduction of local battery storage policies is supported by policies and targets within the London Plan
- Merton's policies aim to support the delivery of battery storage by:
    - Defining where the technology sits within the energy hierarchy
    - Providing a methodology for quantifying its energy and carbon benefits
    - Linking battery use to the installation of solar PV

Questions?

Thank you!

Jon.Buick@Merton.gov.uk

Portsmouth City Council

Decarbonisation of Leisure Centres

The Mountbatten Leisure Centre

Survey & Investigations

Existing Energy Consumption & Costs

Load Monitoring, Building Modelling & Data Analysis

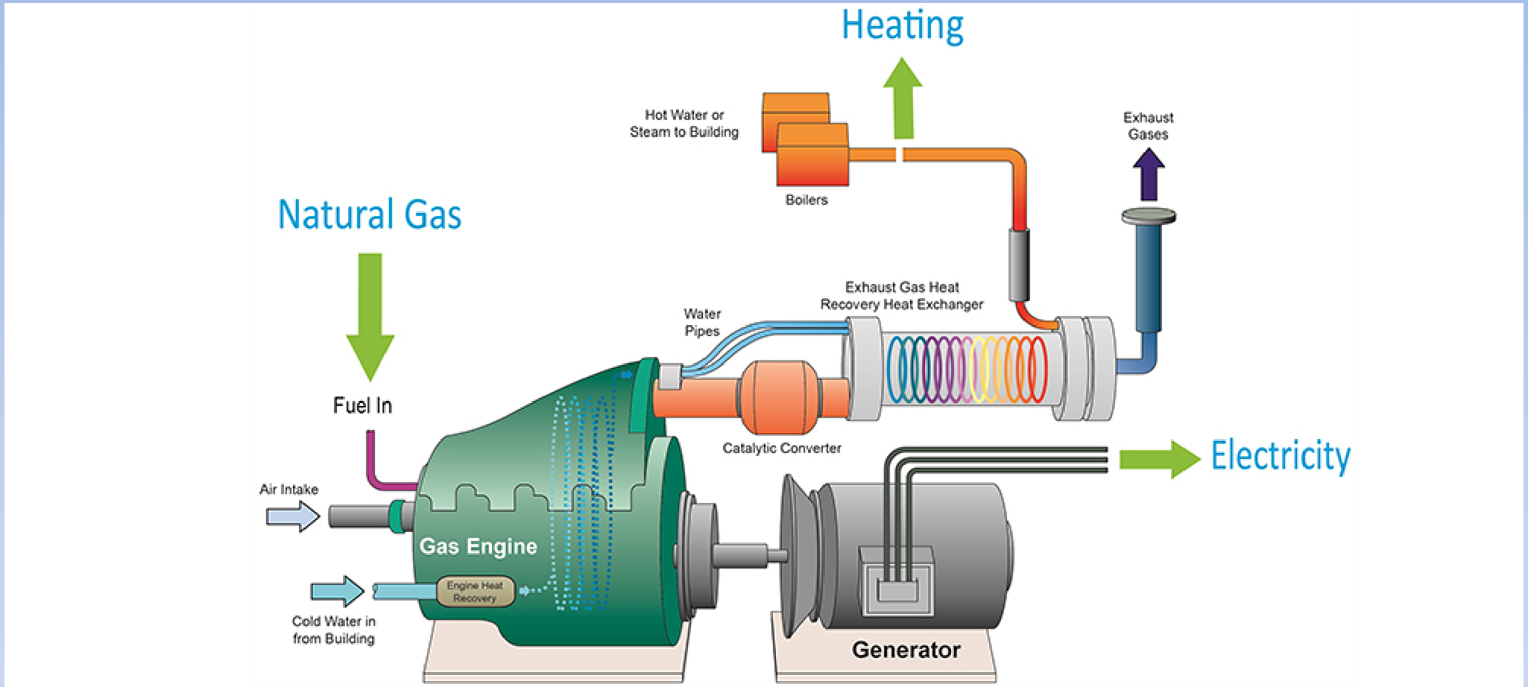
Options Appraisal

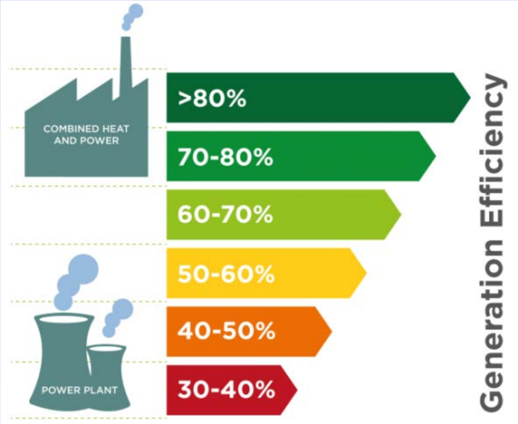
Business Case

Comparison with Competitive Offers

Contractual Arrangements

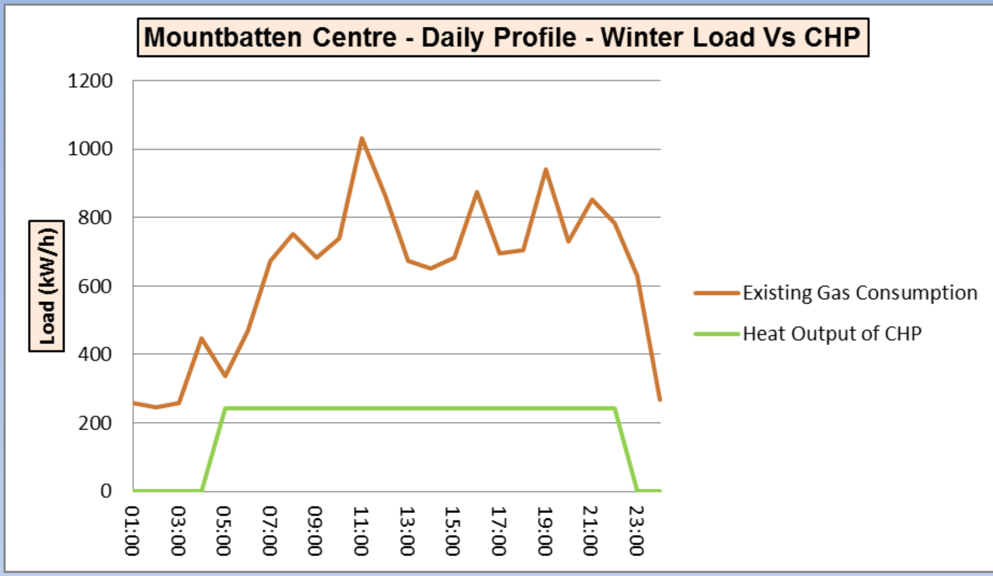
Combined Heat and Power



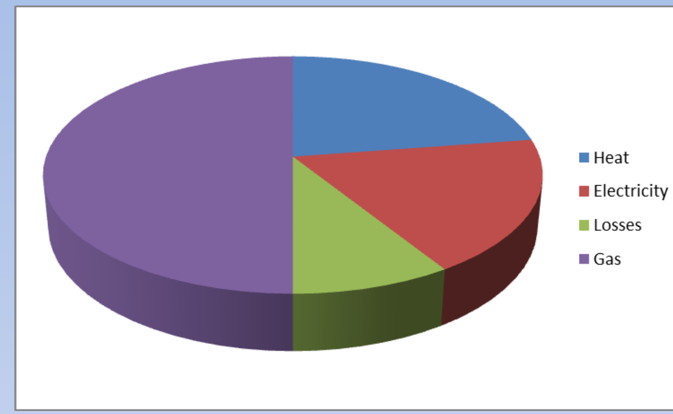


Advantages

Efficient Electricity Generation
Low Cost Electricity Generation
Resilience to Electricity Price Increases
Carbon Emission Savings



Capacity	Heat Output (kW)	Electricity Output (kW)	Gas Consumption (kW)
100%	242	200	538
75%	200	150	426
50%	155	100	312
40%	137	80	291



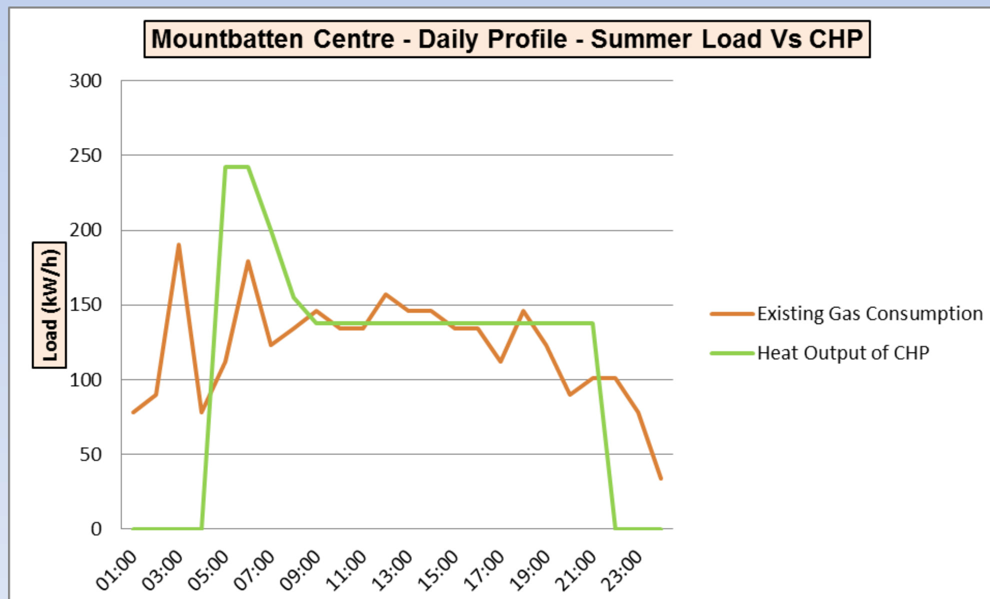
<u>Performance</u>

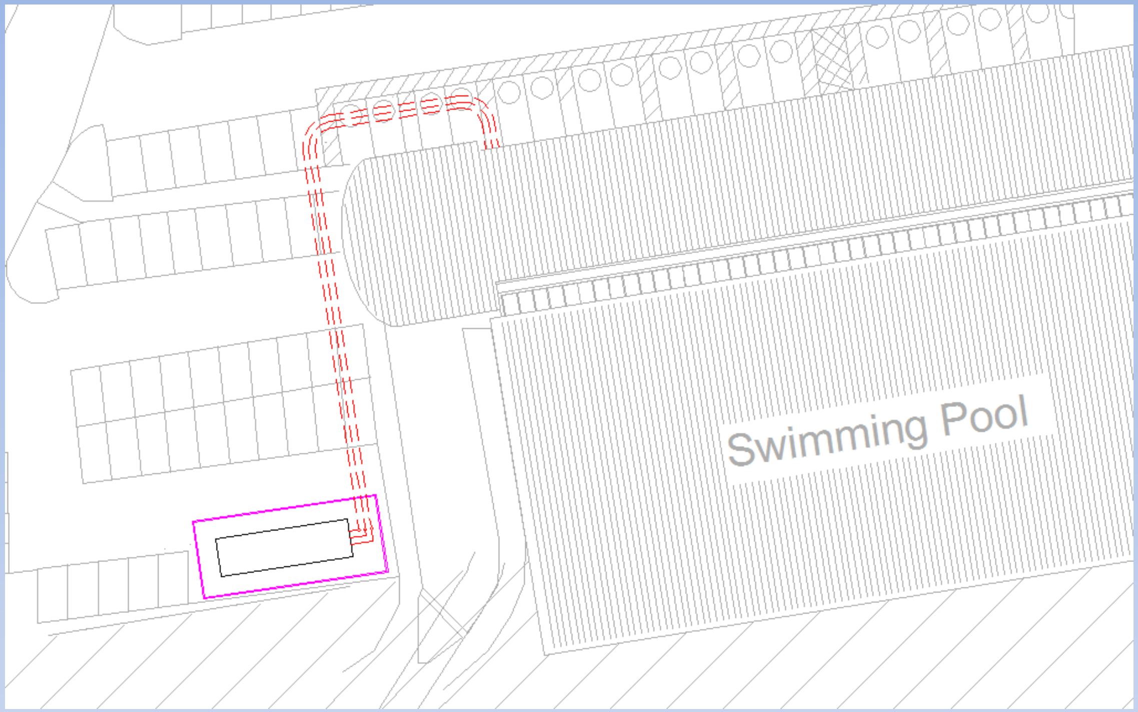
$242kW_{th}$
1.3m kWh Heat Output per Annum

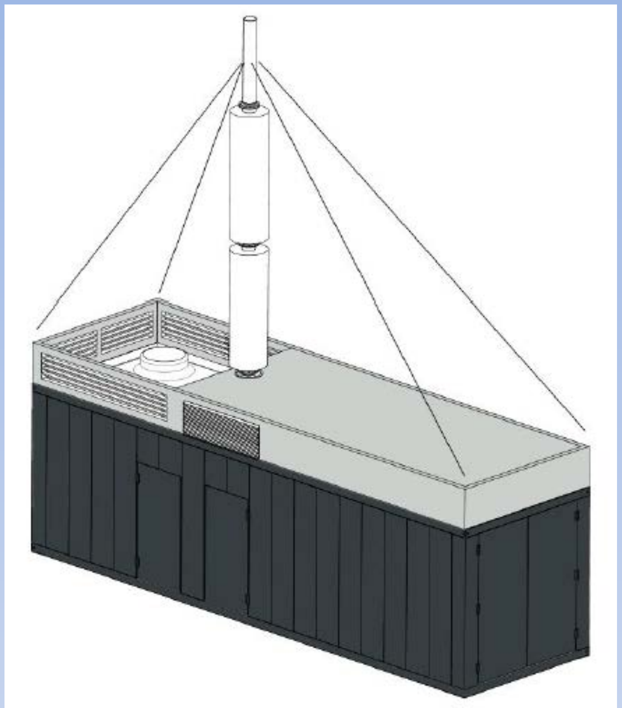
$200kW_{e}$
1.05m kWh Electricity Output per Annum

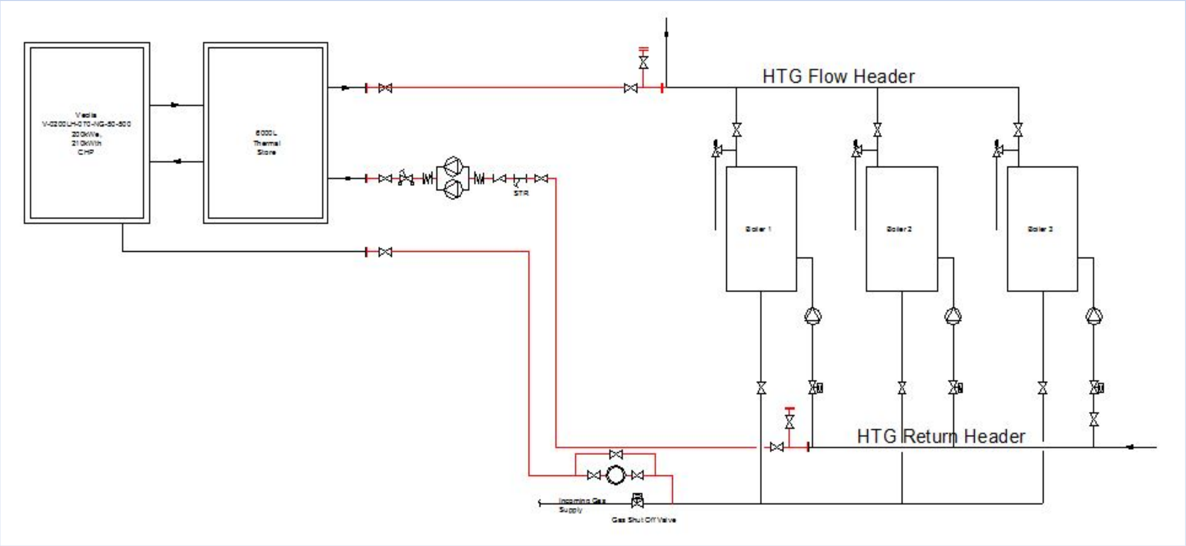
538kW Gas Consumption
2.87m kWh Gas Consumption Per Annum

82% Efficient




Swimming Pool




HTG Flow Header
HTG Return Header

CO2

Carbon Savings
264 tonnes CO2/ Year

£

Cost Savings
£95,000 per Annum

CAPEX

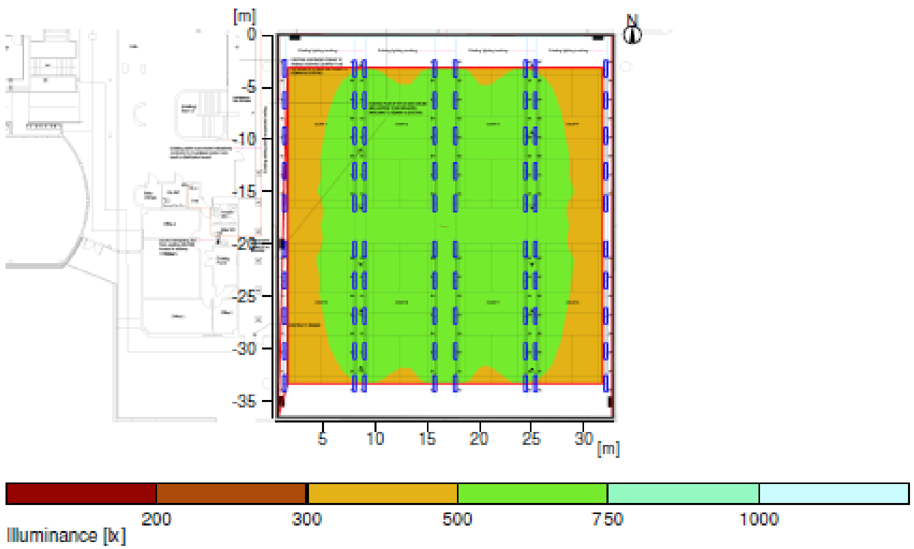
Project Capital Cost
£330,000

Payback in 3.5 Years

Payback

Sports Hall Relux

2.2.2 Result overview, Evaluation area 1



General

Calculation algorithm used	Average indirect fraction
Height of luminaire plane	9.10 m
Maintenance factor	0.80
Total luminous flux of all lamps	756000 lm
Total power	6000.0 W
Total power per area (910.29 m²)	6.59 W/m² (1.22 W/m²/100lx)

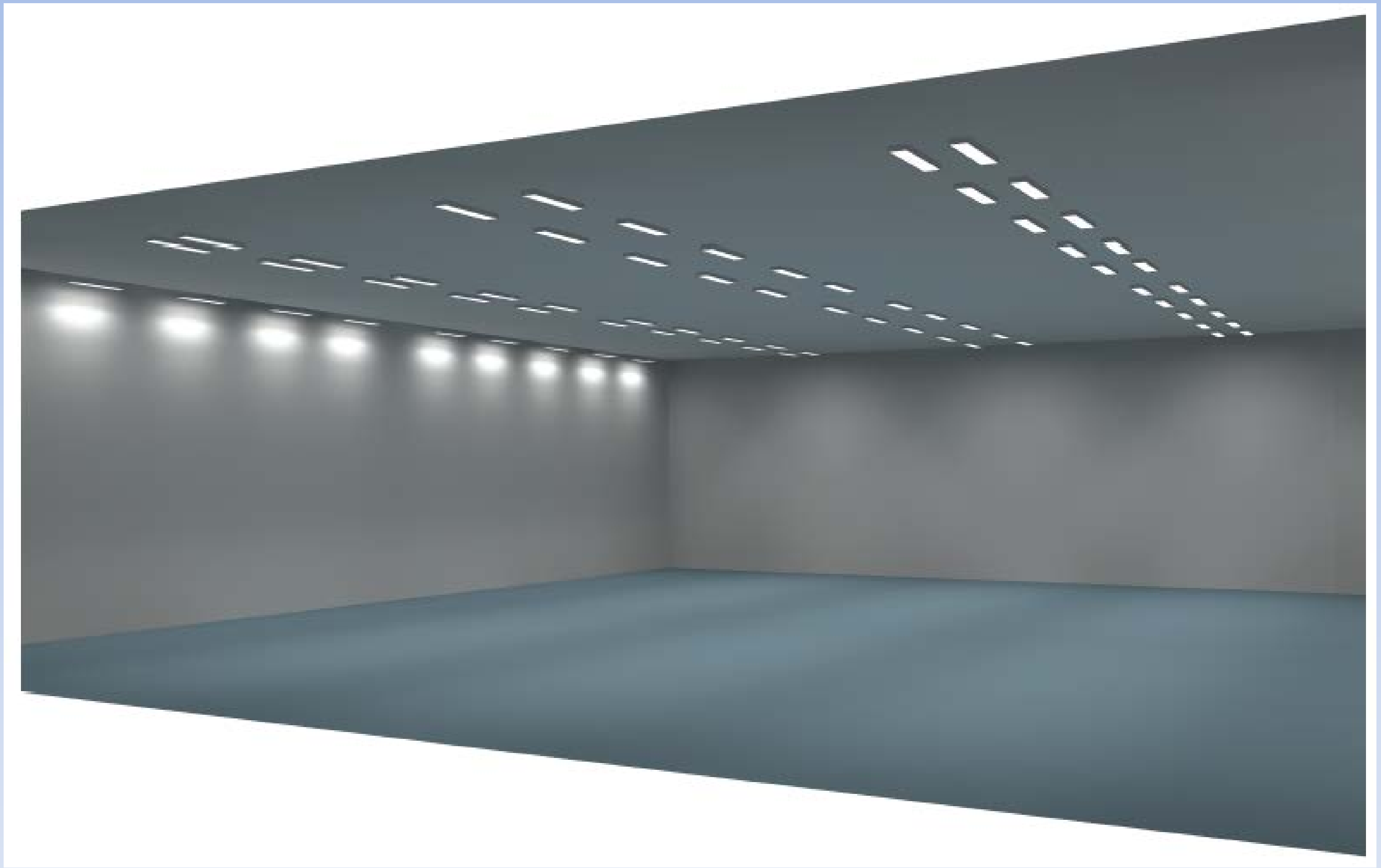
Evaluation area 1 **Reference plane 1.1**

User profile: Educational premises - Educational buildings

5.36.24 (EN 12464-1, 8.2011) Sports halls, gymnasiums, swimming pools (Ra >80.00)

	Horizontal	
Em	542 lx	(>= 300 lx)
Emin	367 lx	
Emin/Eav (Uo)	0.68	(>= 0.60)
Emin/Emax (Ud)	0.55	
UGR (4.1H 4.7H)	<=20.4	(< 22.00)
Position	0.00 m	

Sports Hall 3D Luminance



Original T12 luminaires | New LED luminaire

CO2

Carbon Savings
98tonnes CO2/ Year

£

Cost Savings
£32,100 per Annum

CAPEX

Project Capital Cost
£160,000

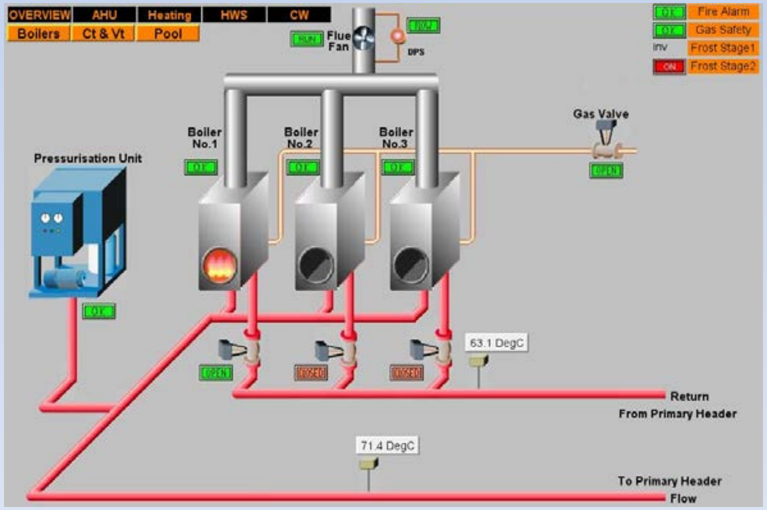
Payback in 4.5 Years

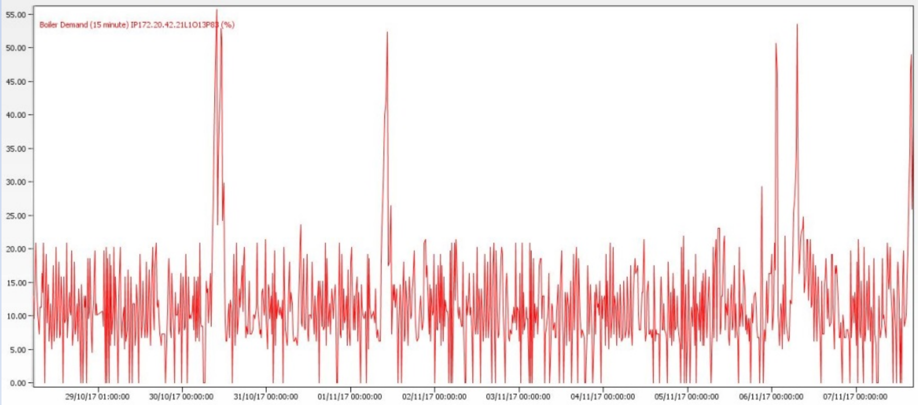
Payback

Building Management System

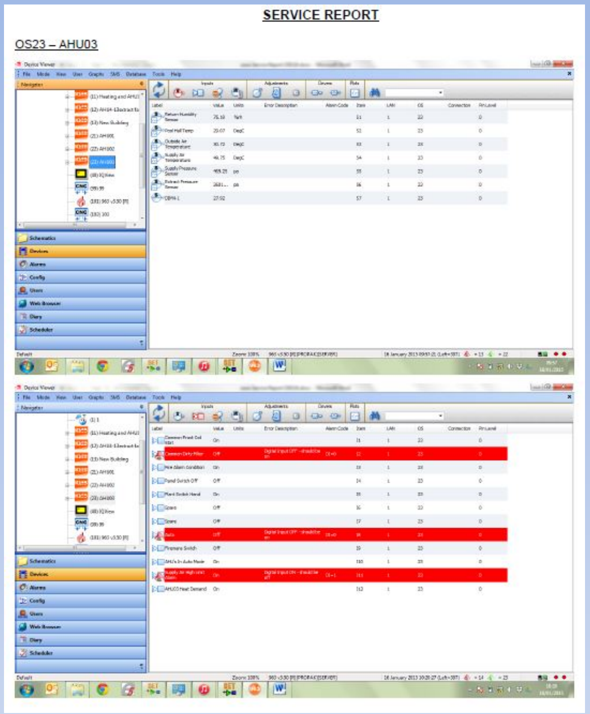
Reprogramming & Control Upgrade

TREND





TREND
TECHNOLOGY CENTRE



BEMS SPECIFICATION

optimise BeMS

- Easy to do
- Low cost
- High impact

Scope of Works

RECONFIGURATION OF EXISTING CONTROL PARAMETERS

- Set point temperatures and dead-bands
- Heating demand signals
- Tune control loops

PROVISION OF NEW CONTROL STRATEGY

- Heating optimum start/ stop
- Internal and external high limit temperatures
- Boiler anti-dry cycling (optimisation)
- Boiler Auto-changeover and pump run-on
- Frost protection systems

CO2

Carbon Savings
46 tonnes CO2/ Year

£

Cost Savings
£4,700 per Annum

CAPEX

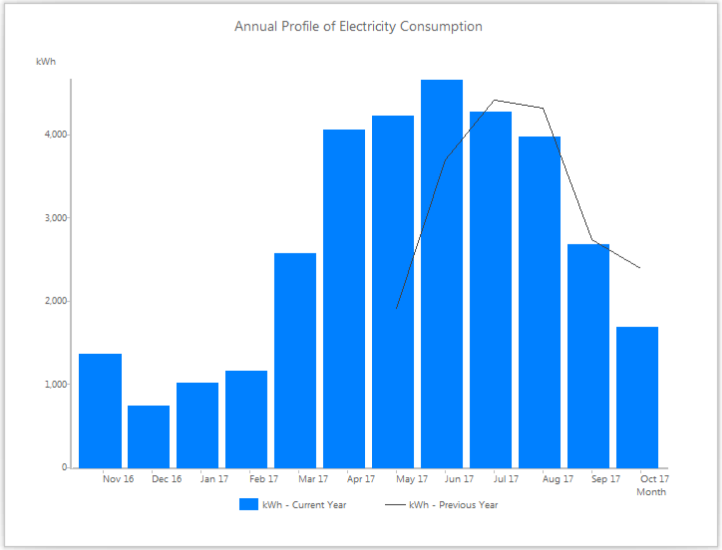
Project Capital Cost
£16,500

Payback in 3.5 Years

Payback

Solar Photovoltaics

- Large unshaded sports hall roof
- Sized with the other technologies in mind in order in order to give highest payback on investment
- Tendered via PCC's PV framework; capital cost of £27,000 for full install
- 30kW(p) string and inverter PV system using:
  - 120no. 250W C-Sun, Tier 1 panels
  - Single Samil 3000TL inverter
- System produced 32,500kWh electricity in year 1; all of which was used in-house
- Total income and savings in year 1 were £6,000; with increases in electricity prices £180,000 in 20 year lifetime
- Saved 14.3 tonnes CO_2/a from the site; 330 tonnes over 20 years



Month	kWh End Oct 2016	kWh End Oct 2017
Nov	-	1,361.1
Dec	-	742.7
Jan	-	1,019.9
Feb	-	1,168.9
Mar	-	2,572.1
Apr	-	4,056.4
May	1,913.6	4,218.6
Jun	3,687.0	4,646.0
Jul	4,408.2	4,271.9
Aug	4,314.9	3,962.7
Sep	2,734.0	2,680.7
Oct	2,393.2	1,682.0
Year	19,450.9	32,383.0

Consumption

kWh End Oct 2016	19,451
kWh End Oct 2017	32,383
Difference	12,932
% Difference	66.49%
Load Factor	0.1462

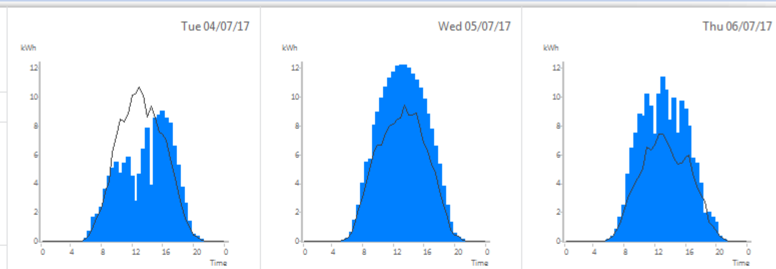
Demand

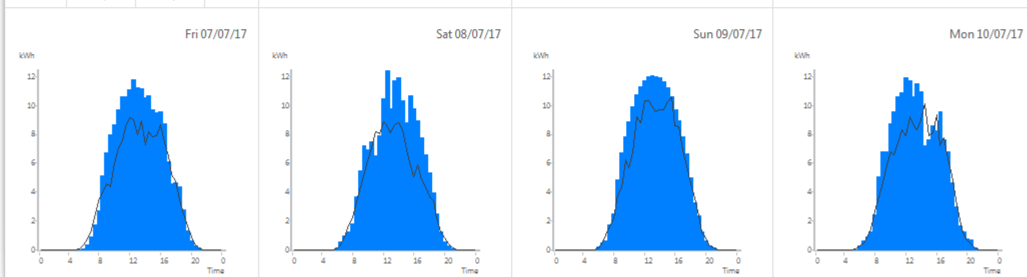
MD (kW) on 14/05/17 @ 13:00	25.3
MD (kVA) on 14/05/17 @ 13:00	25.3
kVArh	0
Average Power Factor	1.0000

Report Time Zone: (UTC+00:00) Dublin, Edinburgh, Lisbon, London (With Daylight Saving)

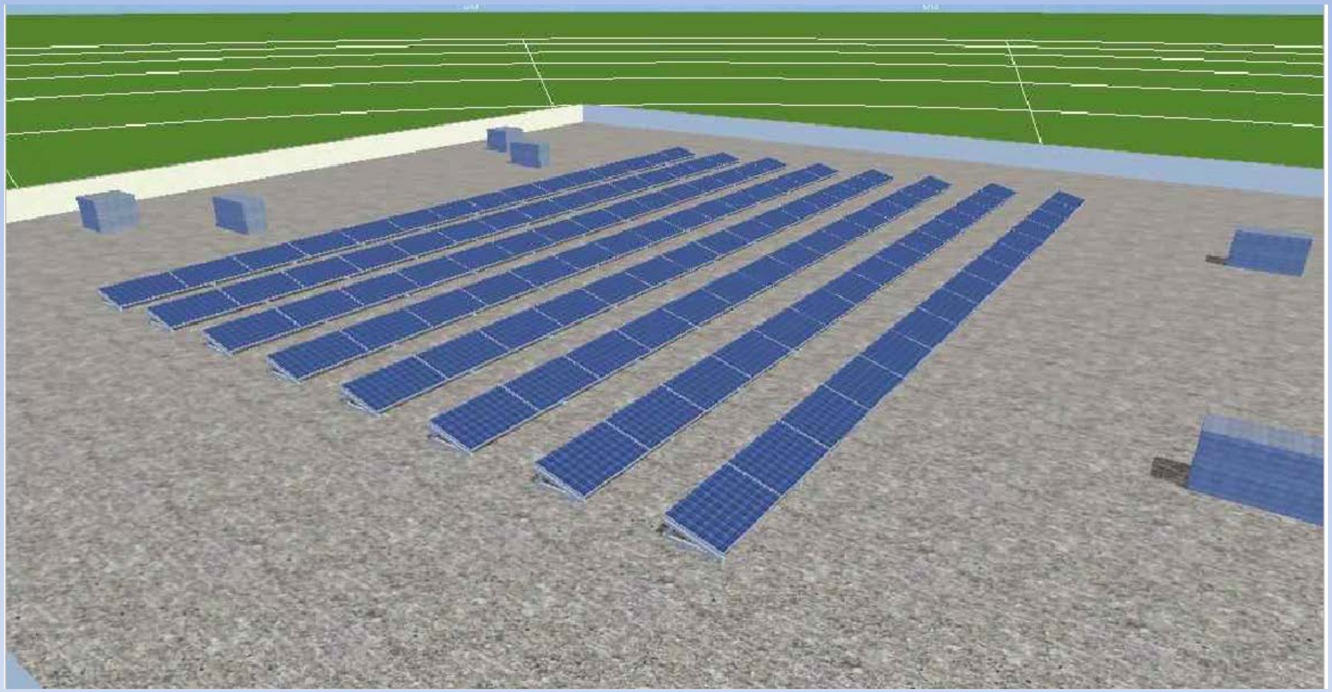
kWh
Average Profile

Date	kWh	Average	% Diff
04/07/17	136	162	-16.11
05/07/17	211	154	37.12
06/07/17	177	120	46.89
07/07/17	194	159	22.41
08/07/17	183	144	27.21
09/07/17	205	174	17.99
10/07/17	189	162	16.10
Week	1,295	1,075	20.42





Report Time Zone: (UTC+00:00) Dublin, Edinburgh, Lisbon, London (With Daylight Saving)



CO2

Carbon Savings
17tonnes CO2/ Year

£

Cost Savings
£7,500 per Annum

CAPEX

Project Capital Cost
£43,500

Payback in 5.8 Years

Payback

Business Model

- Complicated benchmarking contract made it difficult for both parties to realise savings
- Proposed an Energy Performance Contract
  - PCC provided the capital through borrowing
  - Split savings 80/20 with leisure operator
  - 10 year contract with option to extend

CO2

Carbon Savings
435 tonnes CO_2/ Year

£

Cost Savings
£142,500 per Annum

CAPEX

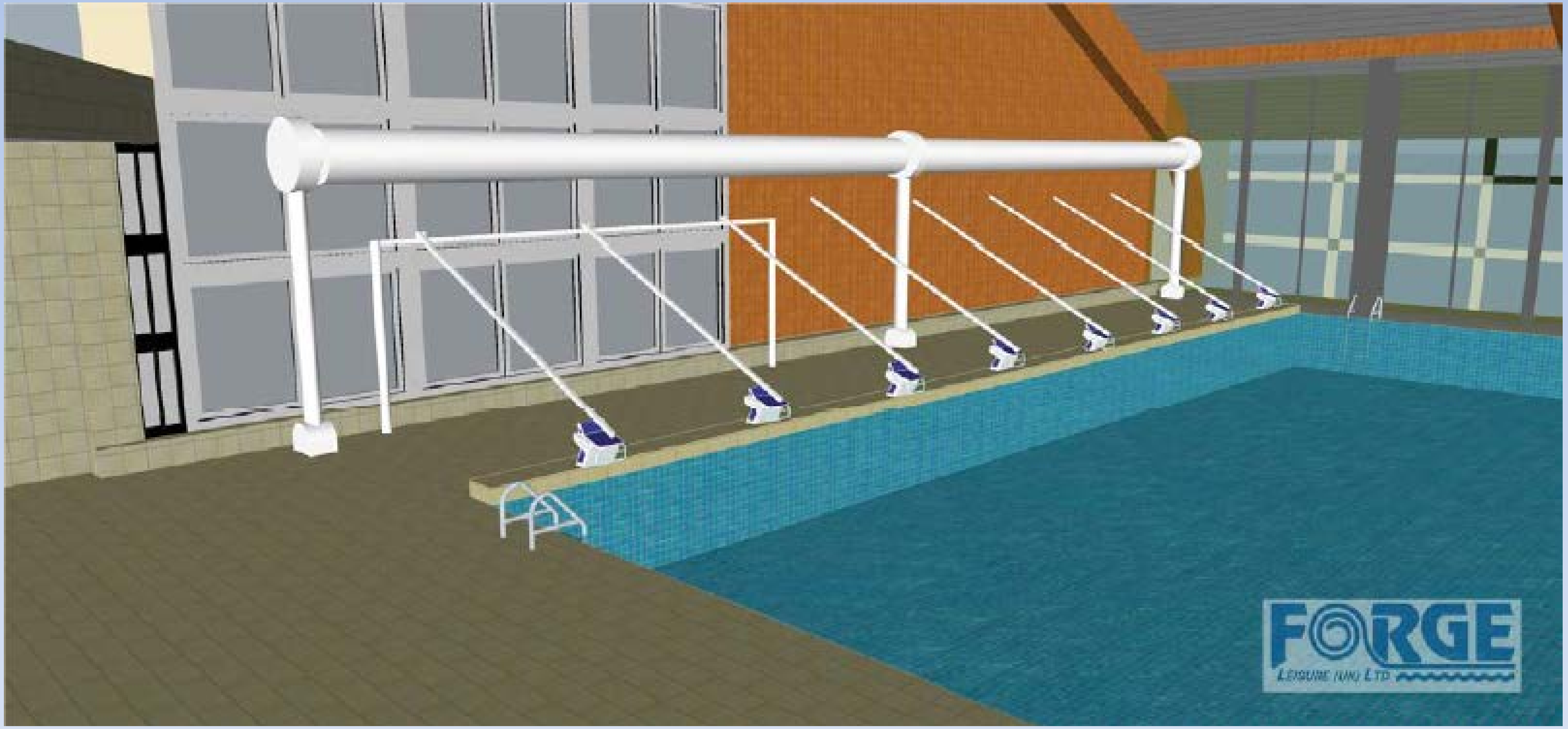
Project Capital Cost
£550,000

Payback in 3.8 Years

Payback

Further Projects – External LED Floodlights

Further Projects - Pool Cover



What next?

- Using the principles and expertise developed during the Mountbatten project; PCC has been able to approach other clients
- These include third party operators of PCC buildings and independent public and private organisations including:
  - Other leisure providers
  - Academies and schools
  - Other authorities
  - Private organisations
- PPAs have become the principle way in which these services are sold, however there is also potential with some clients to set up bespoke EPCs
- Most are principally concerned with reducing their energy overheads, however in the private sector CSR is a strong driver
- Investment opportunity is improved by assessing all technologies as a whole

Questions?

FUEL CELL SYSTEMS®

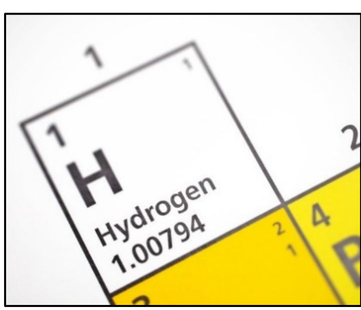
Hydrogen and Fuel Cells
- how councils can get involved

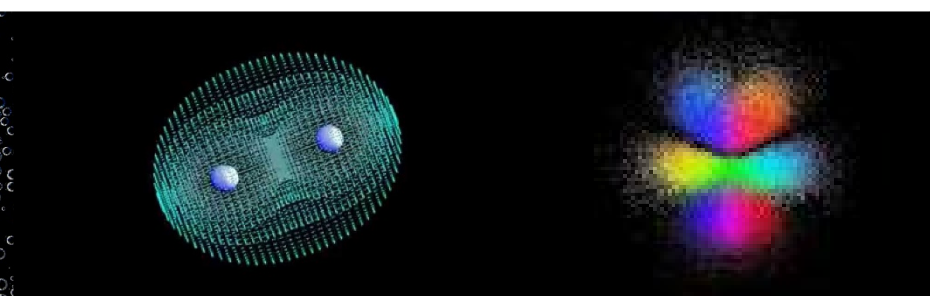
Beth Dawson, Major Projects Manager, FCSL

FUEL CELL SYSTEMS®

Hydrogen

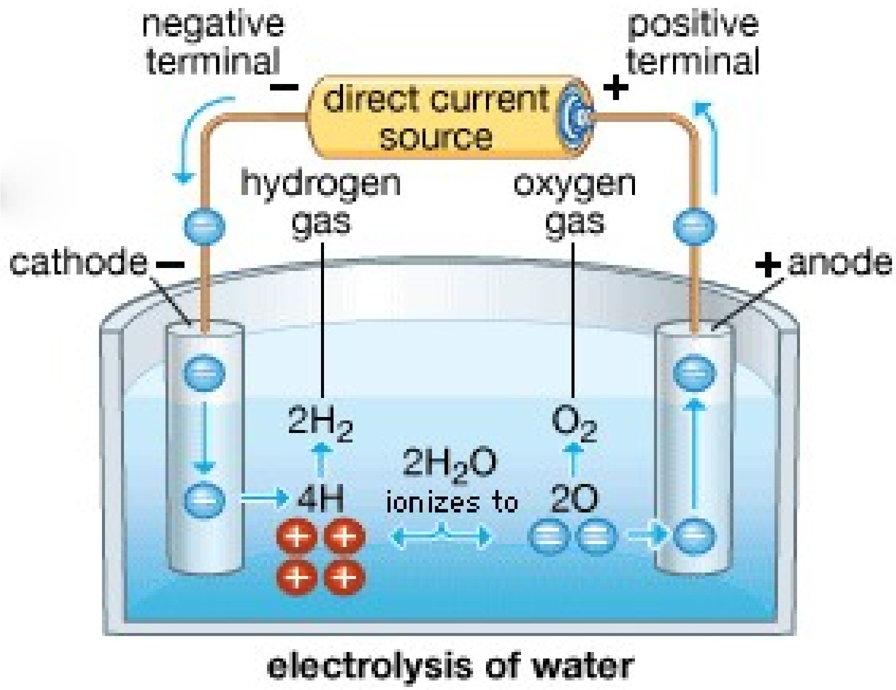
- Hydrogen makes up about 75% of the mass of the universe. It is found in the sun and most stars.
- Hydrogen is the simplest and lightest element on the periodic table.
- Hydrogen gas is almost always bonded to itself or something else. That is why hydrogen gas is represented as H_2.
- Hydrogen is odourless, colourless, tasteless, non toxic and non-poisonous.
- Hydrogen is highly flammable but will not ignite unless an oxidizer (air) and ignition source are present.
- Hydrogen has been safely produced, stored, transported, and used in large amounts in industry by following standard practices that have been established in the past 50 years.

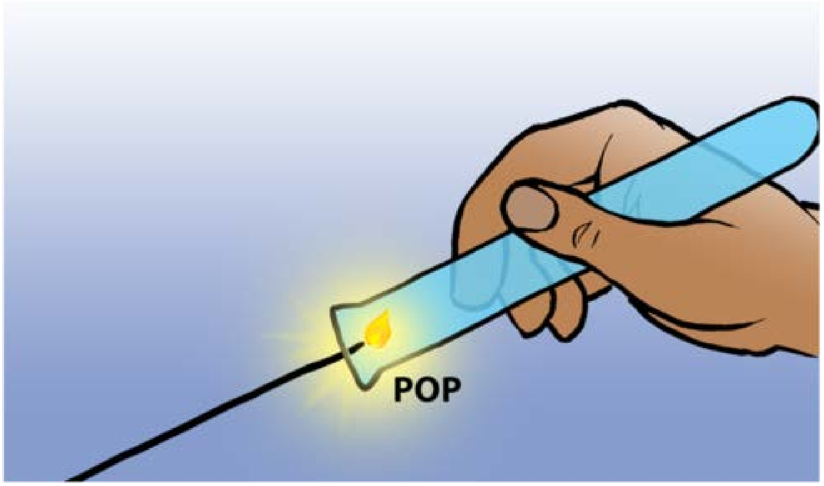




Hydrogen

You are very likely to have handled hydrogen already in school experiments.





Hydrogen

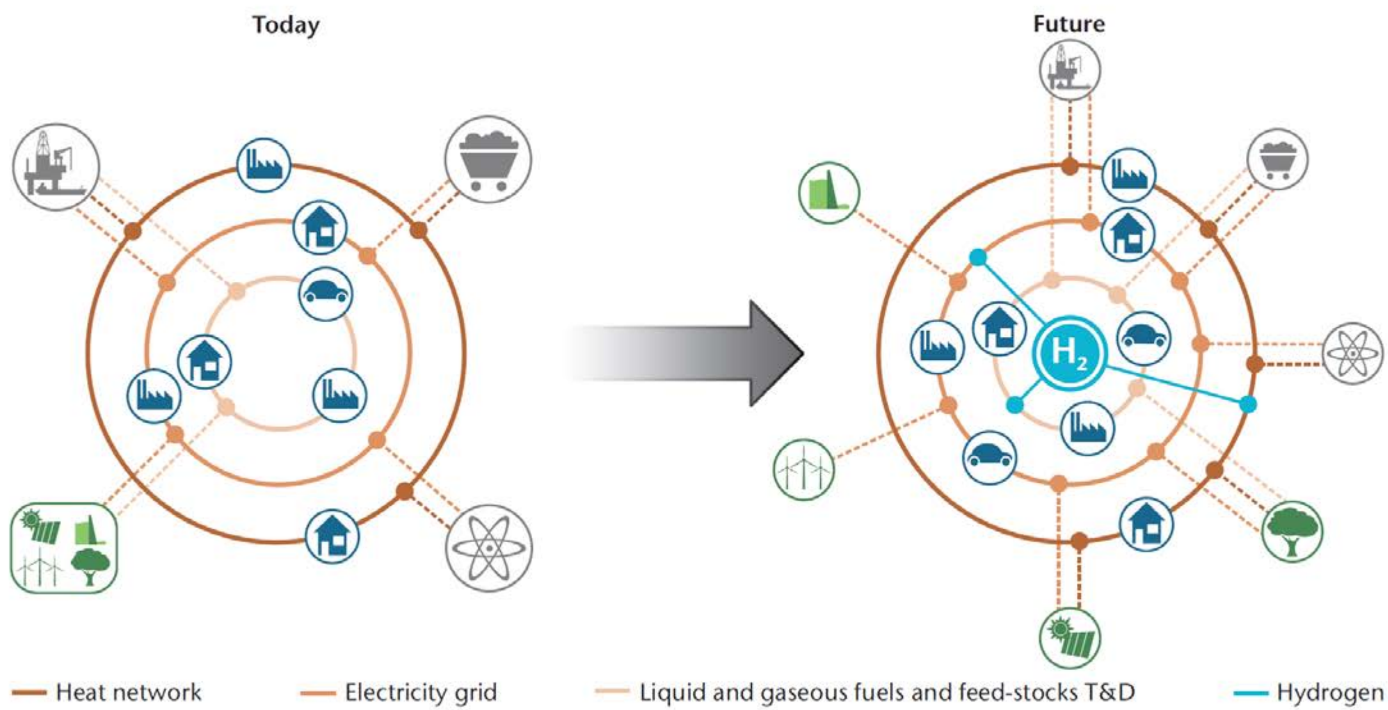
The hydrogen refuelling station (HRS) at Honda in Swindon is essentially a large version of the water electrolysis that you may have done at school.
It uses electricity produced by a nearby solar array to spilt water.
It can produce 50kg of hydrogen per day, which it stores in a battery of onsite pressurised tanks.

Other HRS sites use wind turbines. Some use industrially produced hydrogen from steam reforming natural gas.

Why bother?

Hydrogen is an **excellent** energy carrier.

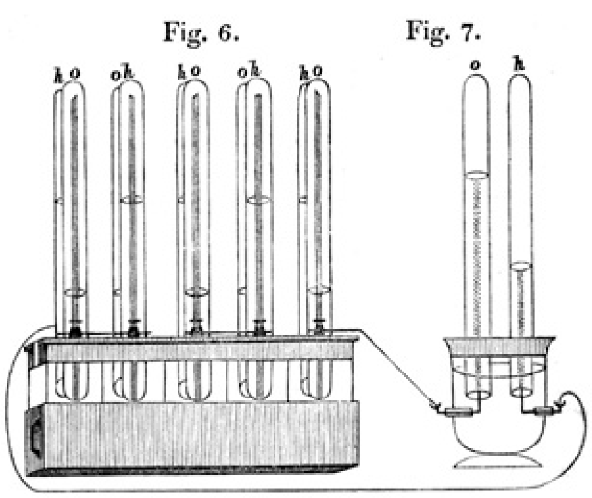
It's not a primary energy source but can be used to store, transport and provide energy. Its energy density is high per unit mass. One of the advantages of hydrogen is that it can store energy from all sources, both renewable, fossil and even nuclear power – it's very flexible. Hydrogen is very likely to play a key role in the necessary transition from fossil fuels to a sustainable energy system.

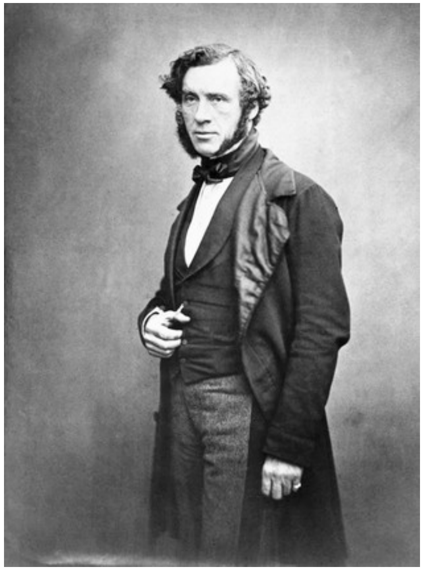


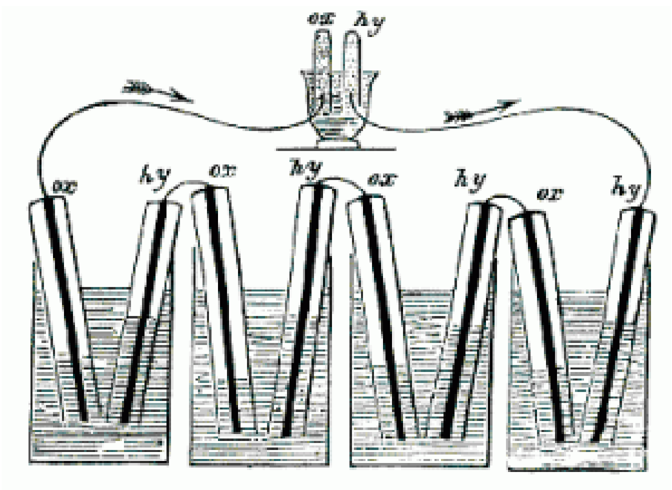
Ok, so what's a fuel cell?

A fuel cell is an energy converter that efficiently transforms the chemical energy in hydrogen to electricity and heat. The only other product is pure water.
They fuel cell reaction is the equal and opposite reaction to electrolysis.

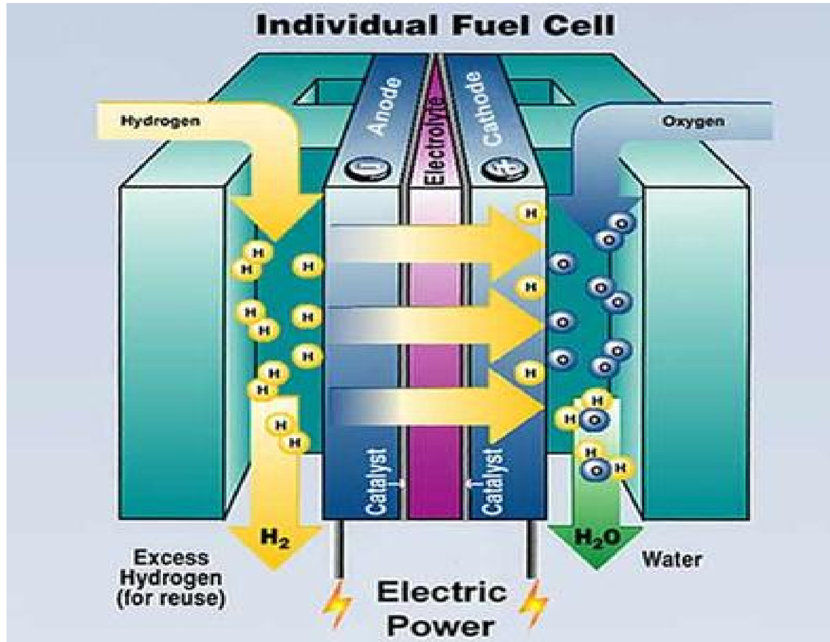
The principle was first demonstrated by Sir William Grove in 1842





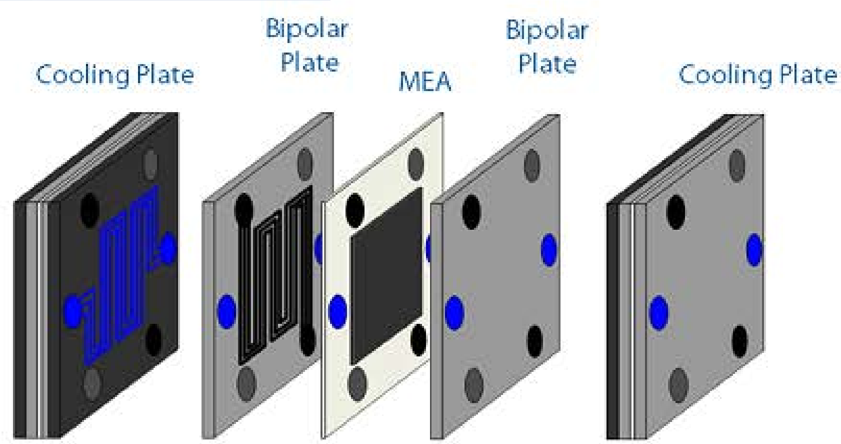


How does it work?



Fuel Cell Stack

Single Cell



Cell Components

FUEL CELL SYSTEMS®

It's just power…

www.fuelcellsystems.co.uk

Available systems

40W – 2MW
Multi Technology
(Hydrogen, Methanol, Propane, Natural Gas, Biogas)

Low Temperature

- DMFC – Direct Methanol – 75ºC
- PEM – Proton Exchange Membrane – 75ºC
- AFC – Alkaline Fuel Cells – 80ºC

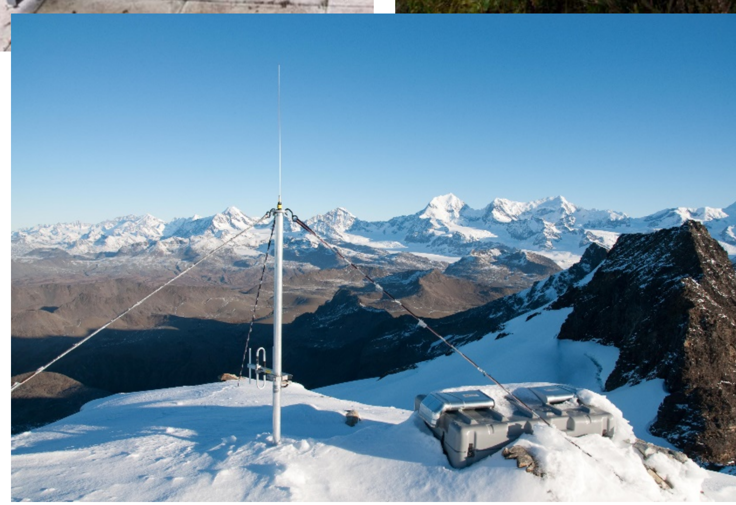
High Temperature

- PAFC – Phosphoric Acid - 200ºC
- MCFC – Molten Carbonate Fuel Cell – 600ºC
- SOFC – Solid Oxide Fuel Cell – 1000ºC

FUEL CELL SYSTEMS®

	25W – 100W	100W – 1kW	1kW – 10kW	10kW - 100kW	100kW – 200kW	400kW – 1.2MW	1.4MW – 3.7MW
FUEL USED							
Methanol	o	o	o				
Hydrogen		o	o	o	o		
Propane		o					
Natural Gas						o	o
TECHNOLOGY							
DMFC	o	o					
PEM		o	o	o	o		
SOFC		o	o				
AFC			o				
PAFC						o	o
MCFC							o
TYPE OF POWER							
Stationary	o	o	o	o	o	o	o
Portable	o	o					
Motive				o	o		
APPLICATION							
Standby Power	o	o	o	o			
Prime Power	o	o				o	o
Off-grid telemetry	o	o					
Off-grid CCTV	o	o					
Portable Signage, Lighting	o	o					
Automotive				o	o		
Telecommunications Backup			o				
Small Computer Room Backup			o				
Large Computer Room Backup				o			
Data Centre Backup					o		
Prime Power (CHP)						o	o

Commercial Applications



FUEL CELL SYSTEMS®

Innovate UK
Technology Strategy Board

SWISH2

Fuel Cell Systems Ltd design and deliver the UK's first fully integrated portable building powered by fuel cell and solar generated hydrogen.

BOC A Member of The Linde Group

BRIGGS EQUIPMENT UK

COMMERCIAL GROUP

HONDA The Power of Dreams

The centre of excellence

Swindon Borough Council

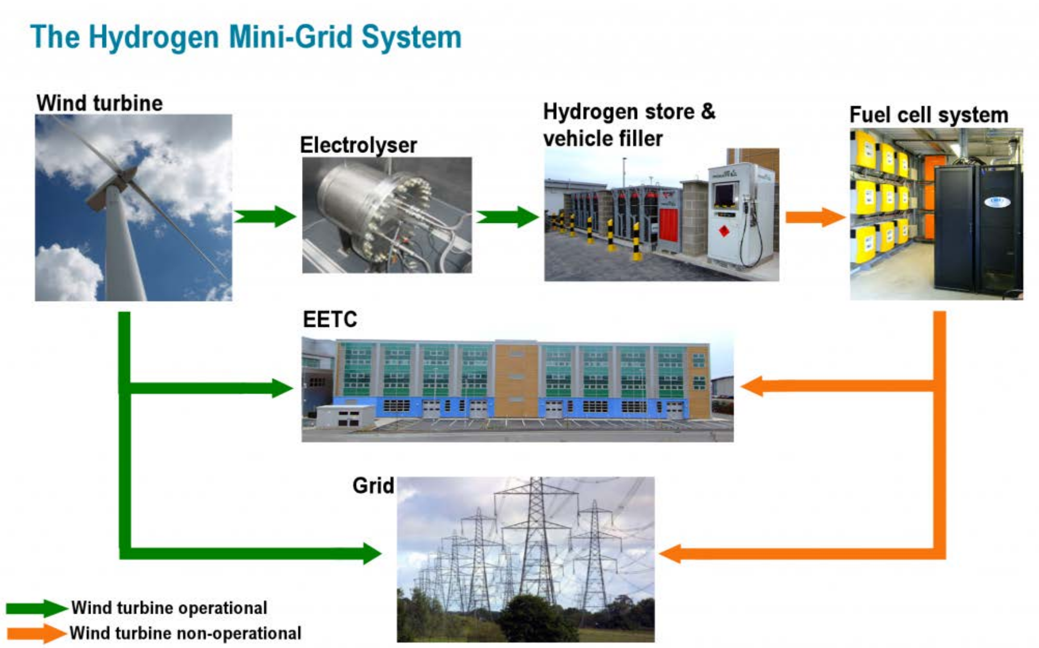
www.fuelcellsystems.co.uk

Innovate UK
Technology Strategy Board

FUEL CELL SYSTEMS®

Rotherham EECT

When energy consultants TNEI were asked to create the UK's first fully-hybridised, stand-alone and completely 'green' hydrogen mini-grid, Fuel Cell Systems Ltd were called upon to specify, supply, install and commission the fuel cell system designed to co-power the new Environmental Energy Technology Centre (EETC) in Rotherham, South Yorkshire.



Larger stationary power

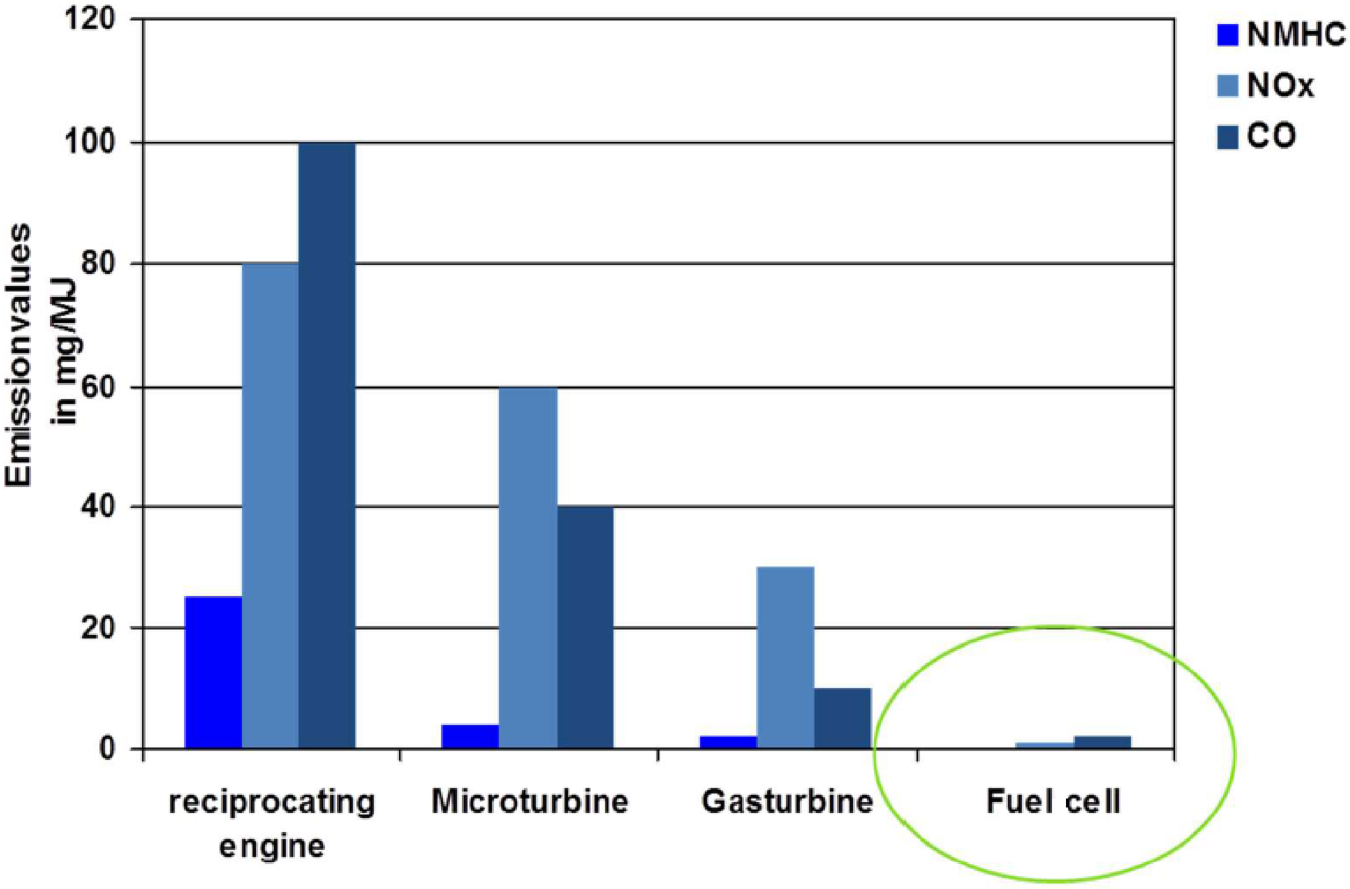
Palestra Building, Southwark

- £2.4M 200kW Combined Heat and Power (CHP) plant, provides electricity, heat and cooling, and hot water to the building.
- At times of peak energy use, the building generates a quarter of its own power, rising to 100 per cent off-peak.
- Cuts carbon emissions by up to 40 per cent and generates £90,000 cost savings per annum.
- Payback period of 10 years.

20 Fenchurch Street, EC3

- The Fuel Cell at 20 Fenchurch Street generates 300kW of low carbon, low emissions electricity
- The Fuel Cell is integrated into a Combined Cooling, Heat & Power (CCHP) configuration to efficiently support the building’s essential services
- Conservatively, the Fuel Cell will reduce the carbon dioxide emissions of the building by at least 270 tonnes per annum

Relative Emissions



Seems like a lot of effort…

Yes, but it also solves a lot of problems:

Grid power and grid reliability are becoming more of a problem. Hydrogen and fuel cells can help.

Renewable power sources are increasing but this brings with it issues of grid balancing. Hydrogen and fuel cells can help.

Heating networks are already under strain. Hydrogen and fuel cells can help.

Air Quality is a major issue for many UK cities. Hydrogen and fuel cells can help.

Government Target:

Effectively zero tailpipe emissions for UK car fleet by 2050

Fuel Cell vehicles are highly likely to play a strategic role in meeting this target. Recent OLEV funding given to increase fuel cell car uptake across all manufacturers.

"We are always looking at new ways to make the vehicles of the future cleaner, and hydrogen fuel cells are an important part of our vision for almost all cars and vans to be zero-emission by 2050.“

Andrew Jones, Transport minister

And the difference to me?

If you drive your averagely polluting combustion engine car 10,000 miles per year, then your car will emit 2.6 tonnes of Carbon Dioxide. If you wanted to offset this amount by planting trees you would need to plant at least 4 trees for every year you spend driving the car.

There is also the beneficial decrease in the nastier emissions – the NOx, SOx and particulates, which are proven to be so damaging to human health.

"40,000 deaths each year in the UK are attributable to exposure to outdoor air pollution. It is also evident that it is disproportionately the poorest of our communities which are most exposed and vulnerable to air pollution."

Professor John Middleton, President of the Faculty of Public Health

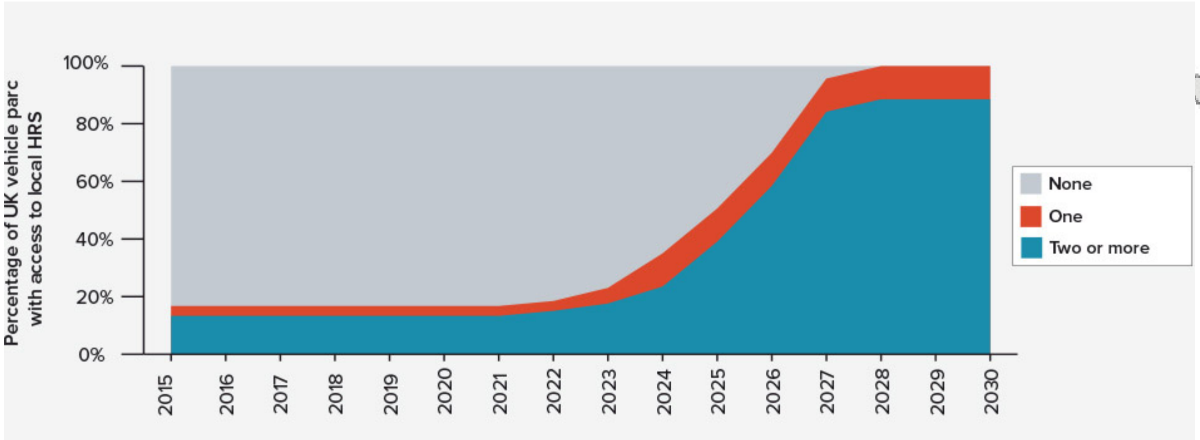
What's the H2 problem?

UK H2 Mobility target: 65 hydrogen stations across the UK by 2020

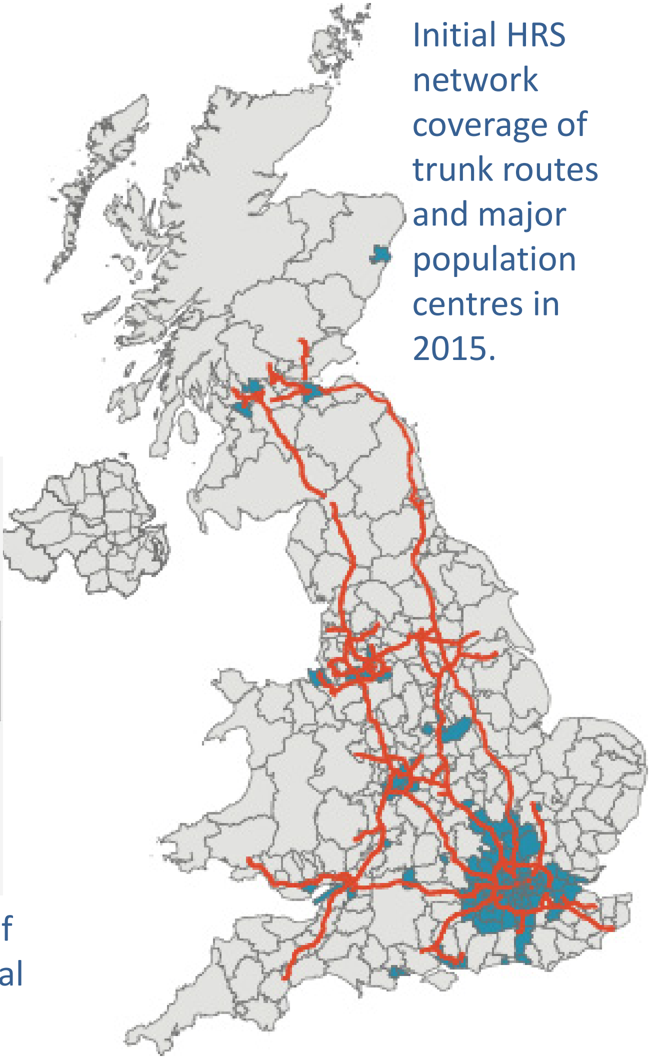
Current publicly accessible sites:

Heathrow, Hendon, Swindon, Teddington (NPL), Rainham, Rotherham, Aberdeen, Baglan (USW)

Plans in place for another 5-10



The development of local HRS network coverage in terms of the proportion of the UK vehicle parc with access to zero, one and two or more HRS in their local district.



Initial HRS network coverage of trunk routes and major population centres in 2015.

FUEL CELL SYSTEMS®

Refuelling product spectrum

Mini hydrogen dispenser (WIP)

Single fill dispenser (a full fill from a larger tank)

Small multi-fill dispenser (3-4 fills, to fit into a transit van)

Medium multi-fill dispenser (FCSL/OLEV refuelling truck)

Hydrogen-producing multi-fill dispenser (a truck with an electrolyser)

Hydrogen-powered multi-fill dispenser (dual fuel or FCEV truck)

Semi-static containerised station

Fully-static installed station

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What can we do…?

- Include hydrogen and fuel cells in your energy strategies.
- Consider electrolysers next to renewable installations – to use excess energy and create hydrogen (that useful energy vector).
- Encourage hydrogen refuelling projects in your area.
- When you have hydrogen available, you unlock a multitude of emission-free fuel cell applications: buses, cars, fork lift trucks, building site power (also other options e.g. dual-fuel transit vans and rubbish trucks; pushing excess hydrogen into the gas grid).
- Ask your planning department to encourage hydrogen and fuel cell use for new developments.
- Ask your transport team to consider fuel cell vehicles alongside BEVs

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Local initiatives

Hydrogen London, run by the GLA.
Their encouragement has led to fuel cell buses and a good number of fuelling stations around London. Some authorities include fuel cells in their planning calls.

Aberdeen City Council have a hugely successful bus project and plans for a second refuelling station – and work with…

Fife Council and Bright Green Hydrogen for their Levenmouth Energy Project, including dual fuel refuse trucks and fuel cell range extended vans.

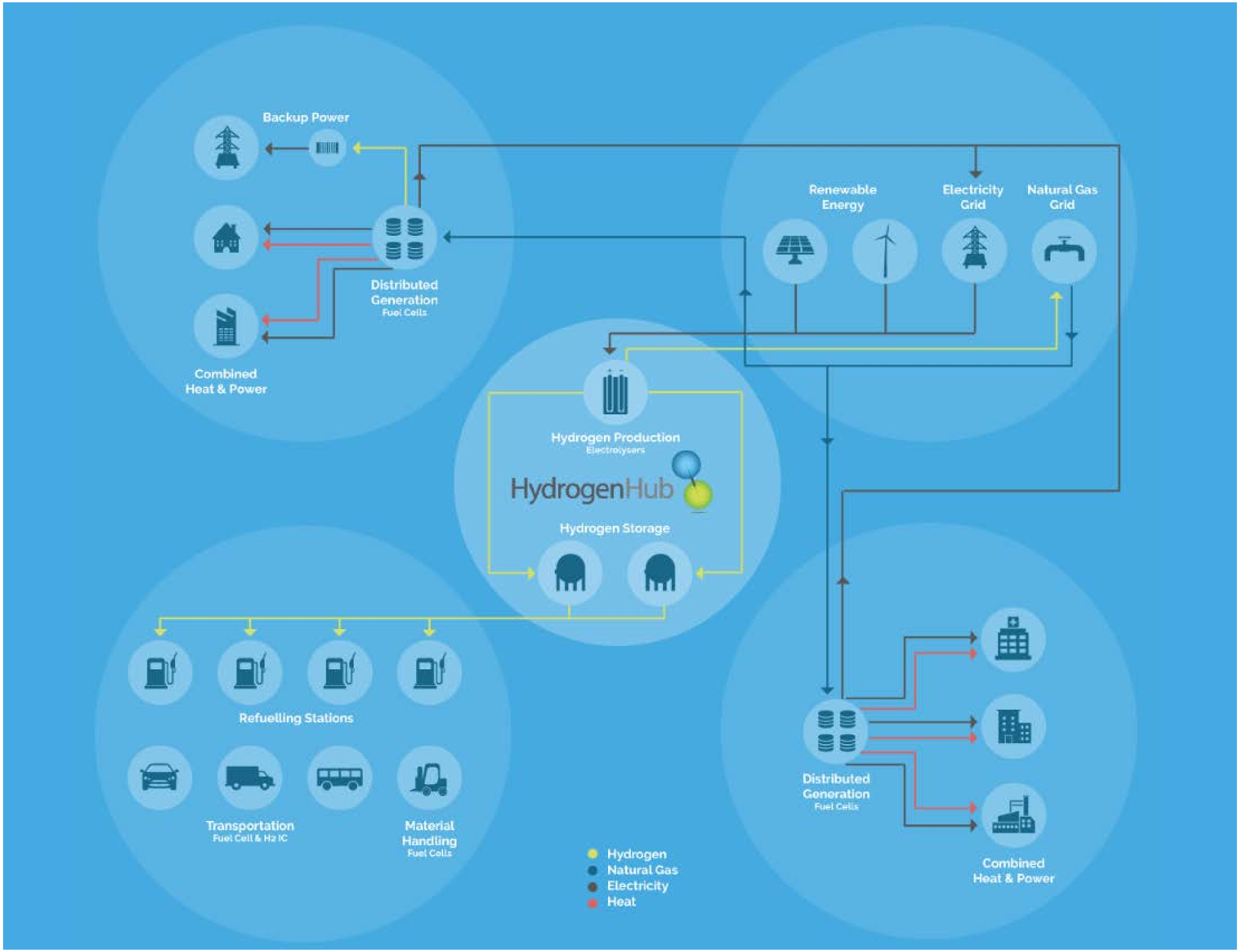
Rotherham have their Hydrogen Mini Grid, sited on the Advanced Manufacturing Park.
Leeds have their H21 project with Northern Gas Networks who intend to demonstrate conversion of the gas grid to hydrogen.

Local Initiatives

Swindon Hydrogen Hub, a council and industry deployment group
Working groups for: cars, materials handling, buses and buildings
To date:
2 fuelling stations, 8 fuel cell cars, 4 fuel cell fork lifts, 4 dual-fuel vans. Actively searching for a building deployment.

Oxford Hydrogen Hub, a sister site to be launched next year. Active submissions for fuelling stations in place. Further projects under review such as residential and commercial property developments, shuttle buses and service buses.

Two cities working together is very powerful for accessing funding as there's the 'additionality' effect. One plus one equals more than two.



Backup Power
Distributed Generation
Fuel Cells
Combined Heat & Power
Renewable Energy
Electricity Grid
Natural Gas Grid
Hydrogen Production
Electrolysers
HydrogenHub
Hydrogen Storage
Refuelling Stations
Transportation
Fuel Cell & H2 IC
Material Handling
Fuel Cells
Distributed Generation
Fuel Cells
Combined Heat & Power
Hydrogen
Natural Gas
Electricity
Heat

DIMES Project

Distributed Integrated Multi Use Energy System for urban developments

This 12 month feasibility project investigates the techno-commercial benefits of integrating energy and waste management infrastructure, with clean transport within the urban area of Bicester.

Project finishes end Nov 2017 – FCSL are project lead.

Objectives: to establish whether this method of utility-scale power generation can be cost-effective.
If it can be cost-effective and there are no hidden barriers, to provide a foundation for investors that will enable the project to become reality.

What's it going to cost?

Including thinking on hydrogen and fuel cells into your energy strategy is free – I highly recommend the IEA Roadmap on hydrogen and fuel cells.

Setting up a local initiative of some sort isn't expensive.

Installing the small fuel cell units is commercial on a whole-of-life basis for traffic signs, off grid CCTV, environmental monitoring etc

A 'suck it and see' trial car/van trial with mobile refuelling is possible and affordable.

Large infrastructure is expensive. Grants are usually available.

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Thank you

Beth Dawson
bdawson@fuelcellsystems.co.uk