Integration of Renewable Energy in Bahrain

Dr Murray Thomson

A keynote speech for the Water and Energy Sustainable Innovation and Industry Conference, Bahrain, April 2018

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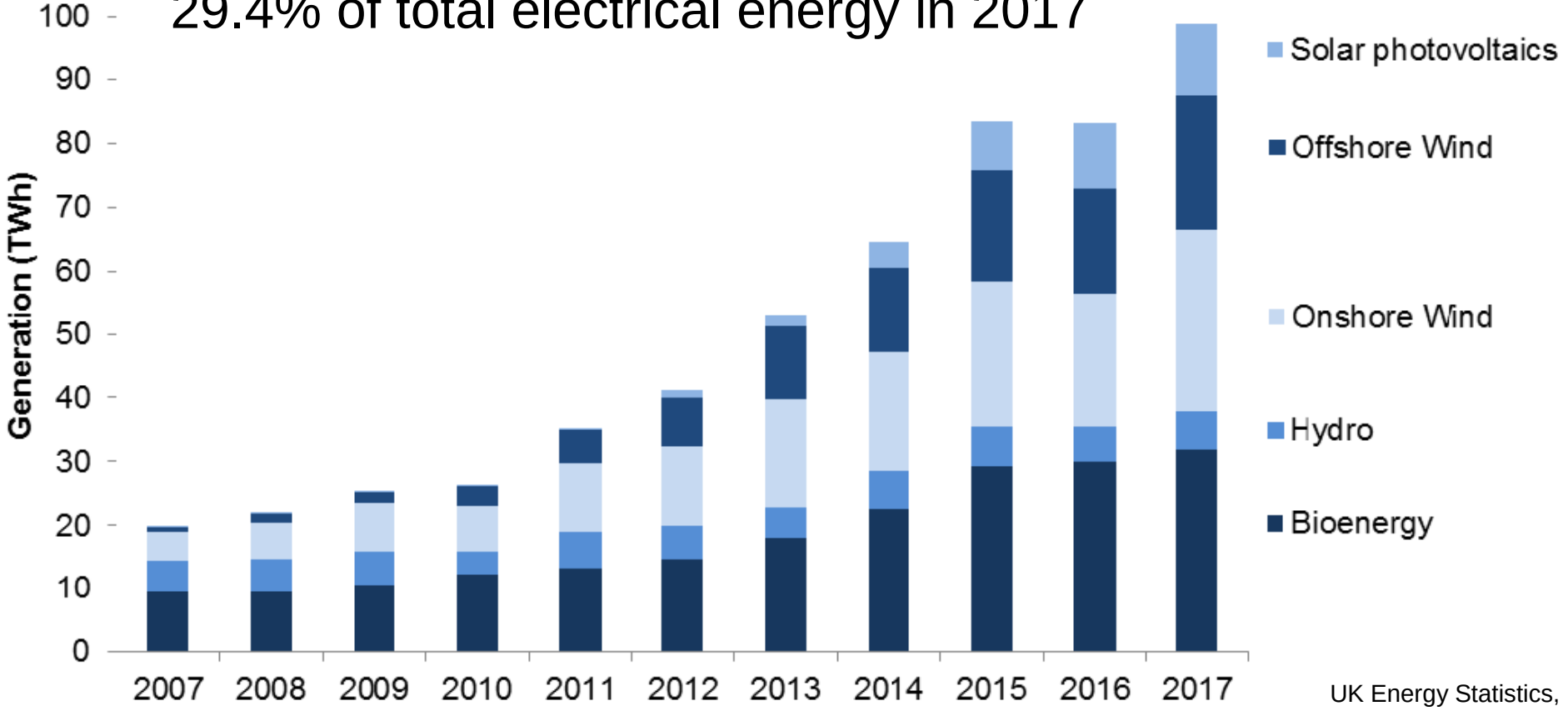
UK electrical energy from renewables

29.4% of total electrical energy in 2017



UK Energy Statistics, BEIS, 29 March 2018

Bahrain NREAP Renewable Energy Targets

Projected Demand	2025		2035	
	Peak Load Capacity	Generated Electricity	Peak Load Capacity	Generated Electricity
	MW	**GWh**	MW	GWh
	5,085	23,640	6,867	31,786

Renewable Targets	2025		2035	
	MW	GWh	MW	GWh
Wind	50	125	300	750
Solar	200	340	400	680
Biogas	5	13	10	26
TOTAL:	255	478	710	1,456
Share of projected	5.0%	2.0%	10.3%	4.6%

Introducing renewables

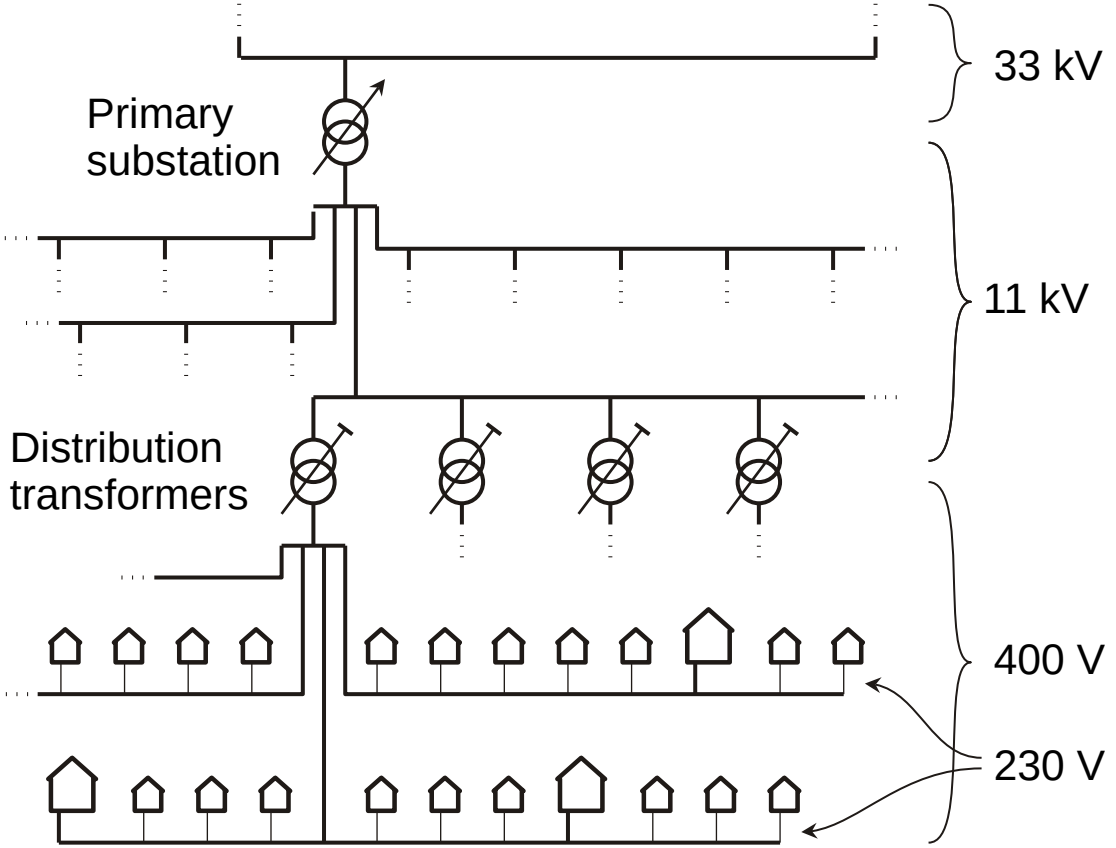
- Allowing renewable generation to connect
- Getting paid
- Incentives and support
  - Must promote good quality, appropriate deployment
  - Can be difficult to steer accurately
  - Can cause surges (very rapid growth over a few months then nothing for a while)
  - Which is difficult for the installers industry

Network integration

- Electricity networks were designed for loads not generators
- Power can flow backwards
  - Networks do this naturally and do it very well
- No immediate need for batteries, no need for local balancing
- No need to control the PV, no constraint or despatch-down
- Local power flow limitations > network reinforcement

Voltage control

- Embedded generators cause voltage rise
- In Bahrain, this should not be a big problem, because existing networks are short and well-engineered



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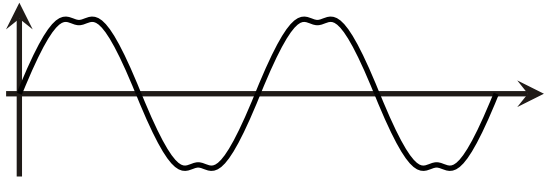
Harmonics and fault-levels



- Harmonics should not be a problem, with good inverters
- Fault-levels
  - (How much current flows if there is a short circuit)
  - Important safety consideration
  - Not significantly increased by PV (not a problem)
  - May decline at higher levels of penetration (needs thought later)

Under performance of PV

- Could be a major issue
- Design of system is critical
- Avoiding shading
- Installation quality
- Monitoring and maintenance
- Dust

- Need to incentivise energy generated (not installed capacity)
- Knowing how much is installed and how well it’s working
- (Otherwise it just looks like a reduction in demand)

Islanding and block-tripping

- PV is normally designed to be grid connected
  - and not to island
- This is fine. Designing to allowing islanding is expensive and unlikely to be justified with a reliable grid
- Anti-islanding protection can lead to “block-tripping”
  - Which is bad for the grid
  - This risk can reduce by careful choice of inverters and their settings and having fault ride-through capabilities

System inertia and frequency control

- The conventional system relies on the rotating mass of all its conventional generators to provide inertia and keep the frequency steady at 50 Hz
- PV and wind provide no inertia
- Becomes a concern at high penetrations, once conventional is significantly reduced and taken off line
- Operating low-inertia power systems is a current research challenge
- Interconnector will help (or expand the challenge)

Flexibility of conventional plant

- Turndown ratio
- Ramp rates
- Challenge for nuclear and coal plant
- Bahrain’s gas plant should be flexible
- But associated (thermal) desalination needs consideration

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Electrical energy storage

- Not needed in the early stages
  - Just turn down the gas generation
- Challenge arises when gas cannot turn down any further
- Mismatch between the time of generation and demand
- Time difference is mostly just a few hours
  - Easier than UK and Ireland
- Even then, batteries may not the first solution…

Store cold

- Air conditioning:
  - Big part of the demand
  - Big opportunity
- Storing cold either in, the building fabric (concrete) or in ice (same water each day, not consuming water)
- Straightforward proven low-cost
- Low value when gas powered, but will become very valuable
- Important to start developing and installing this flexibility now

Store desalinated water

- Assumption: all desalination goes to reverse osmosis
- Cheaper to store energy in desalinated water than in batteries
- But, requires oversizing of the RO plant
- Cost of RO plant vs batteries?
- Concern about membrane fouling – lack of evidence on this one

Electric vehicles

- Bahrain is a small country
  – well suited to electric vehicles
- And if that electricity is from solar or wind
  – it is a another big opportunity to decarbonise
- Charging should be timed to suit available solar or wind
  – this should be introduced from the start

Conclusions

- Bahrain has great opportunities to decarbonise
- The required technologies are ready to deploy
- Integration of large penetrations of solar and wind in to the energy system should be:
  - technically straightforward (relative to other countries)
  - There are know solutions to the early challenges
- Interesting research and planning still to do on:
  - Flexible air conditioning and desalination

Thank you

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