Building & Operating a Resilient Renewable Electricity System

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NZ Situation

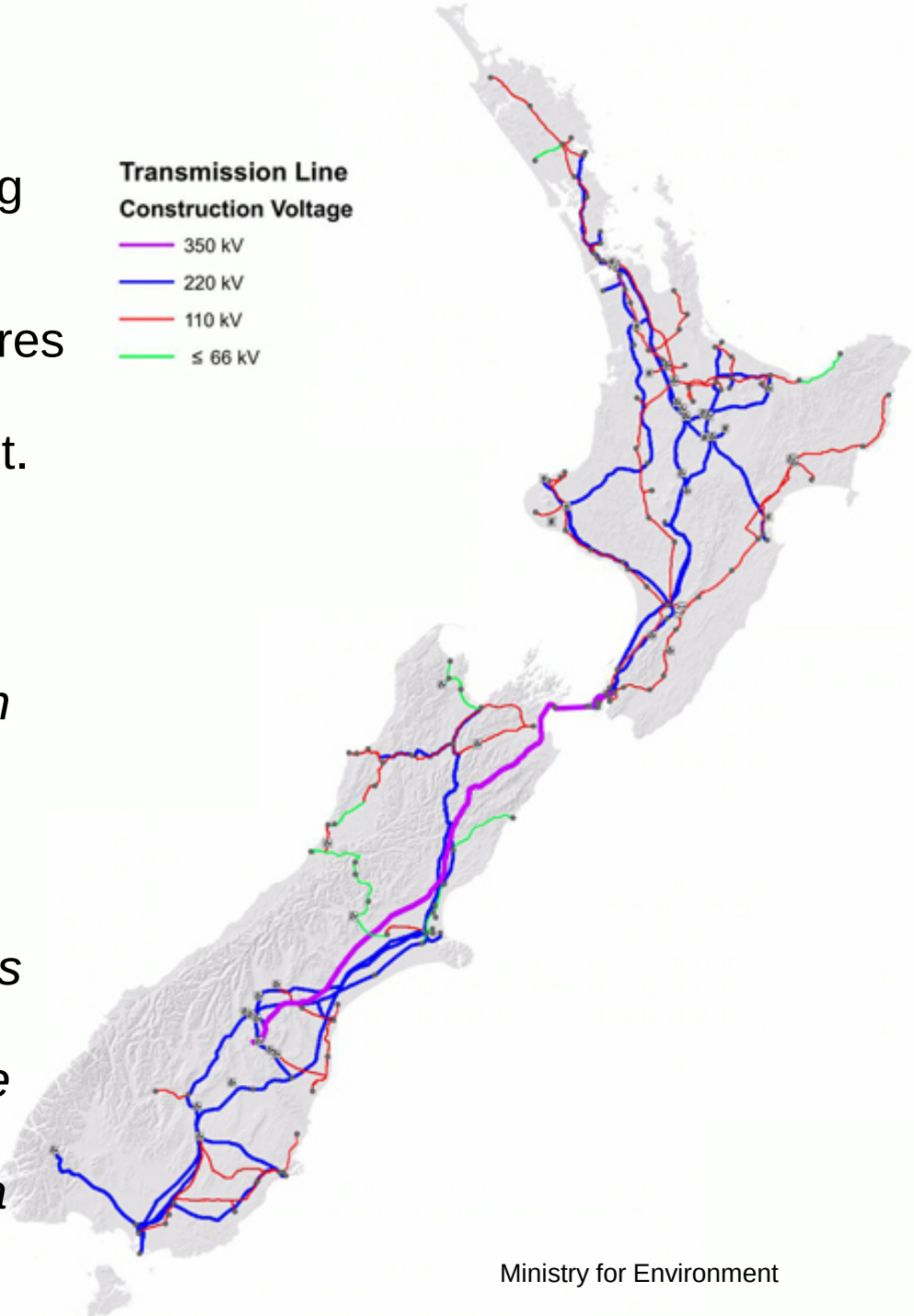
Grid is approximately 1,900 km long from northern to southern tip.

Generation and main demand centres are predominantly located in the North Island but are well spread out.

Fully integrated power system and market.

New Zealand is unique – a medium sized island network with high RE (>80%) and no country interconnections.

High RE in interconnected networks is very easy by comparison and generally experts familiar with large systems fail when they try to implement high RE penetration in a weak system.



Ministry for Environment

Past Challenges in NZ Power System Integration

We have achieved 80% RE penetration and are gradually moving towards 90% in spite of a very challenging power system environment

Remarkable achievement in a weak islanded system with world class System Security and no RE subsidies

- Designing and Commissioning 1240 MW HVDC link into small system 1200MW – 3500 MW NI load
- Combined Cycle Gas Turbines (380 MW)
- Static Var Compensators & STATCONs
- Manapouri hydro power station: 840 MW in small island system
- Wind farms
- Emerging – energy storage, distribution level solar

All these new technologies were seen as challenging when first developed.

Now all are generally accepted as having diverse benefits.

How did we do it?

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Lessons Learnt from NZ's RE Progress

All new technologies initially seen as unconventional – later seen as beneficial

The sky will not fall on our heads when we introduce new technology

- Engineers needed re-educating
- Power system performance can be very bad, or it can be better than conventional generators – set same standards for all ! – but accept deviations "around the edges" when it doesn't matter
- Wind and solar can improve power system dynamic and transient stability
- Wind and solar generation can provide ancillary services (voltage and frequency support)

The important lessons are:

1. ***A holistic approach to generation integration is required***
2. ***Information, discussion, information, discussion …. Work Together***
3. ***A strong transmission grid is essential for economic high RE penetration – provides security and diversity***

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Development should be done as an Integrated Whole

The Power System consists of:

- The Electricity Market
- Load
- Distribution
- Transmission
- Generation

Consider the attributes and contribution from each sector – use their contribution intelligently to develop the best overall economic solution

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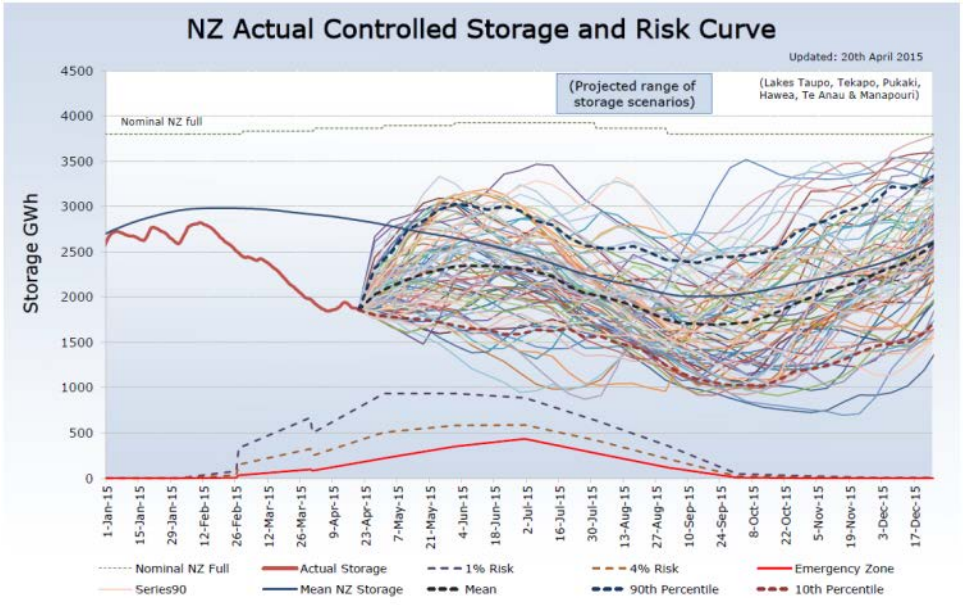
Information sharing: Identify and Understand Risks

Data Gathering, Understanding and Risk Information Sharing

- In open fully competitive electricity markets, where generation adequacy is not centrally planned and instead is left to market forces to determine, information and analysis transparency is crucial (e.g. National Meteorological and Hydrological Services) so that market participants can plan and respond appropriately to potential generation effects.
- Good data enables designers to design generation facilities to withstand conditions appropriately and market participants can respond to generation reduction forecasts
- Generators and retailers can respond to forecast changes in supply (e.g. wind, hydro and solar production) and demand (e.g. heating and cooling) by modifying supply arrangements such as purchasing additional hedges or fuel stock, or conserving hydro reserves.



Example:

The New Zealand System Operator periodically publishes a range of future hydro storage trajectories and risk profiles. These projections are based on recorded hydro inflow sequences since 1931 and a complex model of the power system and electricity market.

The analysis assists the competitive electricity market to respond to hydro risk appropriately.

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A Strong Transmission Grid is Essential for high RE

We have a fully integrated electricity system and electricity market enabled by a fully interconnected Electricity Transmission Network

60 years ago, leaders and decision makers showed great vision and commitment to develop our current 220 kV transmission Grid and then the inter-island submarine cable. Their vision and commitment gave us the ability to harness our lowest cost resources such as the hydro power, geothermal and wind in diverse locations.

It has kept NZ at the lowest end of electricity costs across OECD countries.

The Grid has been at the heart of NZ's reliable and low cost electricity supply.

A robust, high capacity National Grid is fundamental to having a secure, affordable supply of electricity and it enables high RE penetration.

Renewables can be developed across the whole country avoiding concentration of risk. Dispersed development means that each region can make a contribution to a truly national system – a system that is greater than the sum of its parts.

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Pacific Island Experiences

- There are some bad news stories – poor performing RE generators
- Limited expertise within utilities and governments to enable high RE penetration
- Poor advice given
- What we have found useful:
  - RE Roadmaps with sensible guidelines
  - Suitable Grid Code and Generation Connection Standards
  - Suitable RE equipment for islands, and set up for islands

Conclusions

Change and new technologies have presented power system integration challenges.

1. Information, discussion, information, discussion …. Work Together

    - You do not need to have all the answers. Gather information, make information transparency mandatory, share analysis, create an environment that encourages best outcomes, and the best results will emerge

2. A holistic approach to generation integration is required

    - Treat the Electricity Market, load, distribution, transmission and generation as an integrated whole to develop a least cost result

3. A strong transmission grid is essential for economic high RE penetration – it provides security and diversity

Work together, and the sky will not fall on your head.

Thank You

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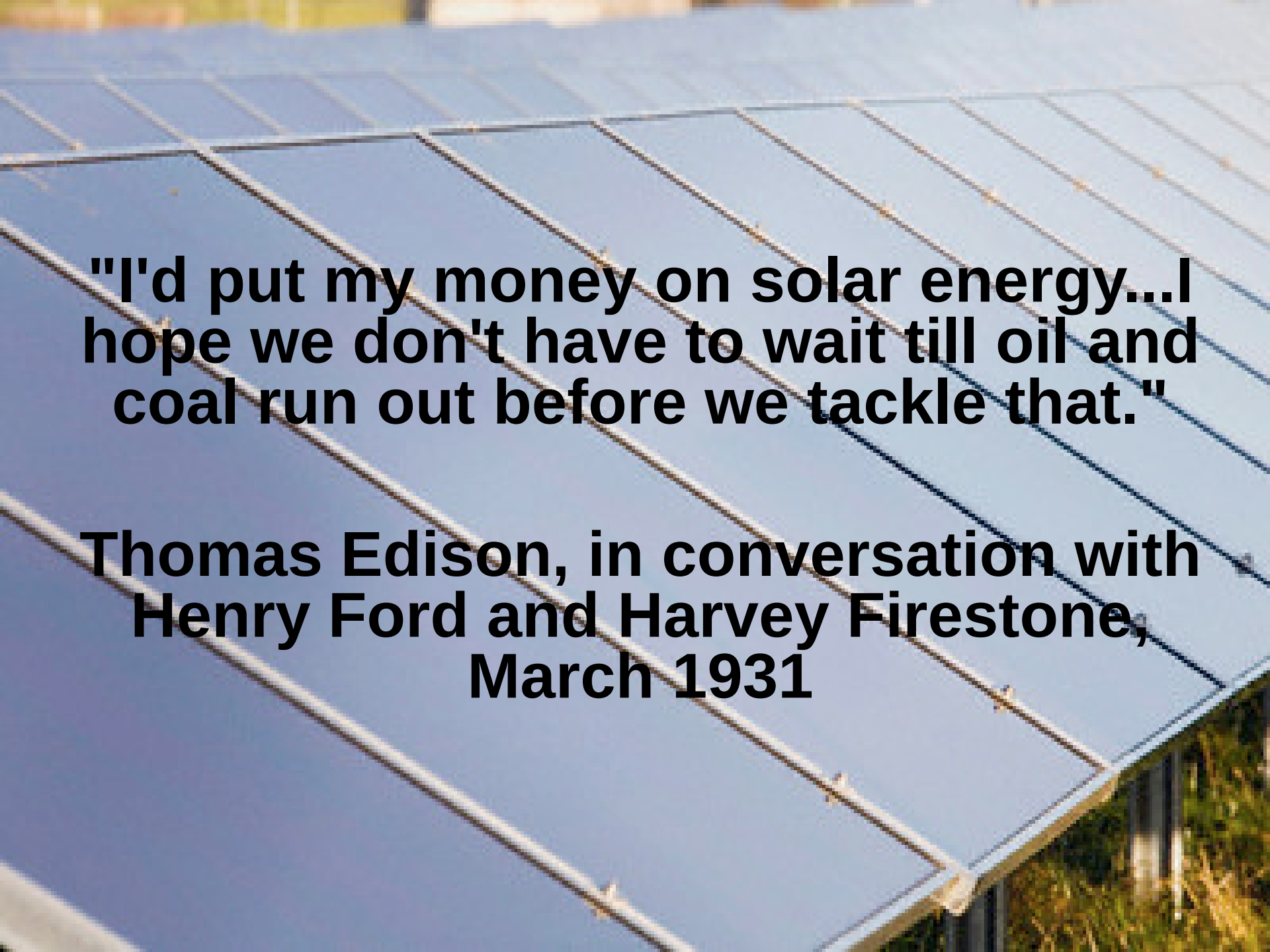

"I'd put my money on solar energy...I hope we don't have to wait till oil and coal run out before we tackle that."
Thomas Edison, in conversation with Henry Ford and Harvey Firestone, March 1931

Substation & 110 kV Line

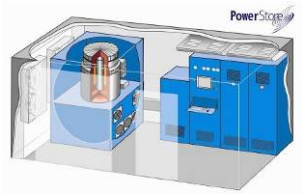
West Wind – Overview (2009)

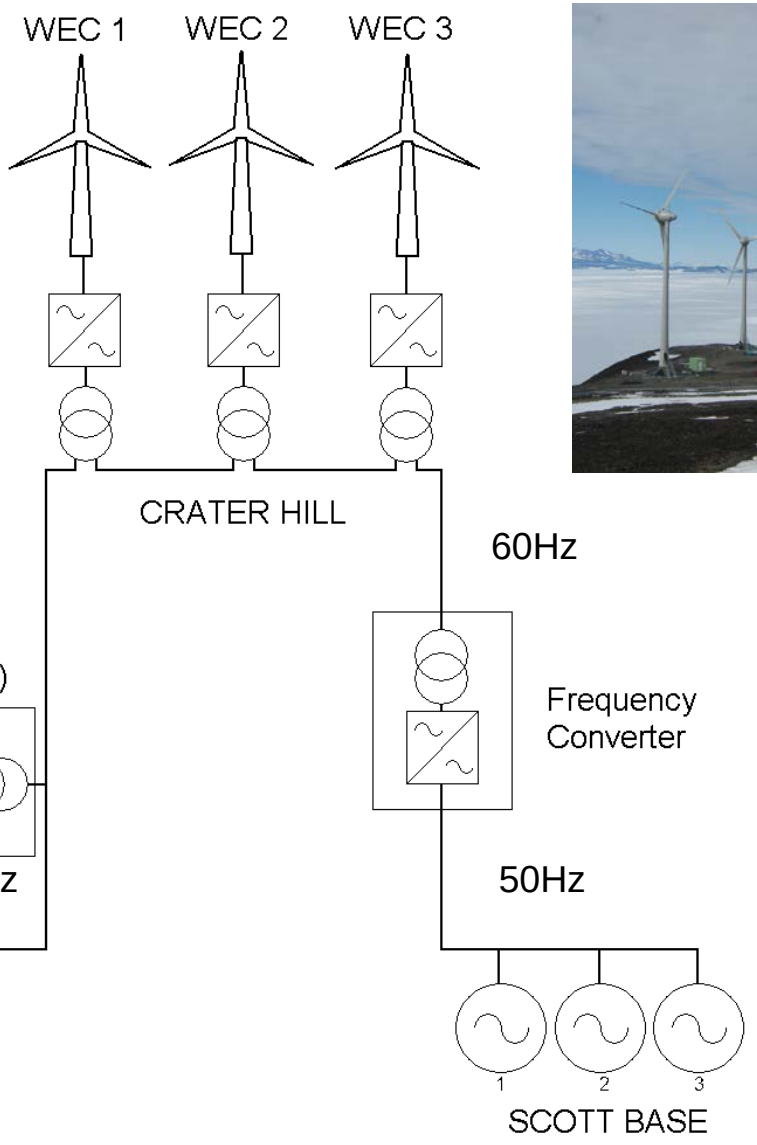
Ross Island Wind Farm

- The World's most southern wind farm (2009)

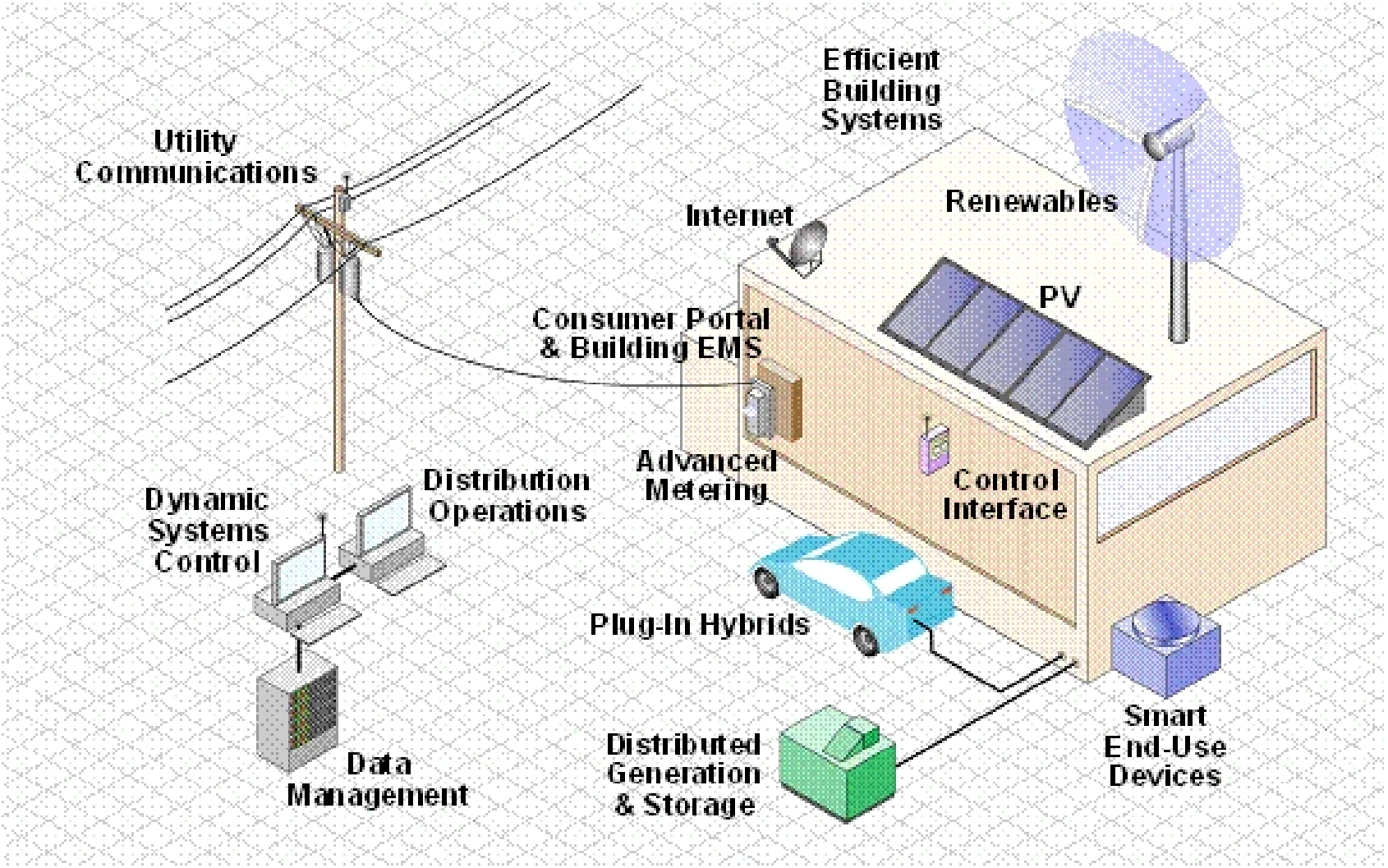
Ross Island Wind Farm

- Med penetration Wind-Diesel System (22% average, 76% max).
- McMurdo (60Hz) average electrical load 1.6MW, Scott Base (50Hz) 150kW,
- Frequency converter
- 3 × 330kW WTGs
- 3000kg Flywheel (1800 - 3600rpm) that can sink or source 500kW for 30secs





Smart Stuff



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Energy Storage

- Storage is not necessarily energy efficient but it can be the right solution
- Solar prices are so cheap (for Pacific Islands) that it can be used to provide ancillary services – i.e. it is OK if not all energy available is used. Can be more efficient economically to spill energy than storing the energy in high RE systems

Tonga, Vaini Solar PV and Lithium Ion Battery Building