Smart Grids
Demonstration in Isolated Systems

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2Introduction

1. Introduction
2. Why Smart Grids?
3. What is a Smart Grid?
4. Smart Grids in large interconnected system
5. Smart Grids in smaller isolated systems
6. Smart Grids operating today

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Peak exceeds average load Growth

The Retail Market

- **Price spike represent**
  - <1% of electrical energy
  - >20% of wholesale market turnover
- **Network Peaks**
  - Occur <1% of the time
  - Represent >10% of the capital invested
- **To remove these inefficiencies requires**
  - <3% of customer demand
  - For <1% of the time (<80 h pa)
  - “Probably the most cost effective way of significantly reducing greenhouse gas emissions” (DEUS)

Source: CSRIO

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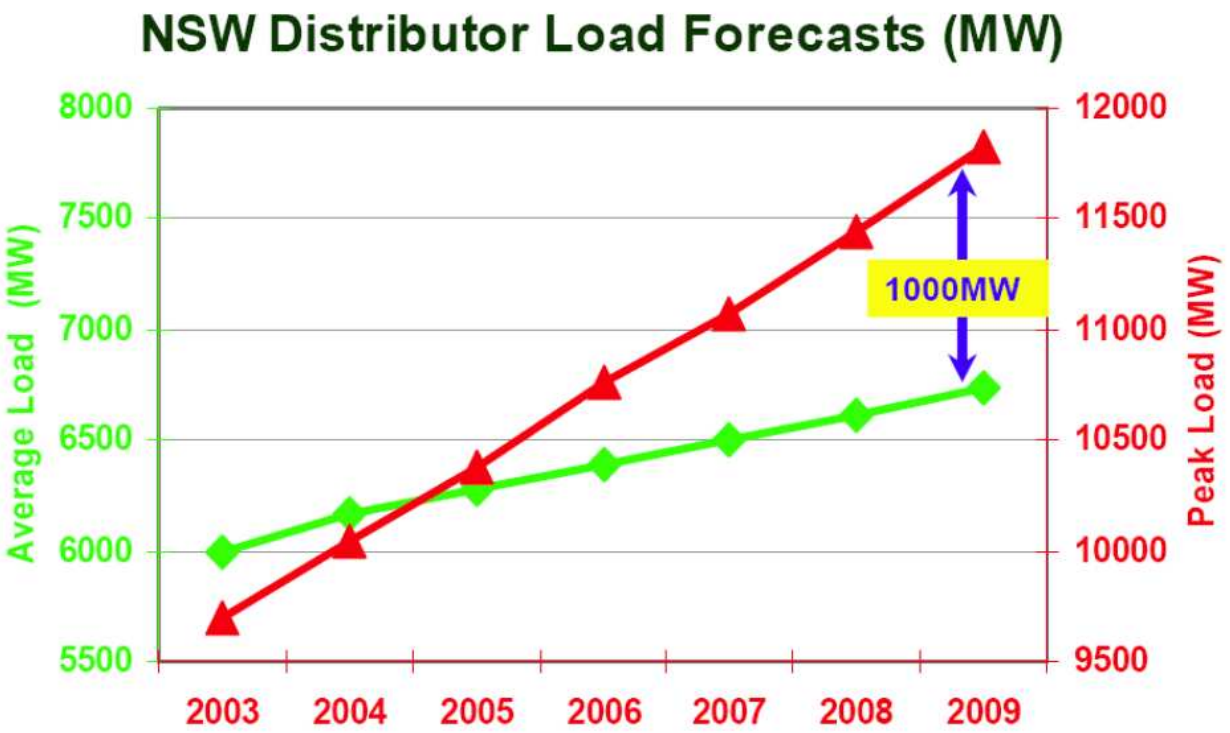
Peak versus Average Demand

Network Challenges



Source: CSRIO

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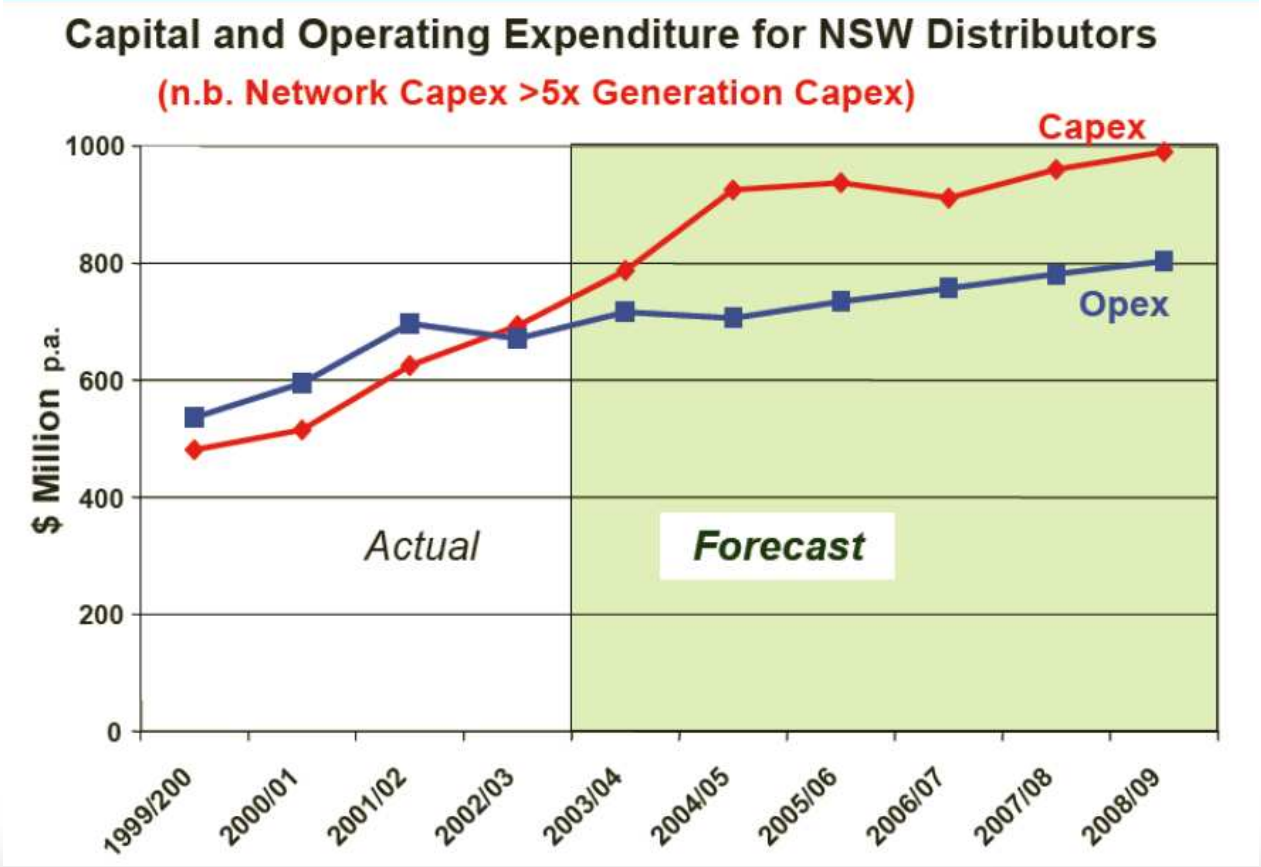
Ageing Distribution System

Network Costs



Source: CSRIO

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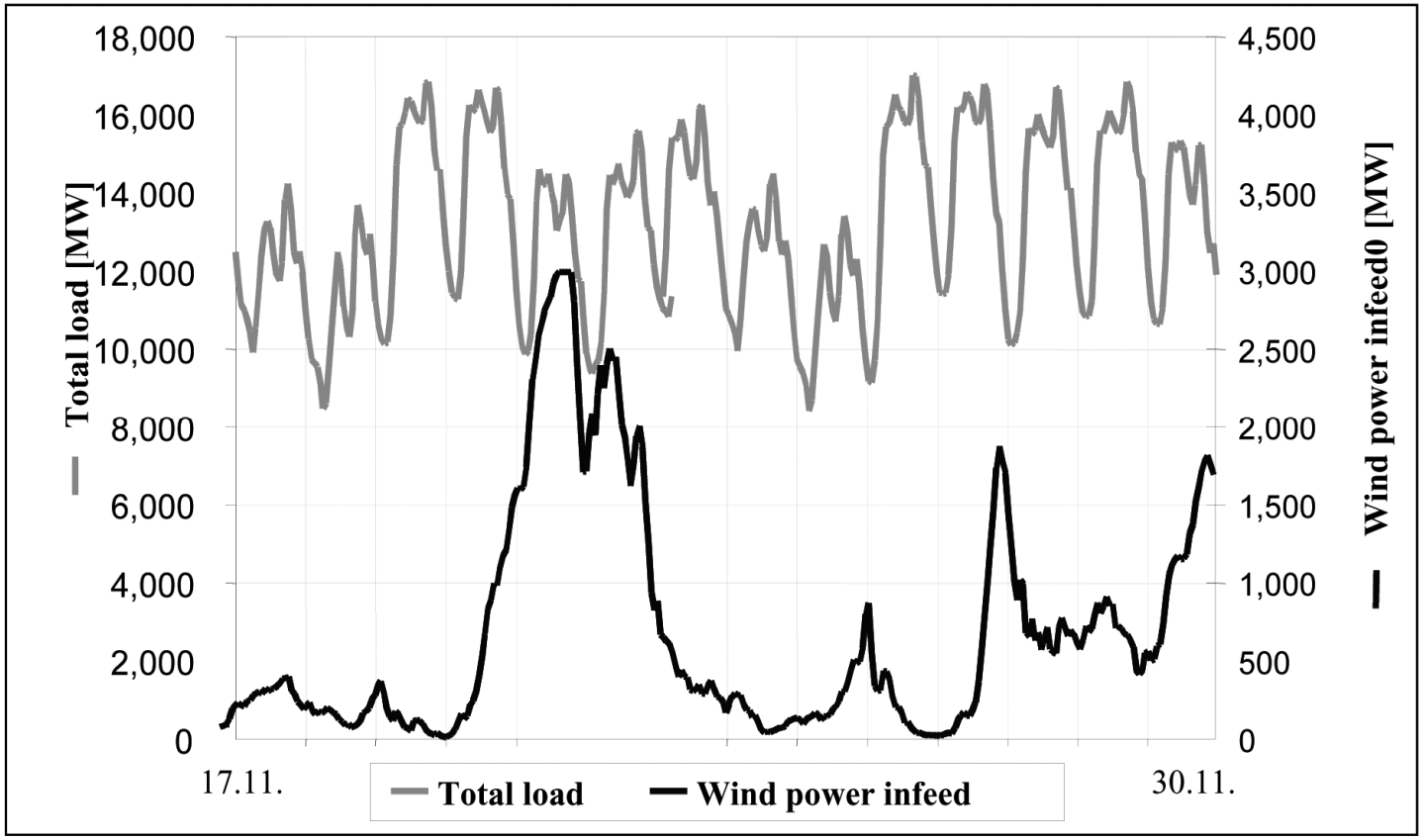
Increase Renewable Generation



Source: E.ON - 2003

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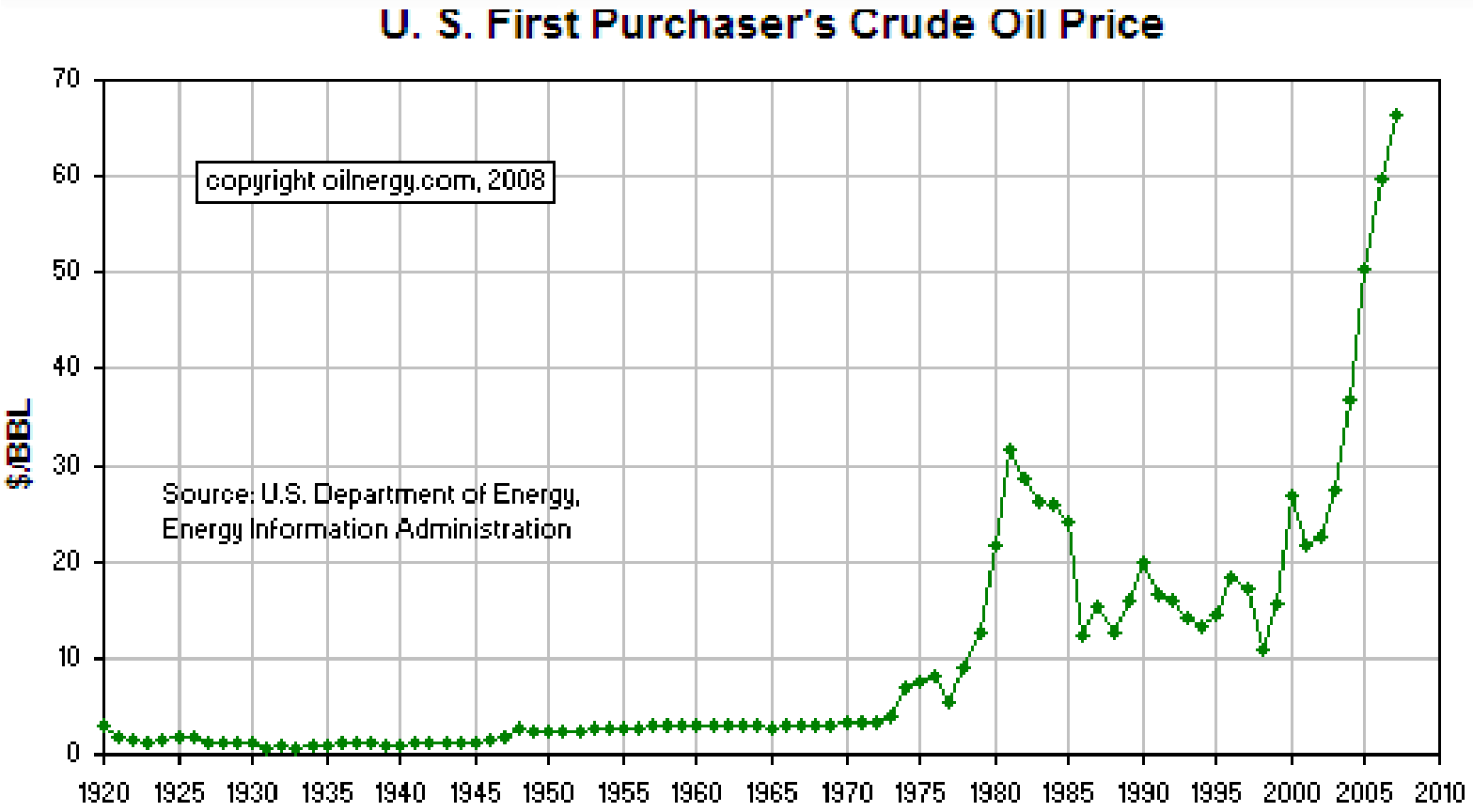
Increase in fuel & emission costs



Increase in cost of Emissions through government policy

Political, Social and Environmental

- Increased risk of Terrorist Attack
- Increase pressure to act on Climate change
- Large demand increase for energy in developing countries without centralised power infrastructure, dependency on oil

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What is a Smart Grid?

- **What is different in a Smart Grid?**
  - Decentralised power generation instead of single large stations
  - Integration of consumers/load into one system
  - Aggregation of generation and consumer loads

- **A Typical Smart Grid consists of**
  - Combination of conventional and/or renewable on/off the grid energy sources
  - Stationary or mobile energy storage system to compensate for renewable intermittency
  - Smarter Buildings/loads ready to integrate with Smart Grid
  - Communication infrastructure of all Smart Grid elements

Need for a standardized Smart Control system to optimize and manage generators, energy storage and loads within the Smart Grid.

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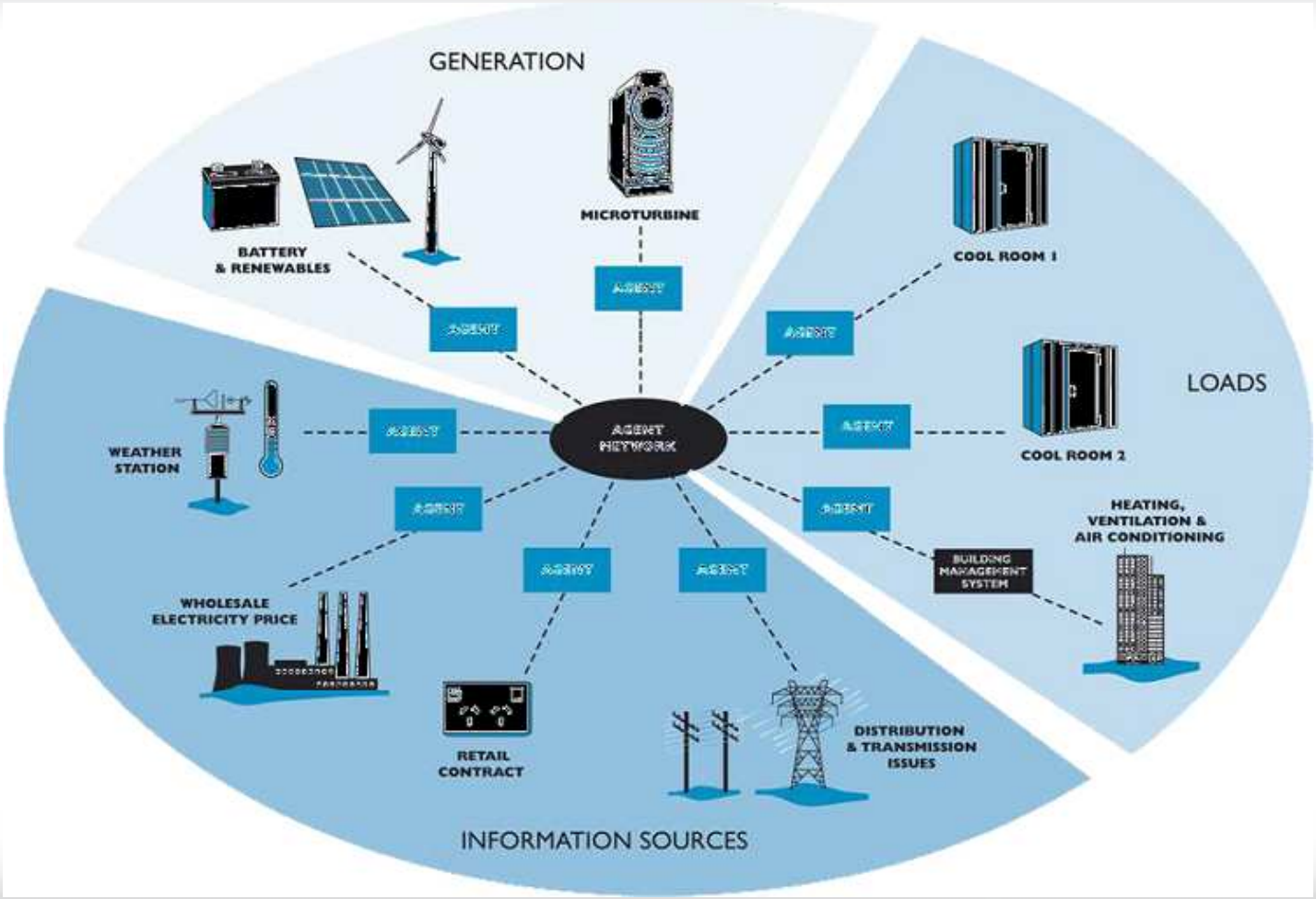
Smart Grid Elements



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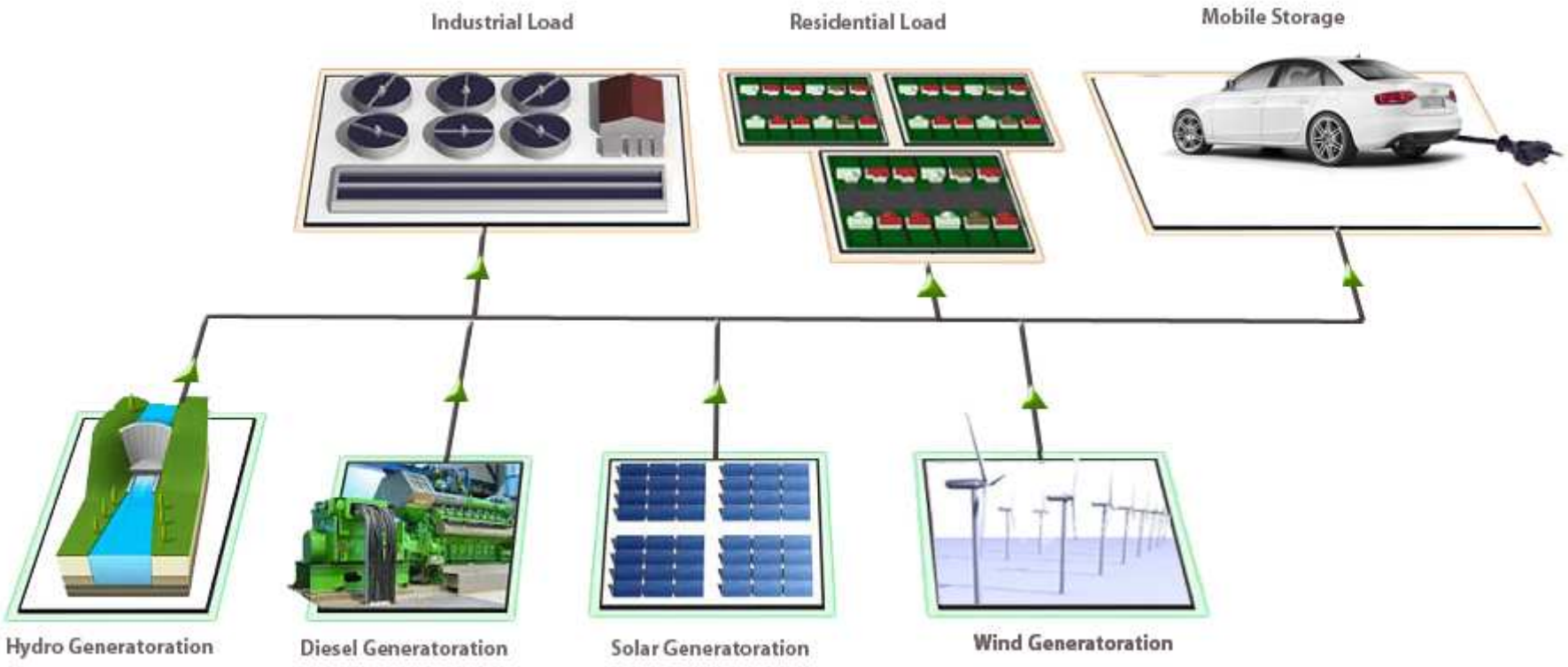
Isolated Smart Grid



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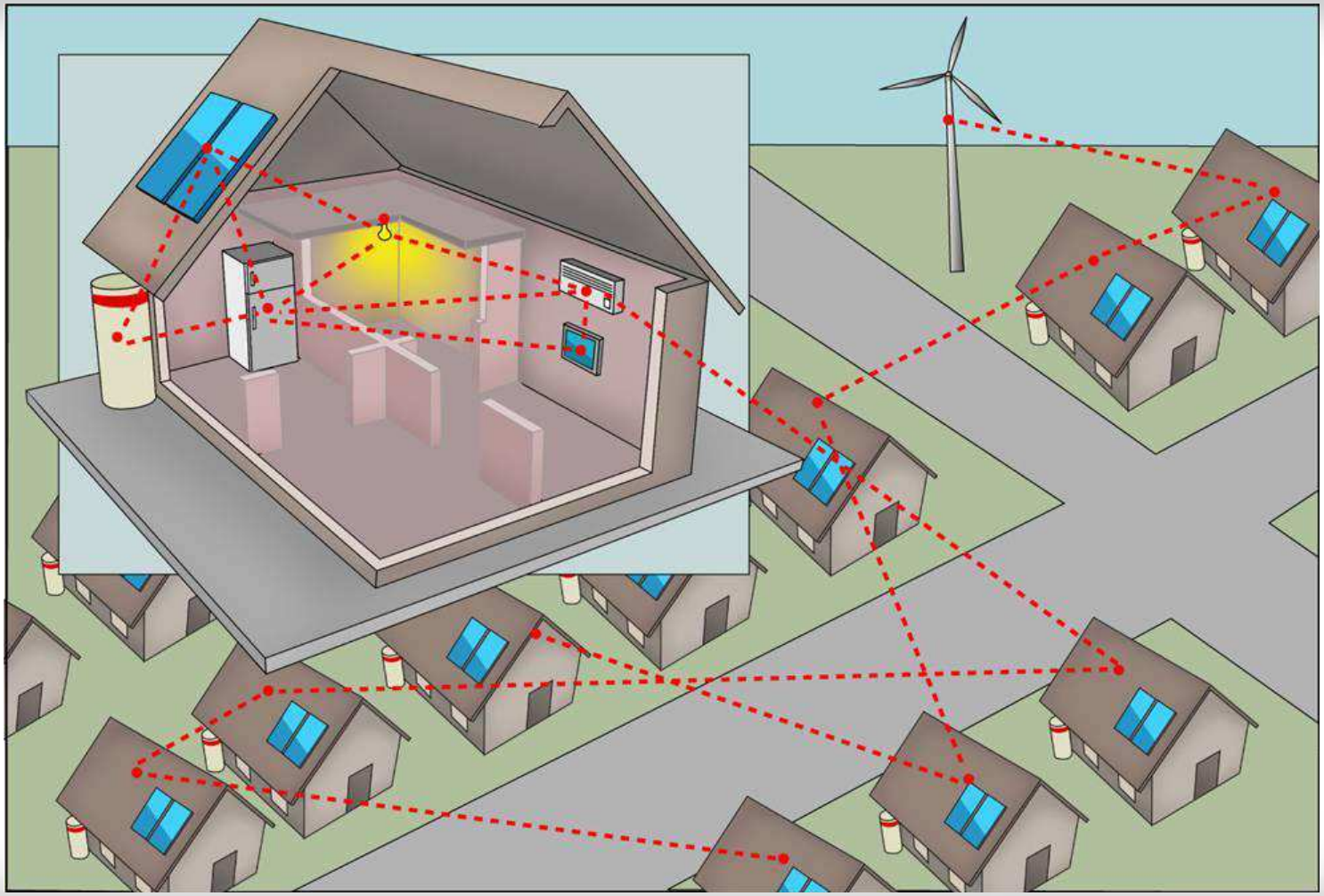
What is a Smart Grid?



Source CSIRO

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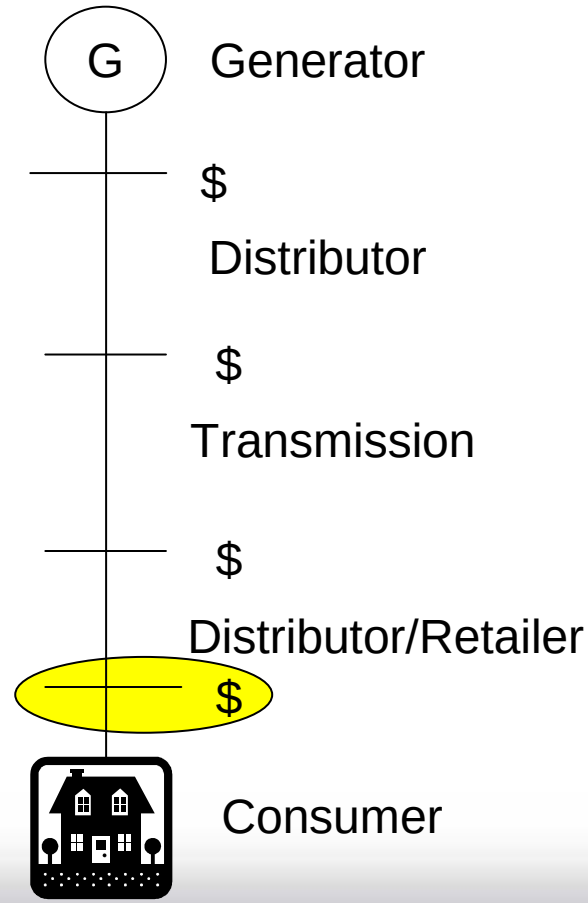
Large Interconnected System



Issues

- Many entities between Generator and Consumer
- Long Distance between generator to consumer
- Slow and difficult implementation

Current Approach by Utilities:

- Smart Metering to use pricing for demand control
- Smart Metering to provide feedback via web to consumer
- Education and Energy Efficiency
- "Control" with time lag of 15-30min
- No feedback into network about consumer load

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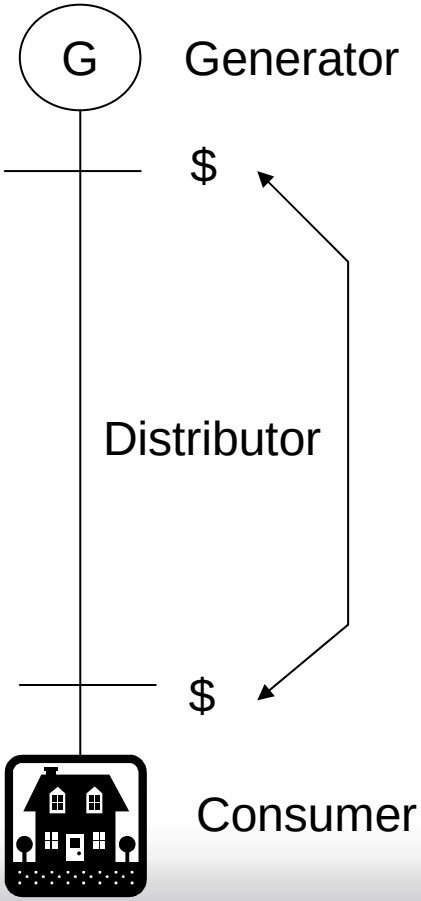
Isolated Systems

Isolated System



Issues

- Less entities, possible one utility
- Shorter Distance generator to consumer

Pathway forward

- Communication between generator and consumer
- Ability to integrate large amounts of renewable energy
- Feedback from load to generator and vice versa for smarter load control
- Ability to demonstrate effect of energy storage such as EVs, heating loop, A/C coolant storage etc.
- Fast Control required e.g. 1sec basis

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Drivers for Smart Grids Today

	Interconnected	Isolated
Load Growth of peak demand versus average demand	√	√
Increase in Renewable energy generation		√
Increased cost of fuel/emissions		√
Pressure to act due to Climate change	√	√
Ageing distribution systems with increase loads	√	
Increased risk of Terrorist Attack	√	
Opportunities due to new technologies	√	√

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Drivers for Smart Grids Tomorrow

	Interconnected	Isolated
Load Growth of peak demand versus average demand	√	√
Increase in Renewable energy generation	√	√
Increased cost of fuel/emissions	√	√
Pressure to act due to Climate change	√	√
Ageing distribution systems with increase loads	√	
Increased risk of Terrorist Attack	√	
Opportunities due to new technologies	√	√

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Conclusion

- Isolated Systems can be used as the **demonstration platform** for Smart Grids.
- Isolated Systems have **stronger drivers** today and **less roadblocks** in place
- We have done it, **Smart Grids are operating today!**

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Rottnest Island: Desalination Control

Water Tank is the Battery

1. Two way control and monitoring of a desalination plant in order to provide:
   - Spinning reserve
   - A dispatchable load
2. To be brought online if
   - Tanks are empty or
   - Excess wind
3. Simple control through on/off signal

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Mawson Antarctica: Heating Control

Heating Loop is the Battery

1. Two way control and monitoring of a heating and melting load in order to provide:
   - Spinning reserve
   - A dispatchable load
2. Through IGBT inverter system
   - Frequency Control
   - Voltage Control
3. Achieves 90% plus wind penetration without energy storage

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Acores: Distributed Generation

1. Distributed Control of multiple generators:
   - Diesel
   - Hydro
   - Wind
2. Through Flywheel system
   - Frequency Control
   - Voltage Control
3. Achieves operation without diesel generators

Water is the Battery

Coral Bay: Distributed Generation

1. Power system consisting of:
   - 7 x 320kW/50Hz diesel
   - 3 x 200kW wind turbines
   - 1 x 500kW flywheel
2. Demonstration of utility Power Quality despite large wind disturbances
3. Opportunity to deploy load control with desalination plant next door

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Ross Island: Distributed Generation

1. Two power systems coupled by frequency converter:
   - 6 x 1500kW/60Hz diesel
   - 3 x 225kW/50Hz diesel
   - 3 x 330kW wind turbines
   - 1 x 500kW flywheel
2. Option to include electric heating load
3. Integration of US/NZ power system networks

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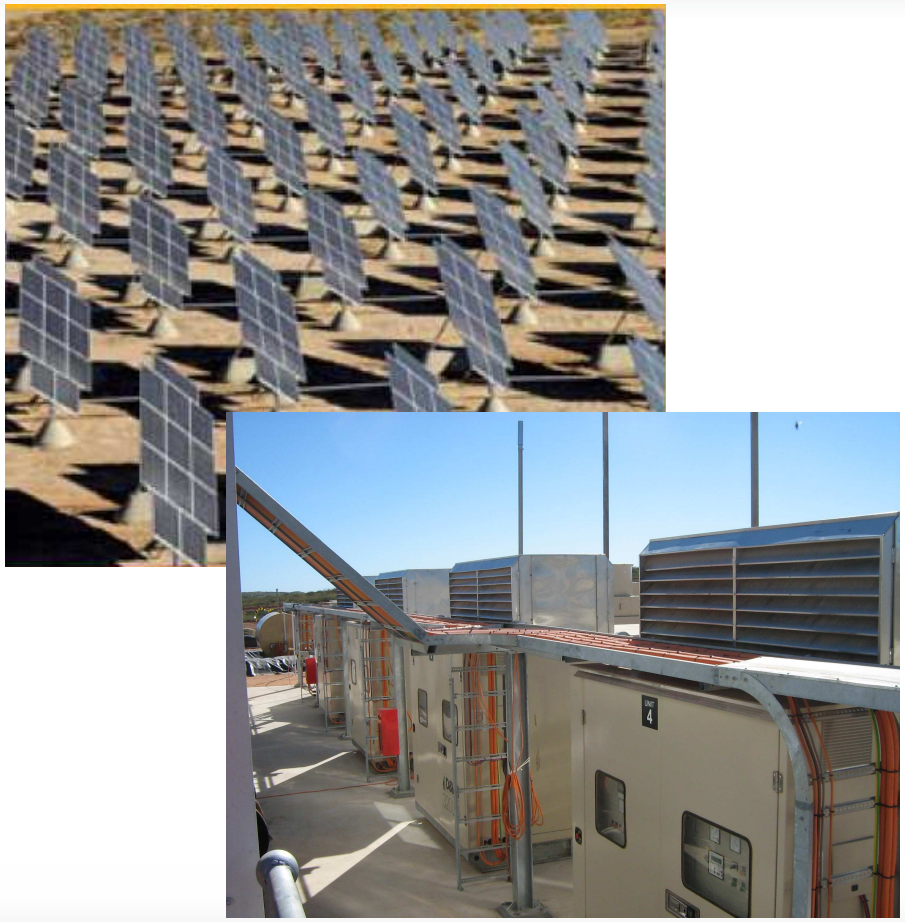
Marble Bar: Distributed Generation



1. Power system consisting of:
   - 5 x 320kW/50Hz diesel
   - 1 x 300kW PV
   - 1 x 500kW flywheel
2. PV/Diesel system without battery storage
3. Opportunity to deploy load control to maximise PV penetration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