MONASH University

Information Technology

Energy Research in IT

Monash Faculty of IT

Monash Energy Materials and Systems Institute

Ariel Liebman, Deputy Director

OES Symposium, OIST, Okinawa, Tuesday, 3 Feb 2015

Outline

1. Global Energy Challenges and Opportunities
2. Australian Energy Challenges and Opportunities
3. Monash University Energy Activities
4. Monash Faculty of IT Energy activities
5. Summary

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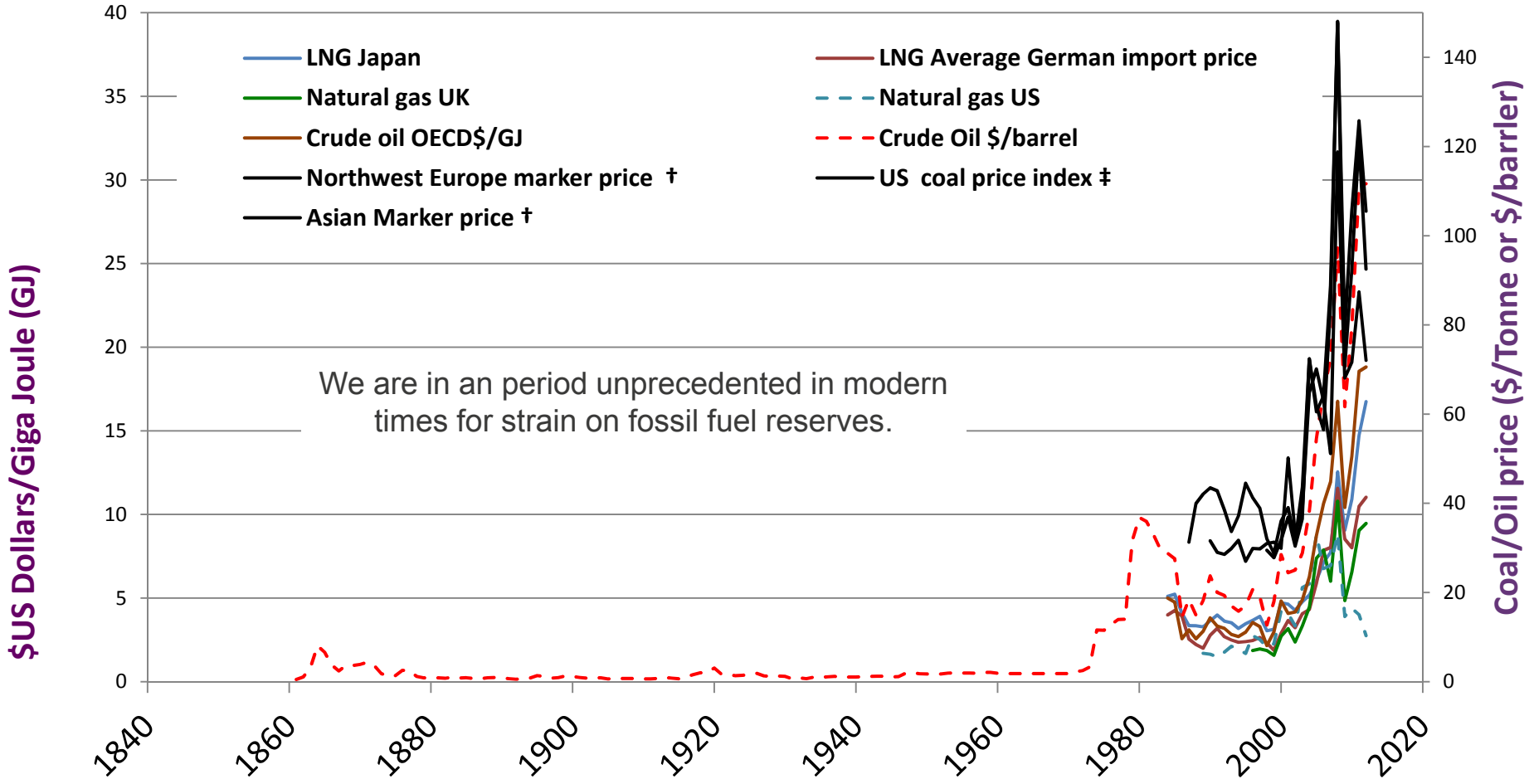
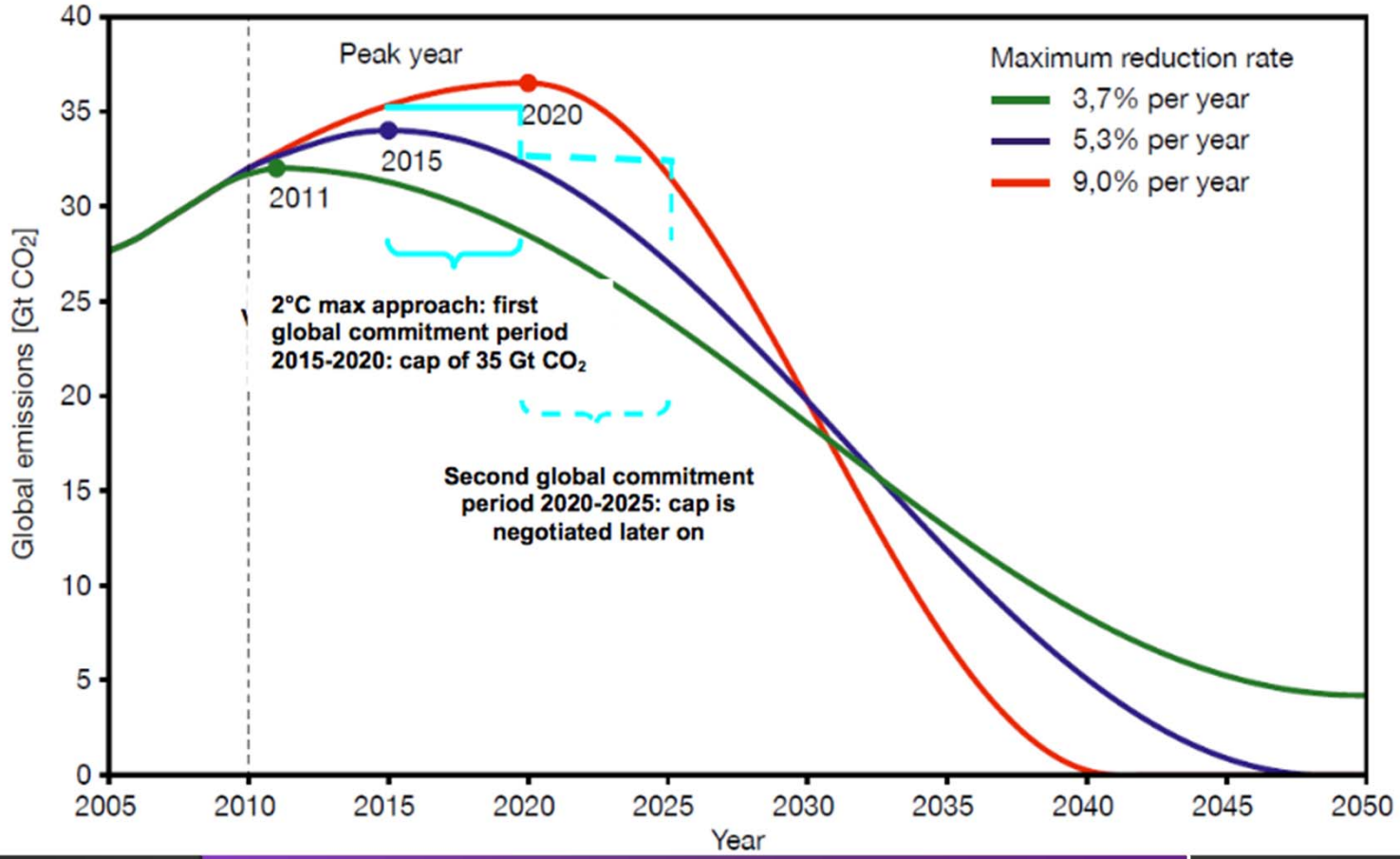
Global energy challenges and opportunities

The Past – Cheap fossil fuels running out

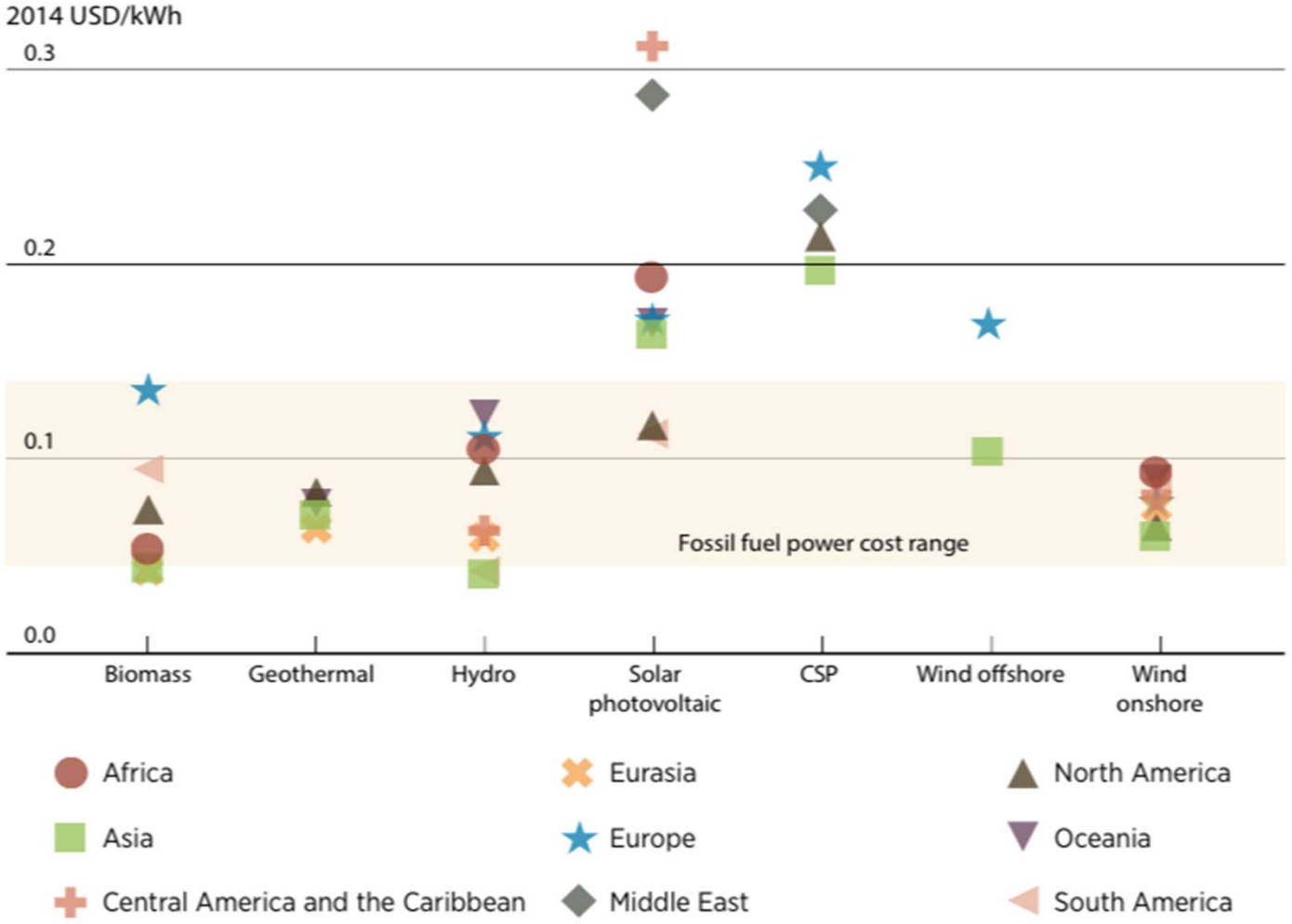


The Future – Climate action is very urgent

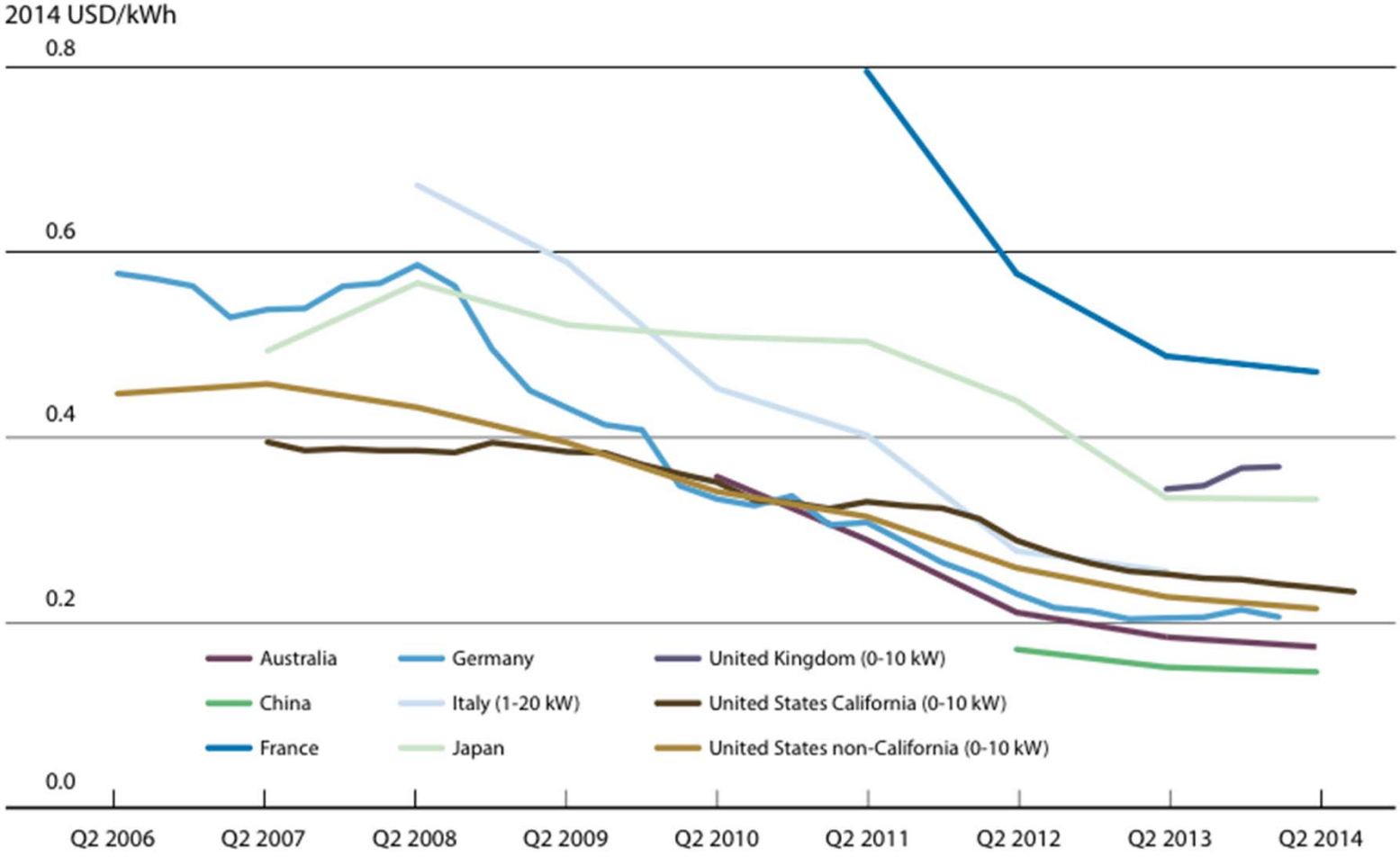
Figure 1: Peak-and-trade emissions limits to remain within the 2°C guard rail



Good News – Renewable Technology is competitive



History of Solar PV costs



Source: IRENA Renewable Cost Database; BSW, 2014; CPUC, 2014; GSE, 2014; LBNL, 2014; and Photon Consulting, 2014.

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Australian challenges and opportunities

The National Electricity Market

- National Electricity Market established in 1998 to facilitate efficiencies.
- Each state has separate price at which generators sell their output and retailers buy their demand.
  - Prices set by supply and demand.
  - Generation, transmission, distribution, and retail functions, separated.
- Transmission and Distribution were deemed natural monopolies. Fixed revenue based on asset value.

Western Australian Market

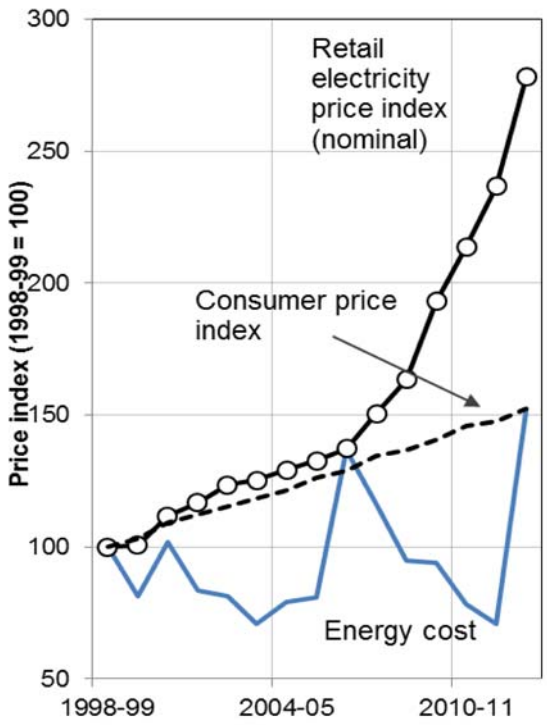
- WA has two networks:
  - South West Interconnected System, the SWIS (Around Perth)
  - Horizon Power's network in the north of WA
- SWIS is a market different design to NEM
  - Energy (net pool) plus Capacity Market
  - Dominated by government owned Synergy.
- Private new entrants operate but market still maturing

New Technology and Paradigms

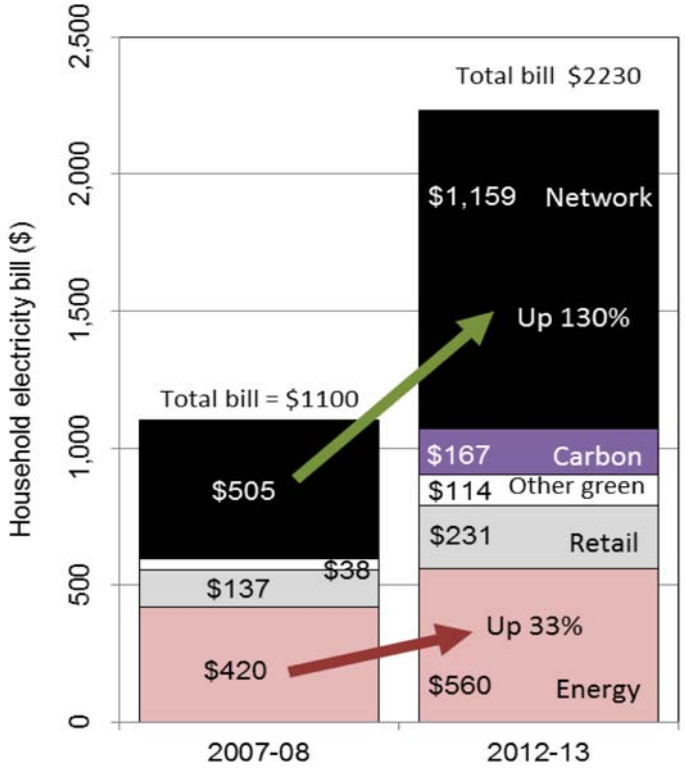
- 20% by 2020 Renewable Energy Target (Now ~ 27%!) -> 4GW PV since 2009
- Victorian Smart Meter Roll-Out – 2million "Smart" Meters.
- NSW Smart Grid Smart City - $100Million (Ausgrid, IBM, others)
- CSIRO Future Grid Forum (4 Scenarios) –> CSIRO Future Grid Cluster (Uni's)

Australian retail electricity prices have skyrocketed! Why?

Capital city prices 1998-99 to 2012-13 (forecast)



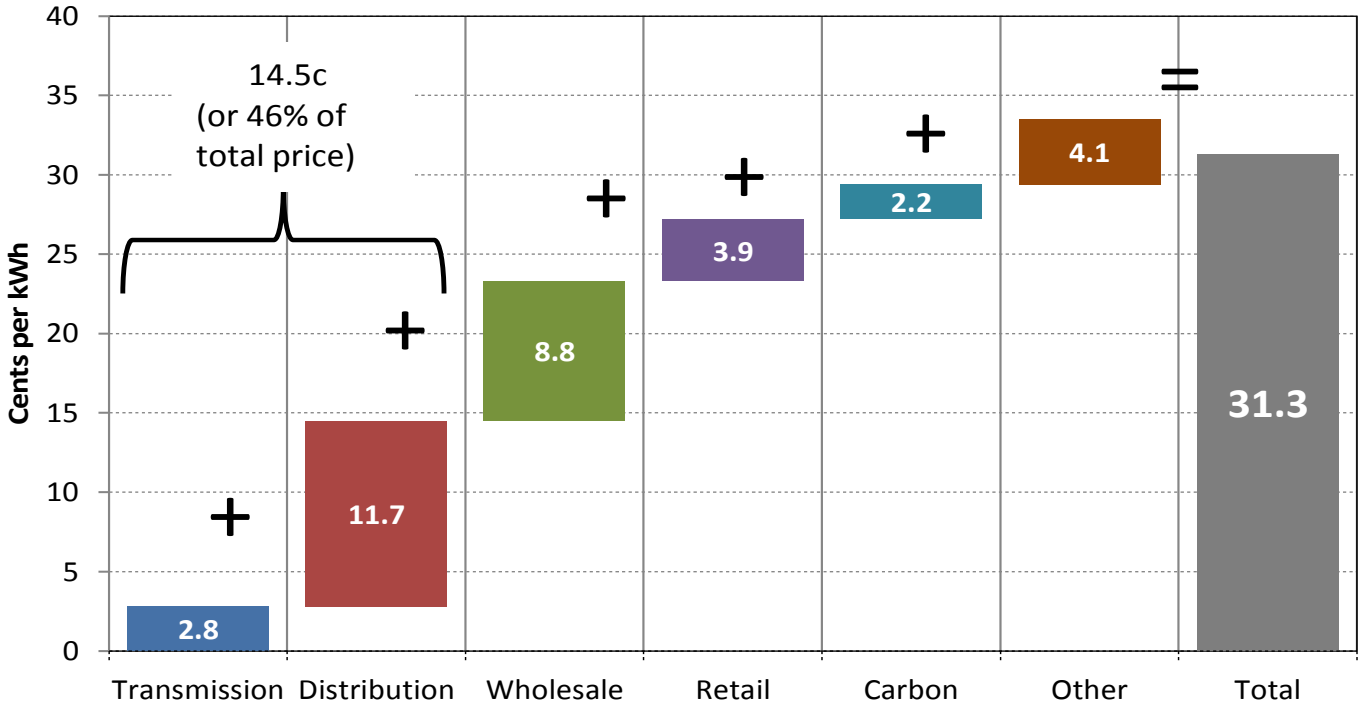
New South Wales household electricity bill 2007-08 and 2012-13



Breakdown of Retail Electricity Price

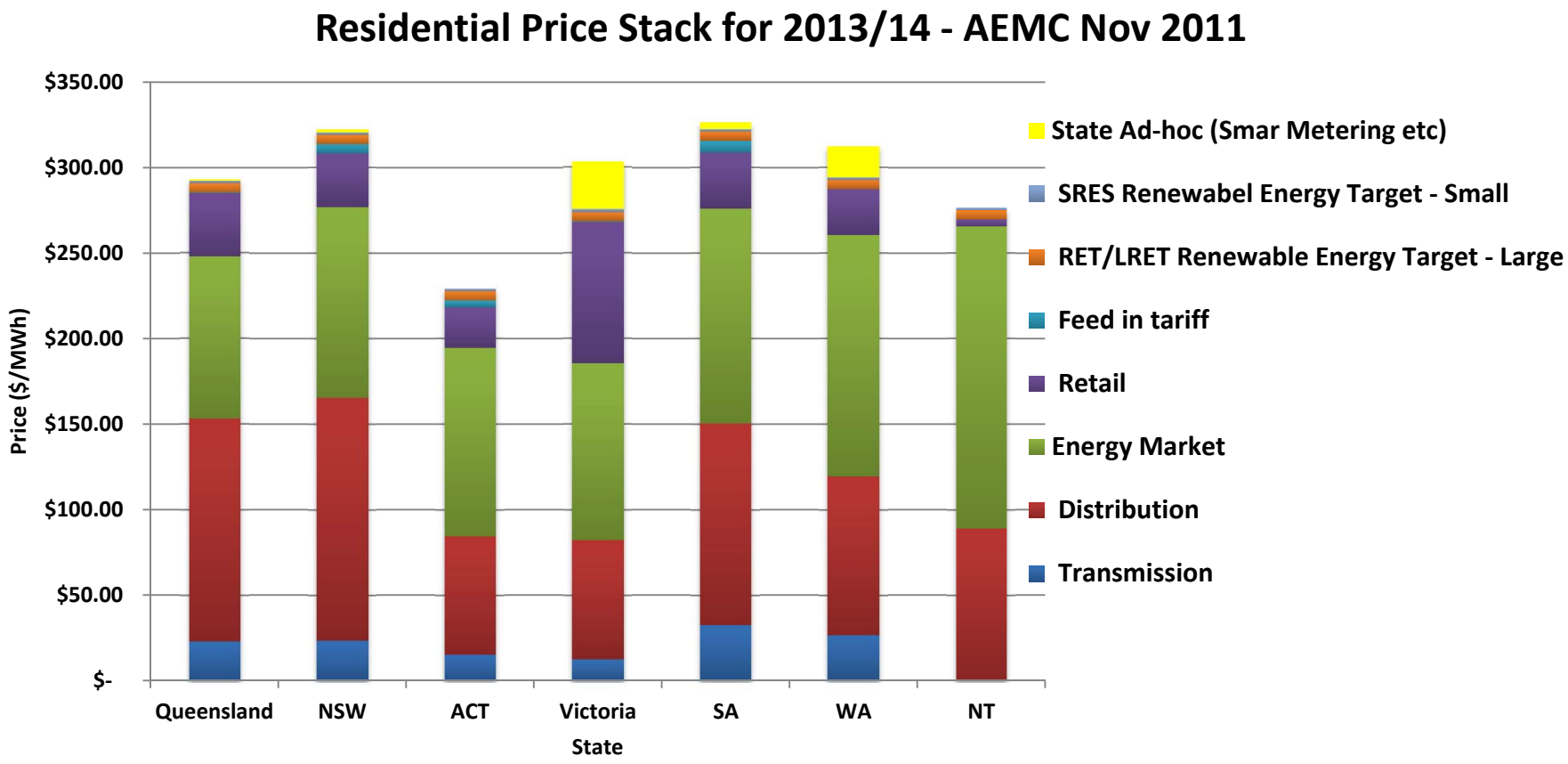
Figure 2.12 **Projected residential price cost components in 2014-15, Australia**

Cents per kWh



Data source: AEMC (2013a).

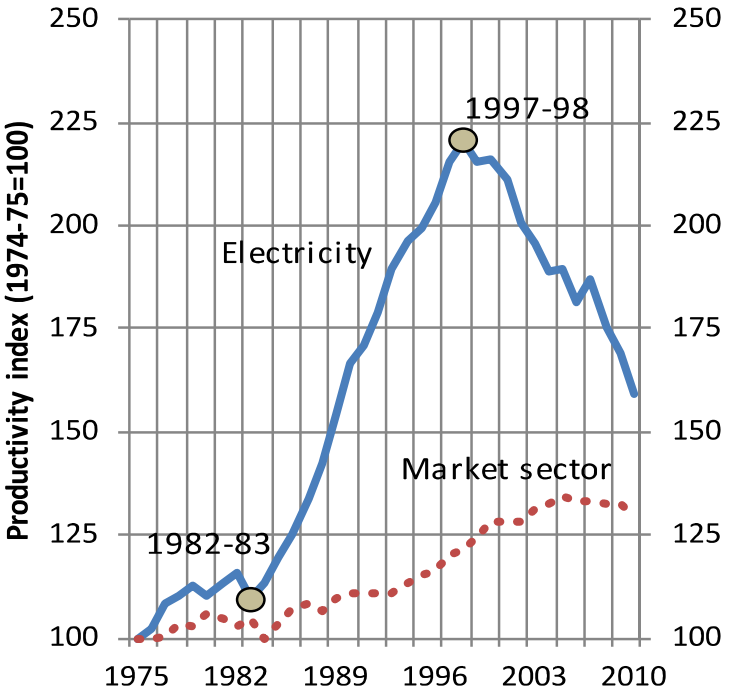
Perverse incentives and unforseen consequences



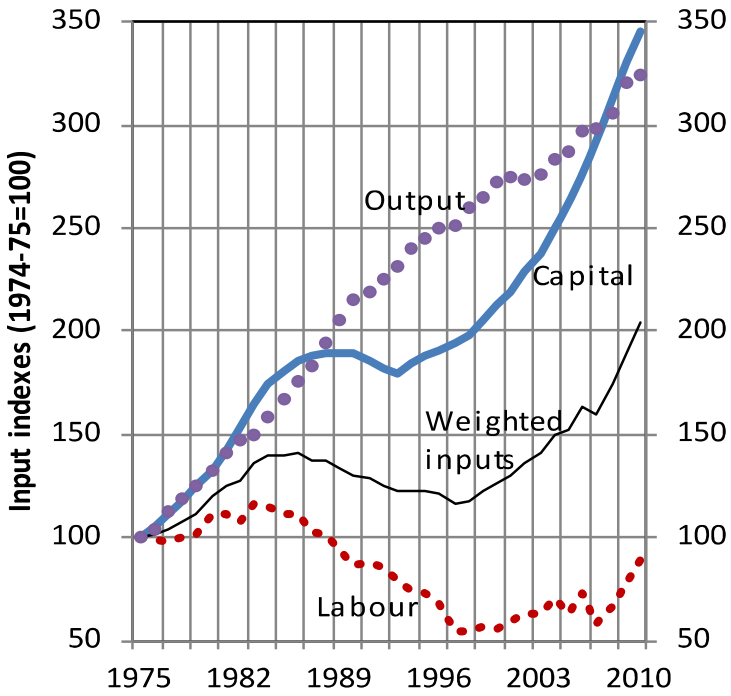
Cause: “Market Reform” – Did it not really work?

Figure 2.15 **Measured electricity sector productivity has been falling**
1974-75 to 2009-10

Comparative productivity performance[a]



Input and output growth in electricity



Challenges for the Energy Sector

World Energy Use:

- Will grow by **56% between 2010 and 2040** (half of this in China and India)
- **CO_2 emissions are projected to increase 46** % by 2040
- To meet '**the two degree target**', **$US 53 trillion** in cumulative investment required during **2013 - 2035** in energy supply and efficiency

Power system management

Legacy challenges:

- Keeping system stable (short time scale optimal control)
- Forecasting Demand (minutes to hours horizon)

New challenges:

- Renewable integration – managing the variability of Wind and Solar etc.
- Integration of fast demand response capability from smart grids
- What to do with all the data from the smart meters?!

System planning and asset management

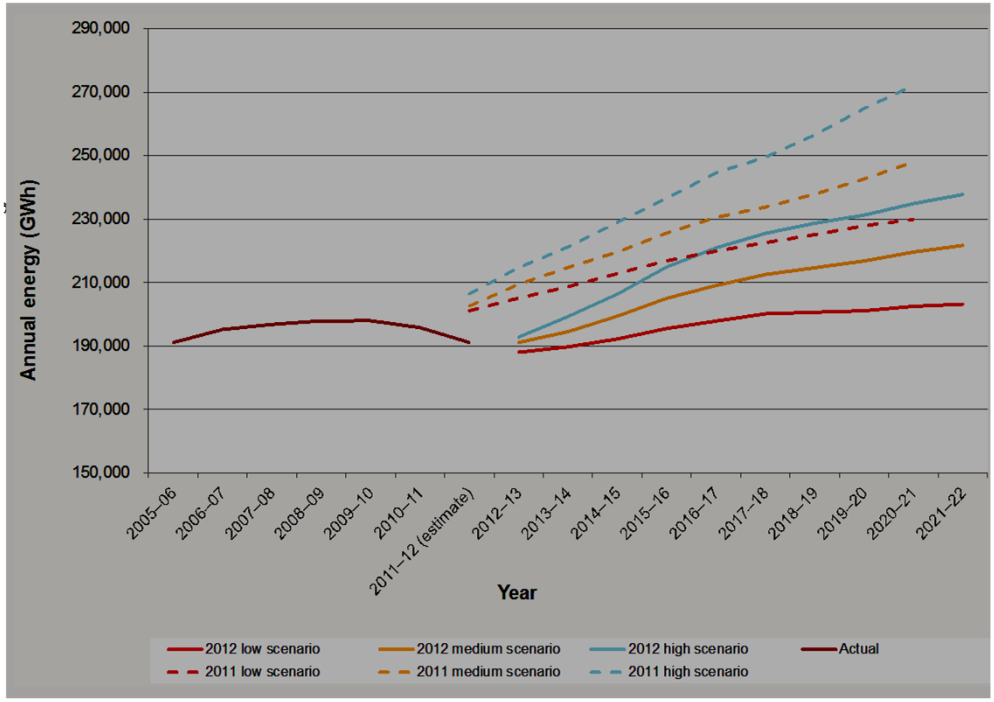
Both electricity and gas system

- Expensive and long lived assets
- Systems need to be expanded, transformed (renewable energy), repaired.

Challenged by*:*

- Demand, technology costs, govt policies, disruptive technogies (**Electric Vehicles**.), energy markets etc -> **Uncertainty**!
- Biggest challenge for Electricity and gas system planners: **Investment decisions under uncertainty**

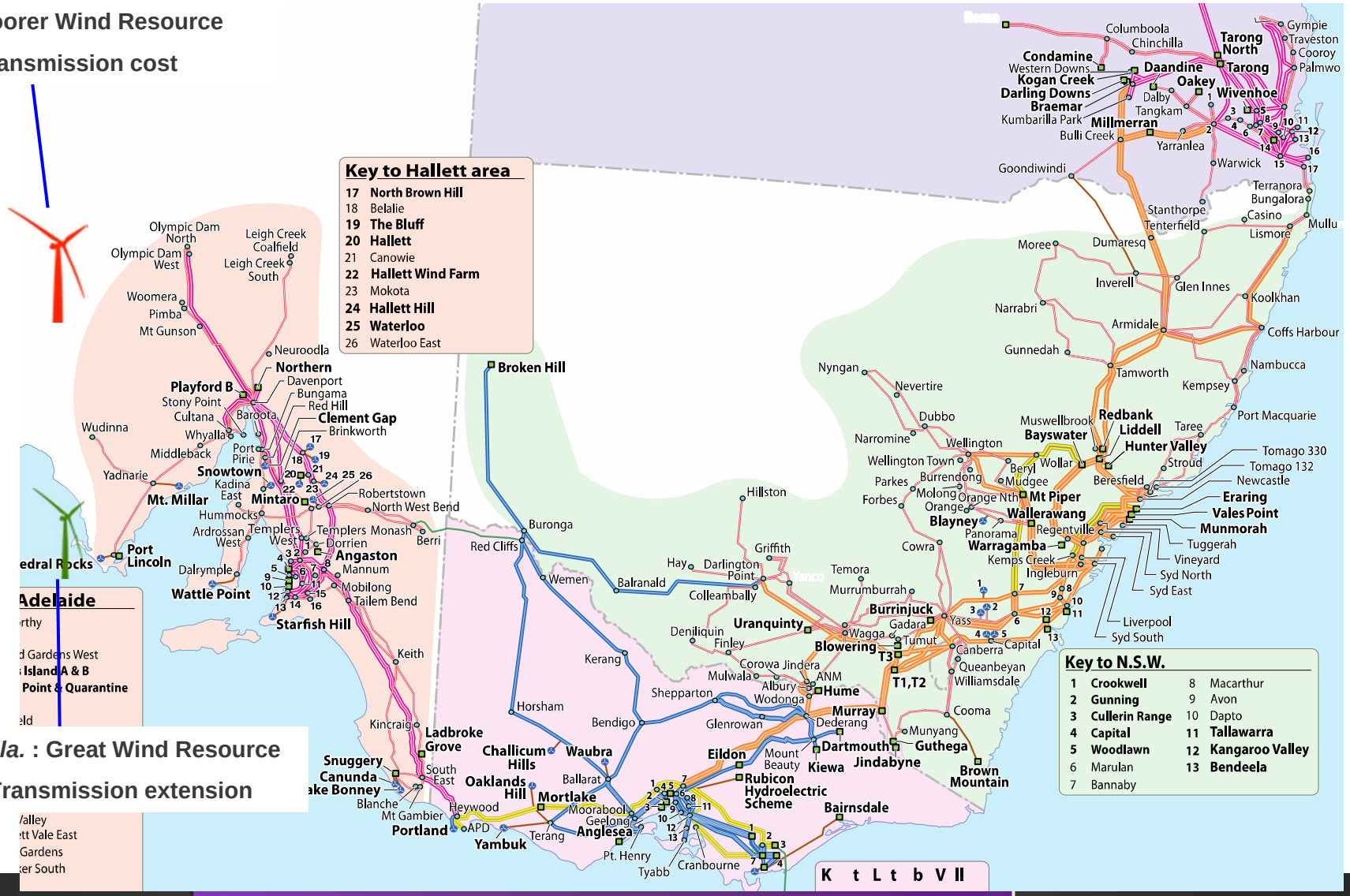
Figure 2-4 — Comparison of the NEM-wide energy projections (low, medium, and high scenarios)



E.g. Co-optimisation: location of renewable generation and transmission

Woomera. **: Poorer Wind Resource**

Minimal transmission cost



AYRE Peninsula. **: Great Wind Resource**

Expensive Transmission extension

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Smart Grids

Smart Grid Benefits and Challenges

Smart grids can:

- make full consumer engagement possible
- Increase productivity
- help with integration of renewables,
- defer capital expenditure (CAPEX) across entire supply chain
- reduce operating expenditure (OPEX).

Smart grids should:

- Decrease the costs of building and running electricity grid.
- Ultimately, all these benefits should be reflected in **reduced prices**
- However, there are up-front **capital costs!**
- Regulators must ensure cost and price reductions (?)
- **Most like new business models will emerge that will bypass existing frameworks, for example, grid-defection! <- > OES!**

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Monash Energy Materials and Systems Institute - Est 2014

Monash Energy Materials and Systems Institute (MEMSI)
Vision: To promote a balanced approach to a socio-economically sustainable path to energy sufficiency by working with industry and the community

a. **Development of new systems for clean energy, as well as**
b. **Improving efficiency and environmental impact of traditional systems.**

MEMSI has diverse research expertise in Energy

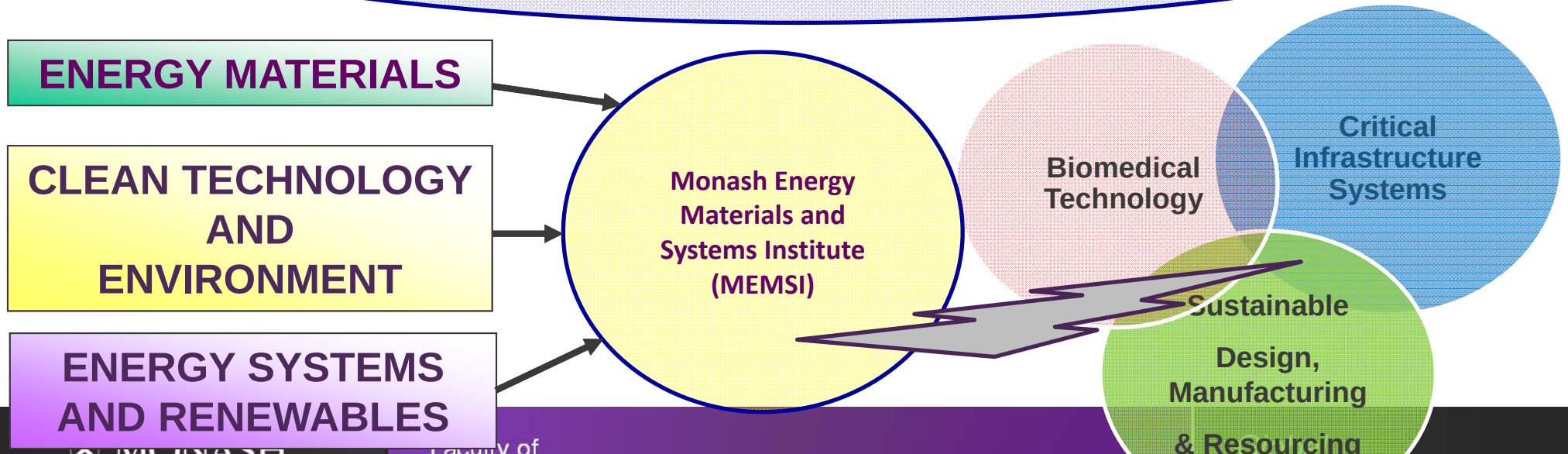
- >70 academic staff (& 200+ of students + post-docs) in energy research spread over four faculties,
- Monash covers most of critical energy research topics
- Monash: An Australian institution that covers the widest spectrum of energy research - International University

MEMSI

Joint venture between Engineering & Information Technology

MISSION

To forge strong and long term collaborations with industry and government for research, technology transfer, and policy impact



Selected MEMSI Research Capabilities

- Advanced materials for photovoltaic materials, Solar Fuels
- Advanced materials for energy storage (e.g. graphene),
- CO_2 capture, storage and geo-sequestration,
- Energy efficient mining and manufacturing
- Geothermal energy, Wind Modelling
- Energy Systems modelling, optimisation and simulation
- Smart grids (Very much at the **interface** of **IT** and **Engin**
- Energy system and market regulation
- Energy policy analysis and advice (**ClimateWorks Australia**)

NICTA

Australia Indonesia Centre – Energy Cluster

The Australia-Indonesia Centre

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Participating Institutions

The Australia-Indonesia Centre brings together leading universities and institutions in Australia and Indonesia to harness world-class researchers, educators and innovators to solve shared national challenges.

MONASH University, Australian National University, CSIRO, University of Melbourne, University of Sydney, Institut Pertanian Bogor, Institut Teknologi Bandung, ITS Institut Teknologi Sepuluh Nopember, Universitas Airlangga Surabaya, Universitas Indonesia

Shared and Complementary Challenges and Opportunities:

- Both economies' are using non-renewable fuels (mostly coal)
- Both economies' are heavily dependent on coal exports and liquid fuel imports
- 30% of Indonesia's population has no access to electricity
- Both have remote areas with high energy costs

Focus solutions around

- Reducing investment risk and providing an investment environment through: Policy certainty, Policy consistency, Policy
- transparency and Policy synchronization across jurisdictions
- Using diversified and innovative decarbonized technologies based on Indonesia's and Australia's comparative advantages

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Monash Faculty of IT Energy activities

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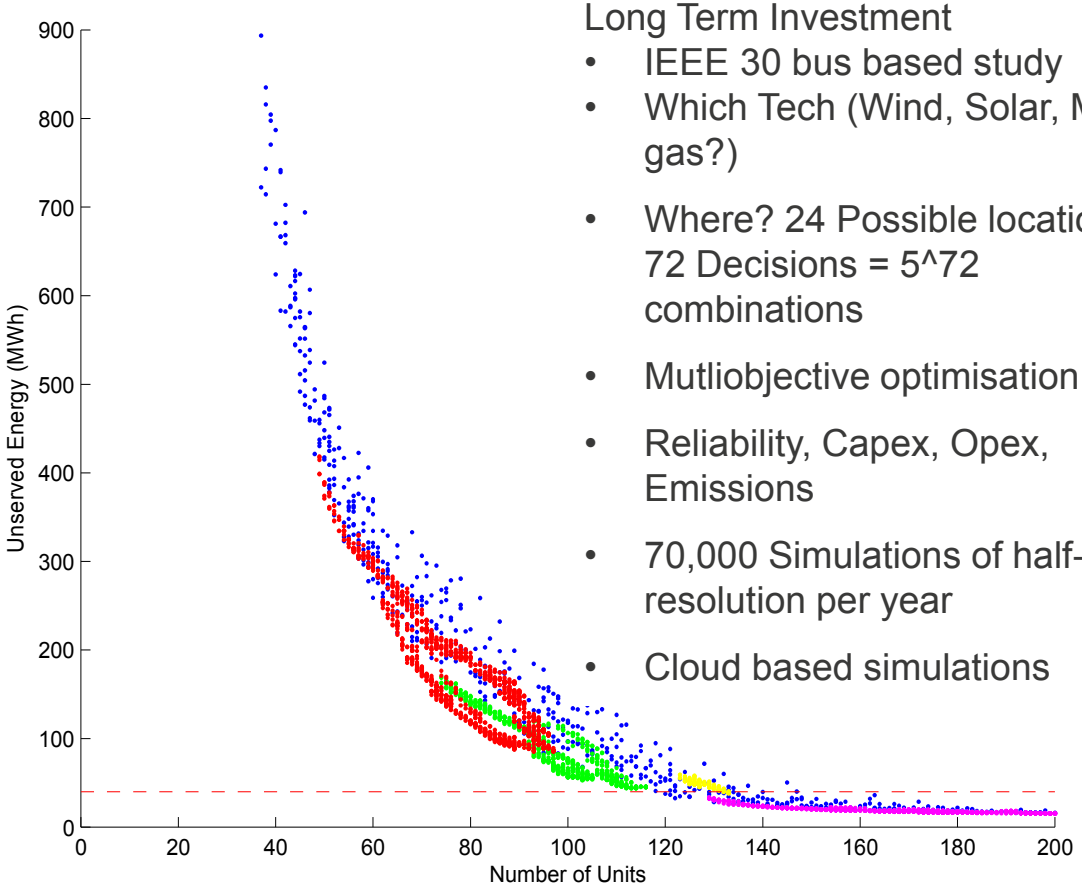
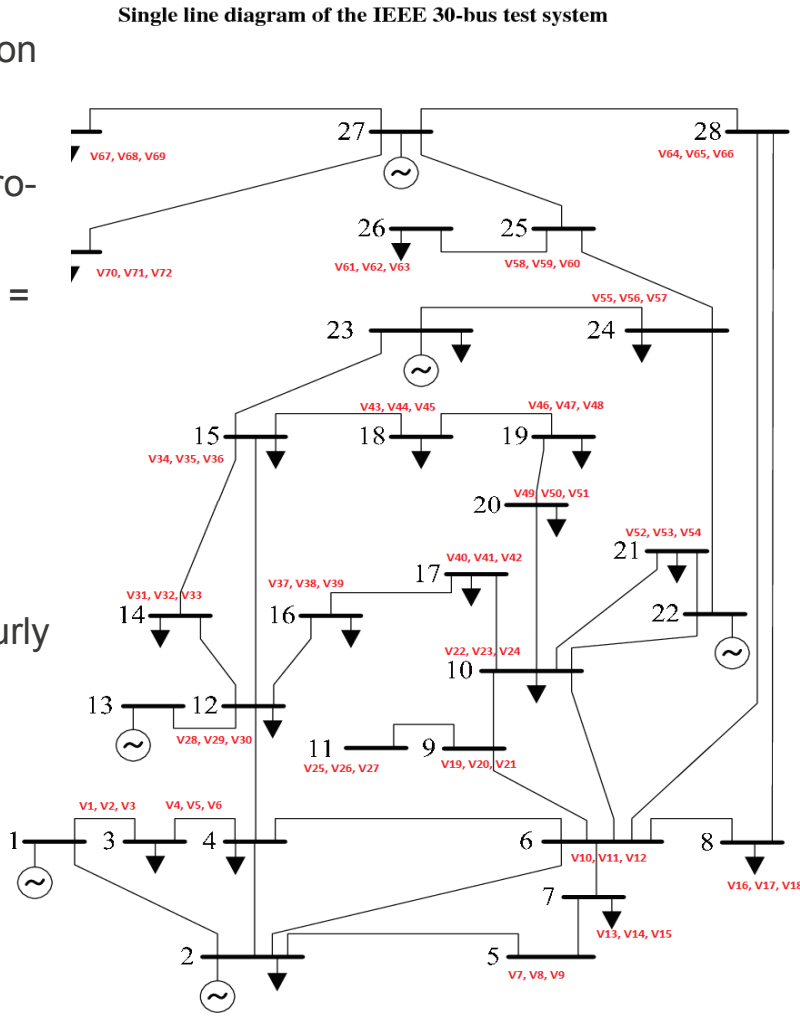
Global
Innovation

Optimal investment in renewables and optimal grid expansion



Economics of renewable integration
Long Term Investment

- IEEE 30 bus based study
- Which Tech (Wind, Solar, Micro-gas?)
- Where? 24 Possible locations = 72 Decisions = 5^72 combinations
- Mutliobjective optimisation
- Reliability, Capex, Opex, Emissions
- 70,000 Simulations of half-hourly resolution per year
- Cloud based simulations



Automatic customer profiling using Smart Meter Data

Electricity consumption profiling on 100,000 customers data:

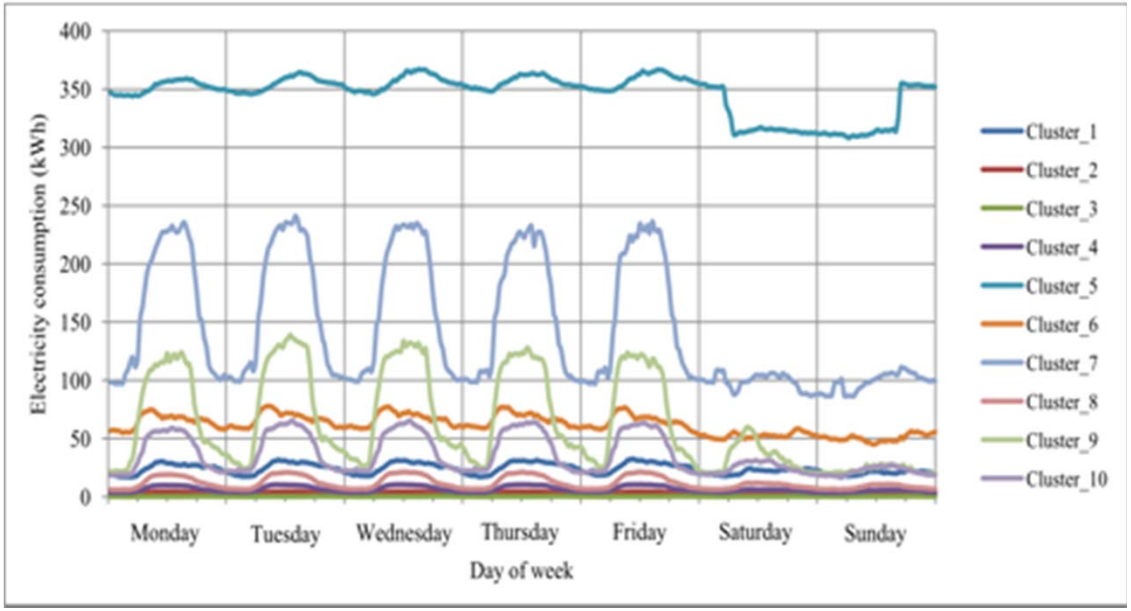
Working with a Victorian **Energy Utility** to deal with smart meter data

- Daily profile analysis
- Weekly profile analysis
- Annual profile analysis

Tools:

- A mixture of Heuristics and
- Machine learning classifiers

techniques



Outcomes:

Groups of different customer types emerge.

***Outstanding question*: how to relate these groupings to behaviour characteristics?**

Risk based asset replacement

Consultancy to Western Power; Transmission and Distribution system operator in Western Australia

The problem: When to replace aging assets?

- Using various data available about condition of power pole, quantify the risk of poles failing
- Use of causal models to predict effects of interventions
- Helps optimize asset management plans and reduce risk while minimizing maintenance and replacement costs.

Customer load disaggregation

The Problem: With only one smart meter: How to inform the consumer what each of their devices is doing?

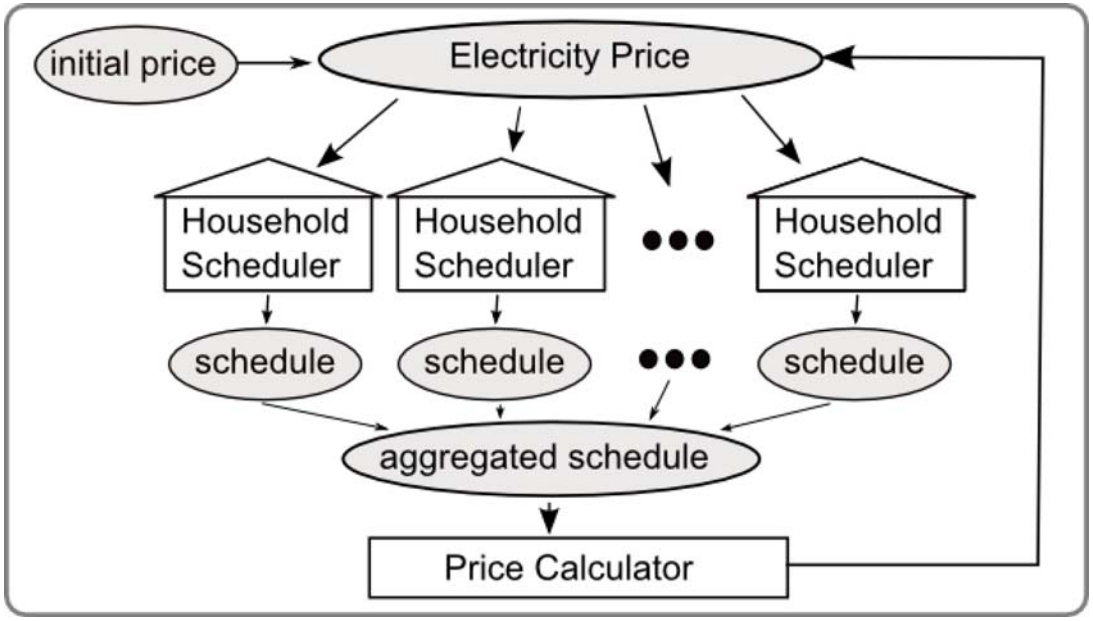
- Use Hidden Factorial Markov Models trained on known devices
- With 1sec interval readings very accurate!
- Next: Extend to 5, 15, and 30 minutes

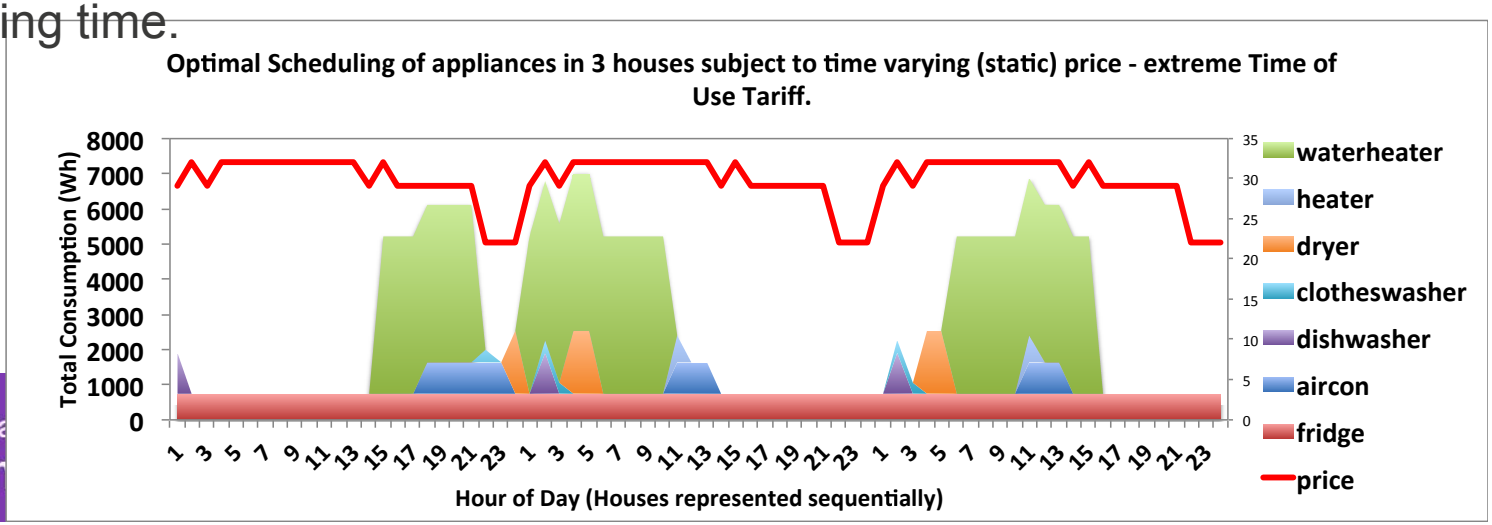
Smart Grids – Simulation and Optimisation

The Problem:

How to best integrate real time pricing with home management systems:

- Multiple Houses with multiple appliances.
- *Goal*: Minimise costs and inconvenience
- Constraints on each appliance
- *Objective function* : Dependent on Half hourly price and degree of deviation for an hour's deviation from preferred starting time.





Information Technology Energy Projects - Team

- **Optimal investment in renewables and optimal grid expansion**
  - *A. Liebman, B. Bethwaite* - Monash, *L. Wagner* - Griffith Uni, Brisbane, *D. Abramson*, UQ, Brisbane, *T. Kipouros*, Cambridge.
- **Automatic customer profiling using Smart Meter Data**
  - *Lachlan Andrew, Ariel Liebman, Sue Beddingfield*
- **Risk based asset replacement**
  - *Ann Nicholson, Kevin Korb*
- **Load Disaggregation**
  - *Lachlan Andrew, Reza Haffari*
- **Smart Grids – Simulation and Optimisation**
  - *Dora He, Campbell Wilson, Mark Wallace, Ariel Liebman*

Summary

- Big Challenges:
  - Energy Growth in Developing world -> CO2 Emissions Growth
  - Very short timeframe to address -> Global Emissions must peak in 2020!
- Big Opportunities:
  - Cheap renewables
  - Information Technology enabling massive transformation of supply chain
- Research institutions must work with business and other stakeholders to:
  - Facilitate the rapid uptake of technologies so that we can displace fossil fuel based energy use.
  - At the same time help the 4+ billion people get access to energy, who do not yet have it
- Lots of luck to all of us!