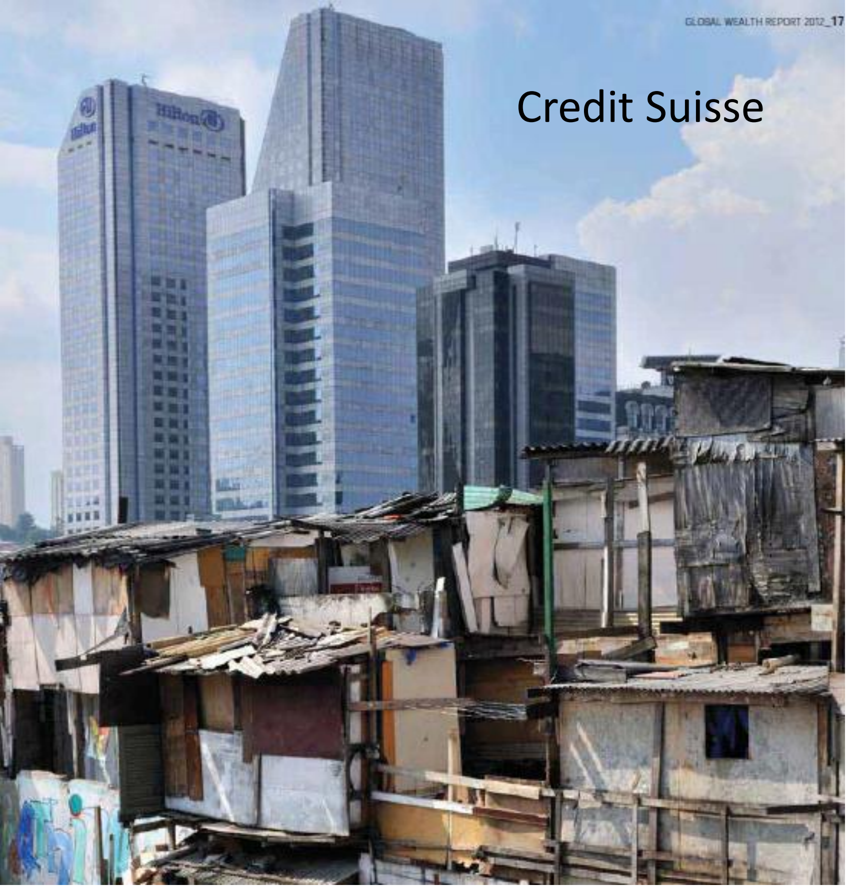


Our efficient, smart, flexible, distributed and diverse energy future

UNSW 17 Nov 2016, based on

Presentation at APEC Energy Ministers' Meeting 13 October 2015

Alan Pears AM

Senior Industry Fellow RMIT University, Melbourne Australia

Associate Consultant Buro North

Extreme energy efficiency transforms our thinking about reality: world record holding human powered vehicle – 137.9 km/h

http://gosporttimes.com/2015/09/20/crazy-fast-human-powered-vehicle-sets-new-world-speed-record/

The Energy System – driven by demand

Services:

Shelter

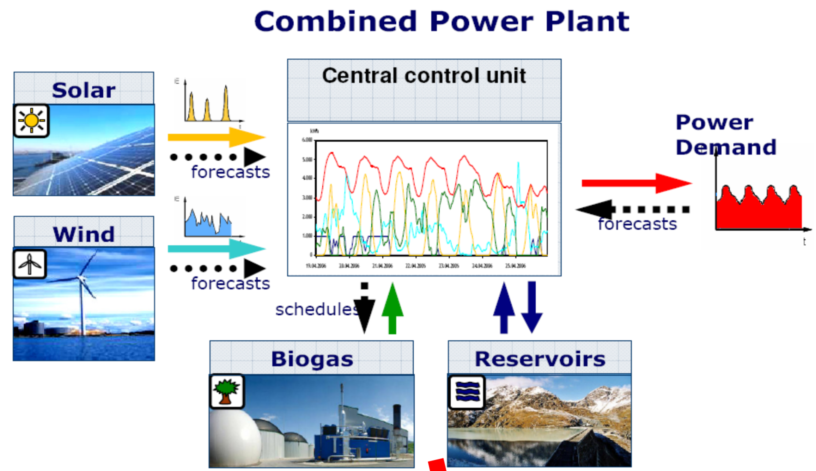
Nutrition

Access

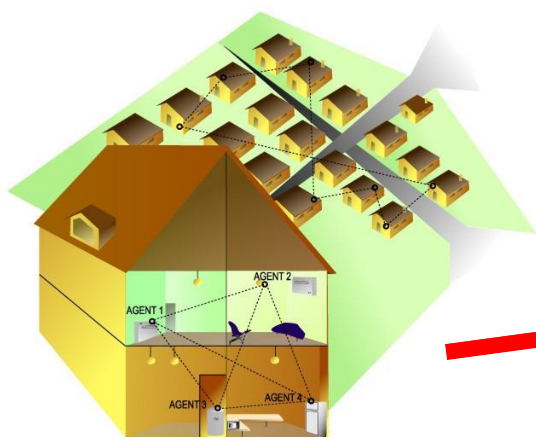
Entertainment

Goods & services

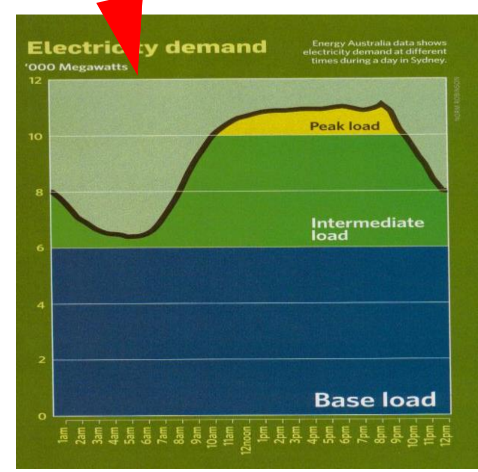
Energy production and supply



End-use technologies: types, efficiencies, usage



Demand for energy: type, amount and timing



Need for investment in supply system can be reduced by smart demand-side action. Historically, we have put the supply side 'cart' before the demand side 'horse'

Change in energy reflects broader disruptive changes in technology and society such as:

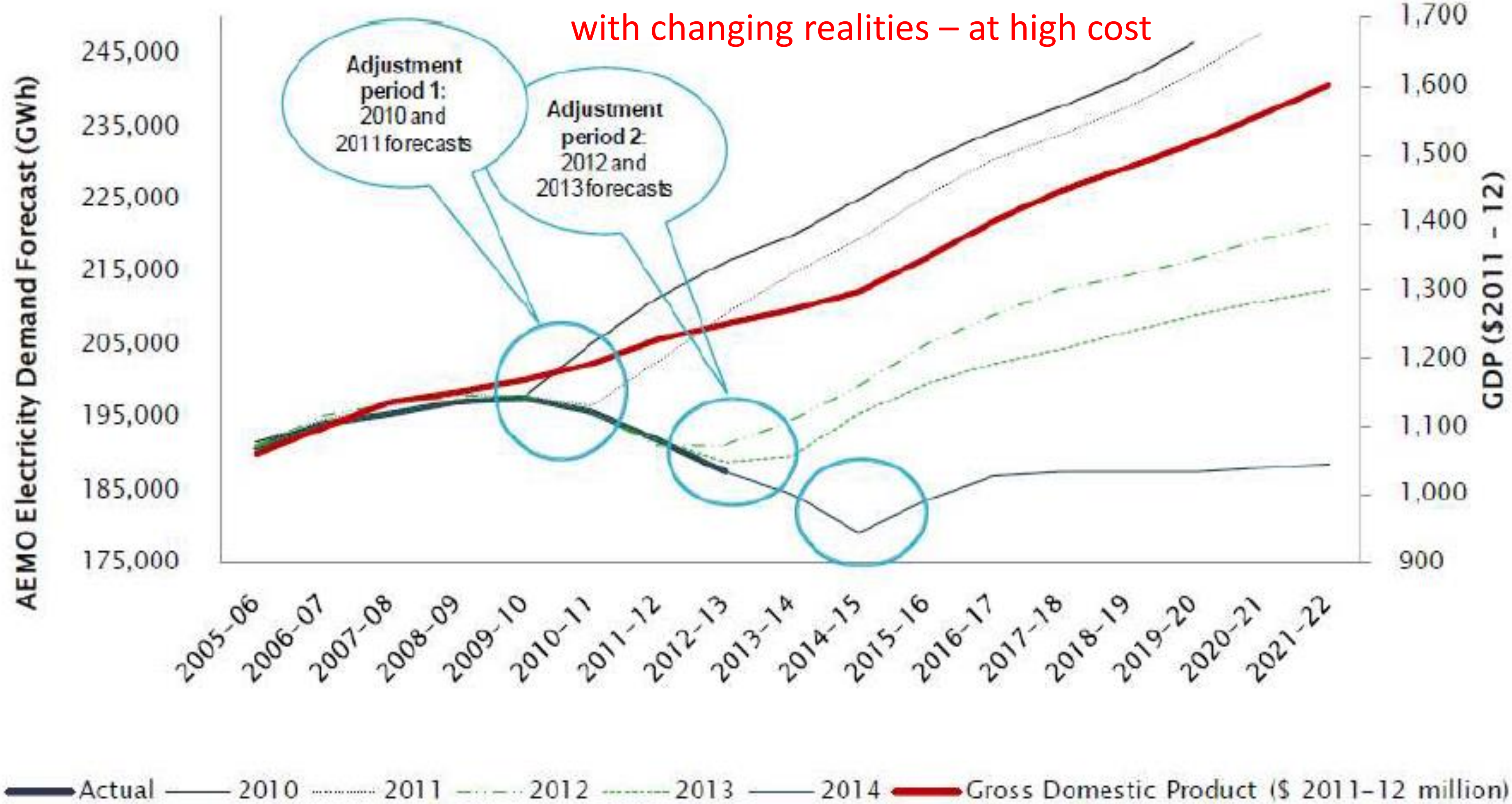
- Internet, ‘virtual’ solutions, dematerialisation
- Green chemistry and alternatives to process heat
- New materials – nanotech, graphene etc
- Computerised design, control, monitoring
- Modular, decentralised technologies, 3-D printing etc
- Urbanisation
- Growth of services economy
- Globalisation

- Energy, resources industries are among the last to face culturally disruptive change and major ‘substitution’ risk

Year by year reductions in projected electricity demand from AEMO – from draft report by A2SE on doubling energy productivity (2014)

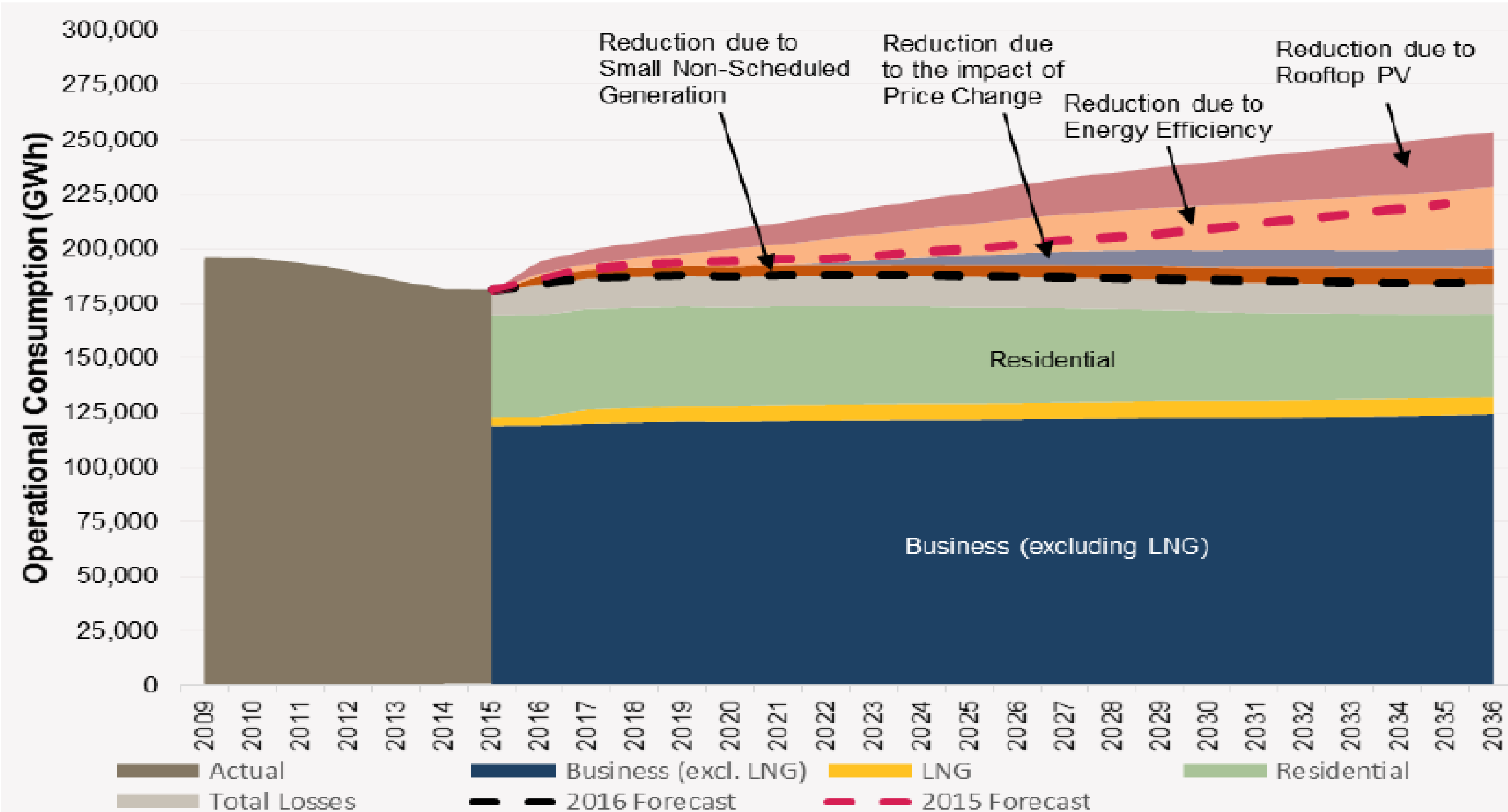
Figure 16: AEMO medium growth forecasts to 2022 compared to real GDP trend

Energy sector has struggled to come to terms with changing realities – at high cost



AEMO National Electricity Forecasting Report (2016) p.4

Figure 1 **Operational consumption 2008–09 to 2035–36**



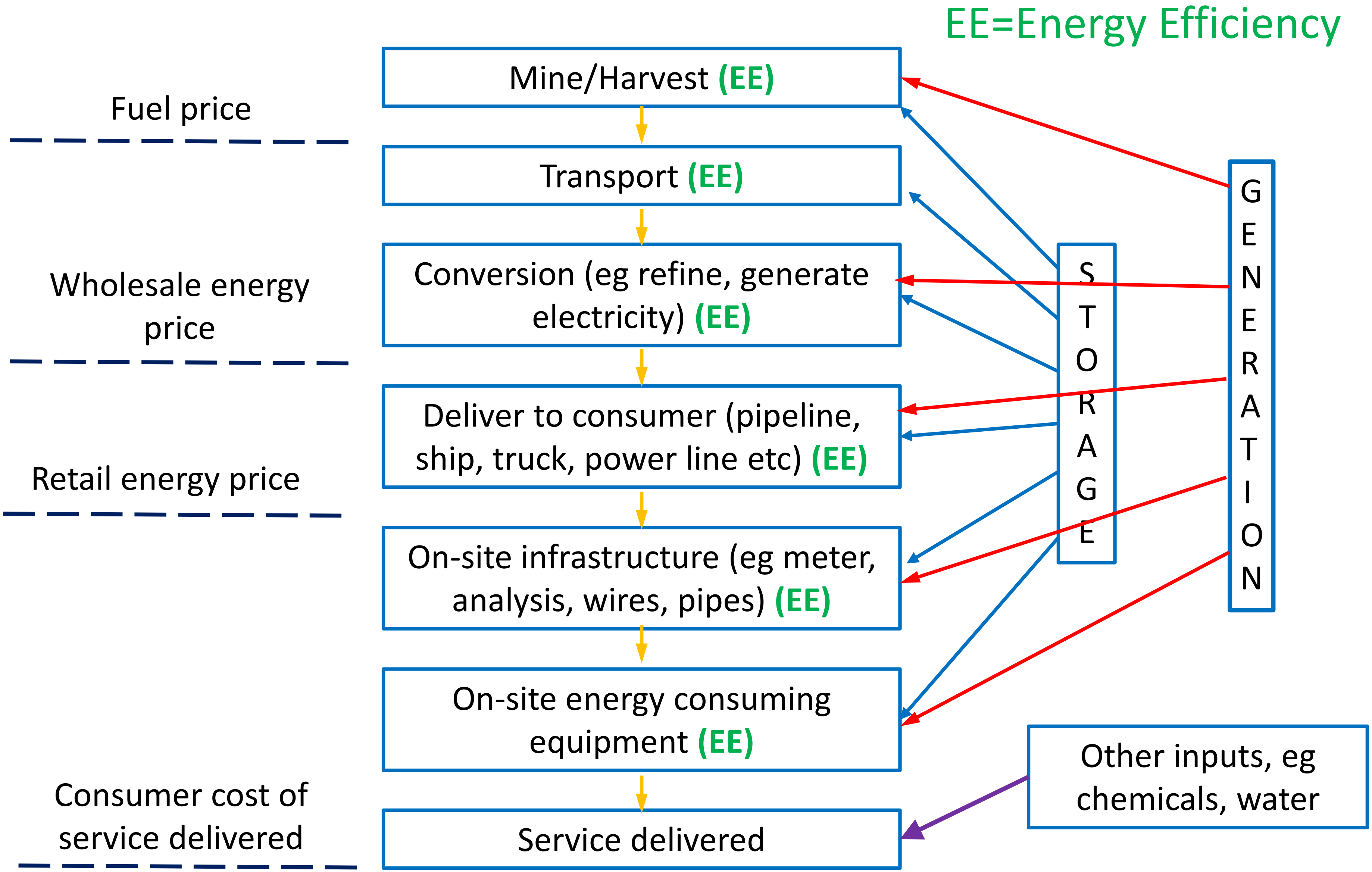
[4] Operational consumption refers to the electricity used by residential, commercial, and large industrial consumers, drawn from the grid and supplied by scheduled, semi-scheduled, and significant non-scheduled generating units (excluding rooftop PV generation and small non-scheduled generation). More detailed definitions are available at: http://www.aemo.com.au/Electricity/Planning/~/media/Files/Other/planning%202016/Operational%20Consumption%20definition%20%202016%20update.ashx

[5] 2015–16 demand is estimated on a weather-normalised basis, assuming long-run median weather outcomes.

Key Energy Drivers

- Our ‘need’ for energy flows from ‘needs’ for services like nutrition or economic output and the materials, products, services and business models used to satisfy them
- Recent innovation dramatically increases options to satisfy ‘needs’ – **substitution** by radically different alternatives
- These involve *integrated* use of combinations of:
    - Innovative reframing of what our needs are (eg virtual solutions)
    - Diverse business models, markets and technology supply chains
    - More efficient energy and resource use
    - Smart management of demand
    - Storage of energy in many forms (heat, coolth, electricity, chemical, gravitational potential, movement)
    - Distributed and diversified energy production or conversion

The 'energy' service delivery system – many options of very different kinds now exist and compete in different markets.

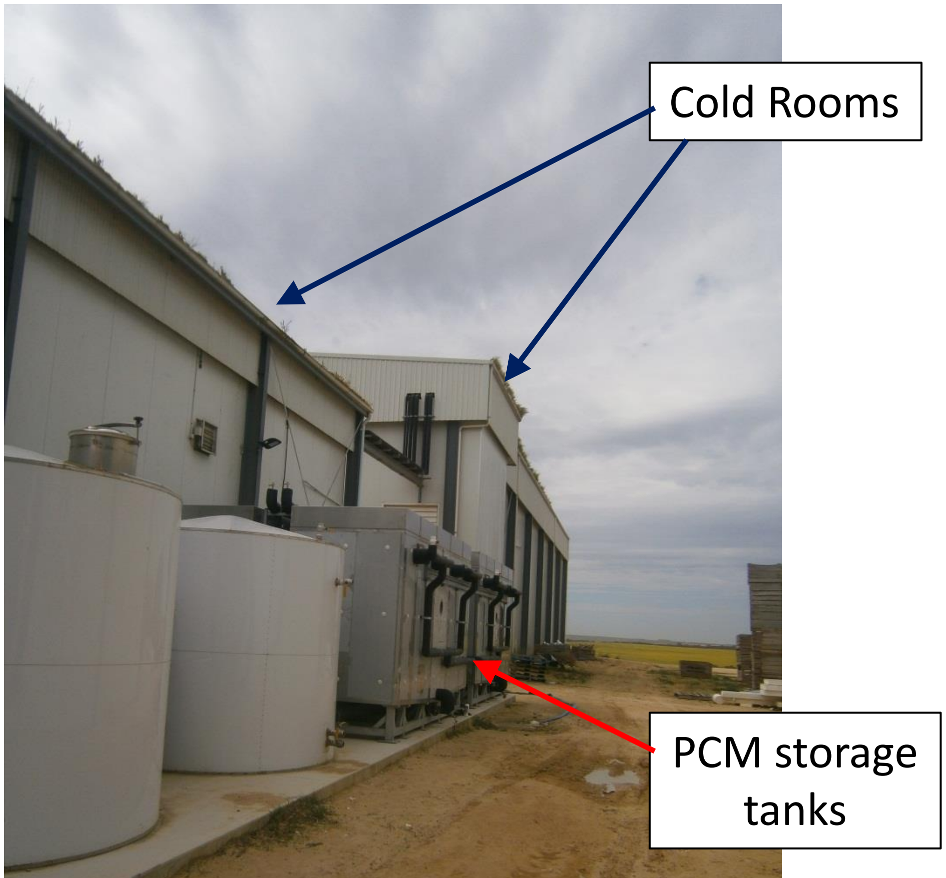


Diverse energy service solutions are emerging. Centralised systems still have a role, but distributed ones are gaining. Combinations of solutions often work best, and there will be ongoing transition

FACTOR	CENTRALISED	DISTRIBUTED
Economies of scale	Through larger size	Through mass production
Flexibility of roll-out	Limited	Large
Capital required, risk, subsidies	Large lumps, long-term, subsidies on-going	Small lumps, early cash flow, subsidies up-front
Innovation and 'learning from experience'	Slow	Fast, from diverse markets and technologies
Planning, construction timeframes	Long, limited flexibility	Short, responsive
Resource suitability	Fossil fuels, dams	Renewable energy, diverse water sources, end-use technologies
Resilience to failures, changing conditions	Limited	Diversity, modularity help
Environmental, social impacts	Local, regional, global	Local, linked to beneficiaries
Overall system efficiency	Significant losses in conversion, distribution	Variable – near point of use, so consumer pays

Example – Cold Storage:

University of South Australia / Glaciem demonstration project



- 120 kWe Refrigeration system
- 1.4 MWhrs e thermal storage (1% floor area)
- 200 kWp of solar PV planned
- 20% IRR for both storage and PV

Potential Integrated Energy Solution

On-site energy efficiency:

- Building: heat reflective paint, insulation, air locks
- High efficiency chillers, smart controls

On-site energy storage:

- Thermal ('coolth' using phase change materials - PCMs)
- Electricity

On-site energy production:

- Rooftop solar PV
- Use waste chiller heat to dehumidify, cool, heat (eg cleaning water)

Integrated energy management

- Optimise operating cost
- Optimise exports and imports of electricity
- Maybe go 'off-grid' or micro-grid?
- Maybe cooperate with other local generation, storage and energy users?

Aluminium smelting: strategies and research projects to cut energy use

- Big picture options to cut aluminium energy use per unit service:
  - ‘virtual’ solutions replace physical ones
  - Design of products for optimal material use
  - High strength alloys, 3-D printing use less material
  - Switch to other materials, eg carbon fibre
  - Use recycled aluminium

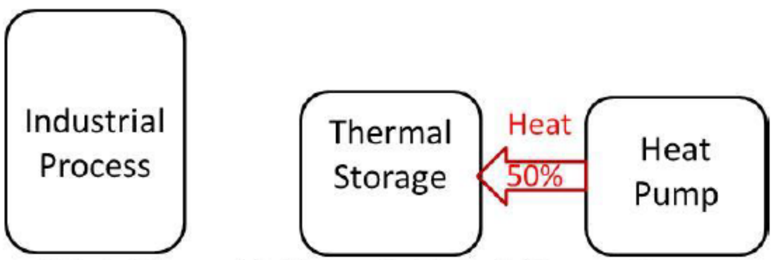
Aluminium smelting uses 3.3% of global electricity

- R&D, eg ARPA-E projects (US government R&D program)
  - **Alcoa:** heat exchanger (using molten glass or salt) built-into pot casing improves insulation, provides flexibility in electricity demand (using heat storage); improved electrodes – **50% saving target**
  - **Gas Technology Institute:** use reusable solvents (chemical dissolution) at near room temperature; could be located near bauxite mines – **44% cost reduction target**
  - **Infinium:** new electrochemical cell, much better insulated and high value by-product (pure oxygen); drop-in retrofit – **50% net saving target**
- Shift to renewable electricity

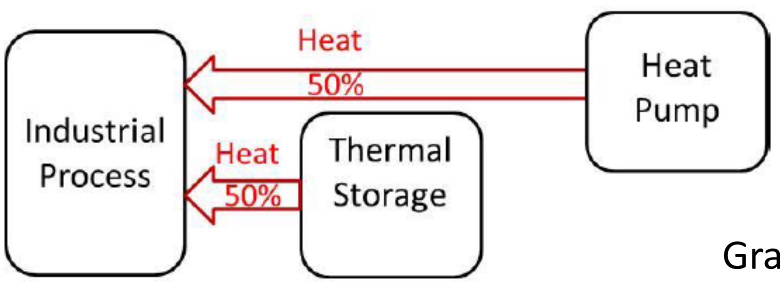
Industrial steam

- Avoid use of steam: centrifuge, microfiltration, depressurisation*
- Advanced high temperature heat pump (up to 165C)*
- Modular hot water or steam generator*
- Renewable heat sources
- Storage (heat or electricity)

* Can use renewable electricity



Nighttime (Off-peak time) Operation



Daytime (Peak time) Operation

Fig. 2.3.2 Overview of system (KOBELCO: SGH series)

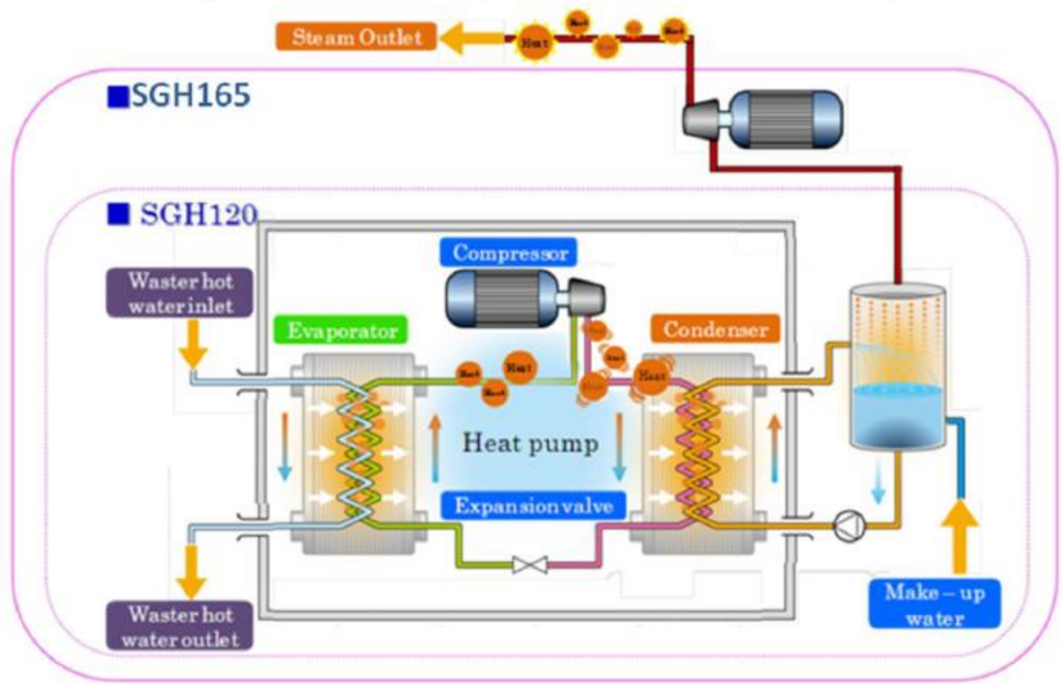
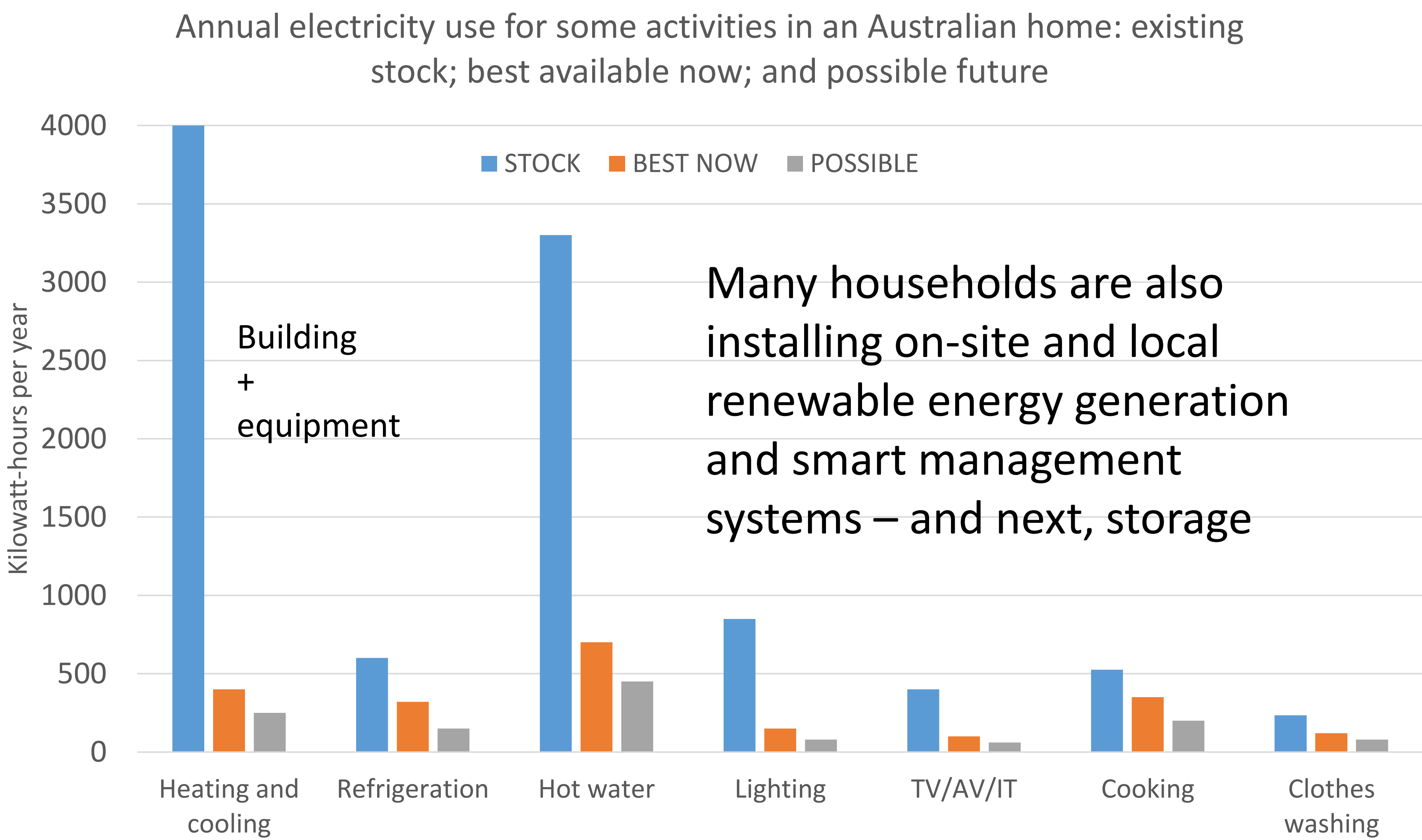


Fig. 2.3.1 System flow (KOBELCO: SGH series)

Graphics from IEA HPP Annex 35 Application of Industrial Heat Pumps, Task 3 (2013)

Residential: Technology transformation

(Based on Pears presentation to Sydney A2SE Workshop, April 2014)



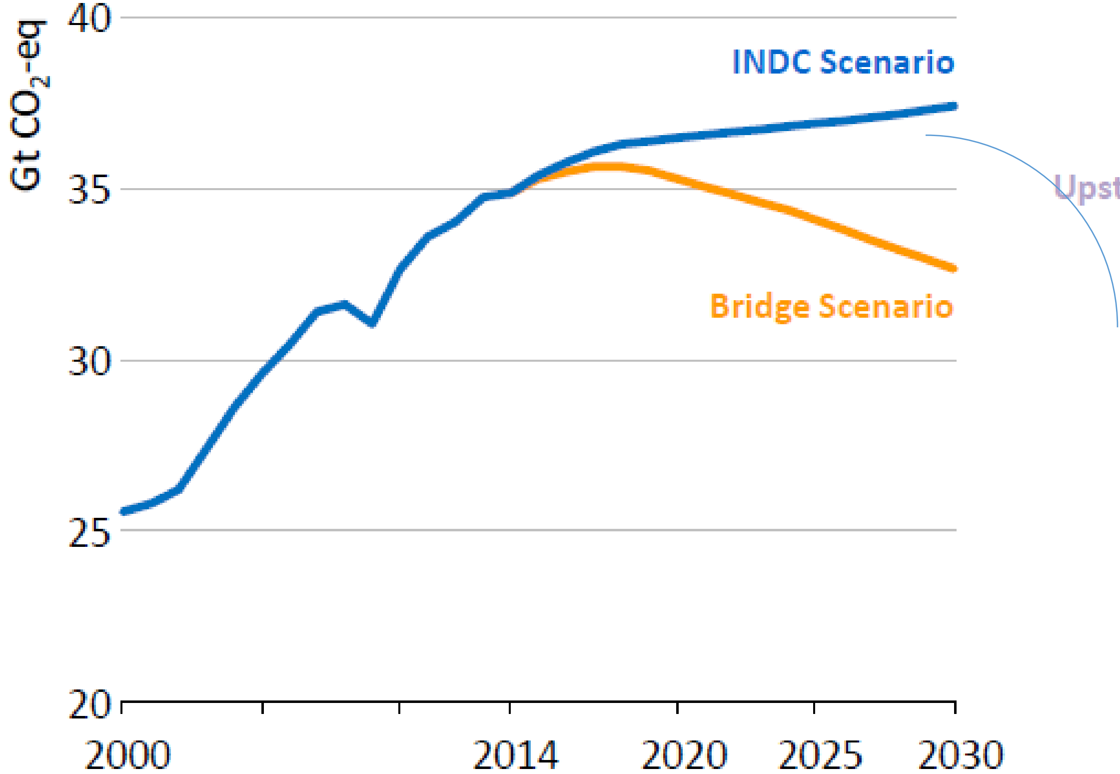
Energy policy tools

- Strategies and targets – visions
- Information, promotion, training
- Voluntary agreements, public reporting
- Regulation, standards
- Taxes and levies, pricing
- Incentives, subsidies and financial facilitation
- Market mechanisms
- Innovation, RD&D, commercialisation
- Government purchase and example
- Institutional frameworks and resourcing
- Managing access to markets and resources
- Management of perceived risks and opportunities
- **Other policies adapted to achieve energy goals too**

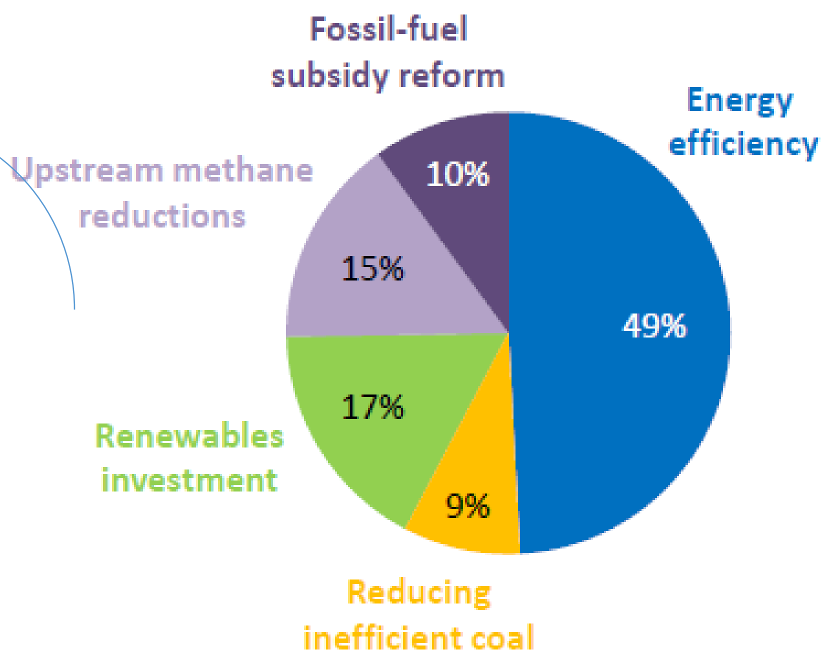
1. Peak in emissions:
IEA strategy to raise climate ambition

WEO Special Report on Energy & Climate Change

Global energy-related GHG emissions



Savings by measure, 2030



Five measures – shown in a "Bridge Scenario" – achieve a peak in emissions around 2020, using only proven technologies & without harming economic growth

From IEA *Energy and Climate Change* presentation, London June 15 2015

Many energy efficiency measures have negative cost

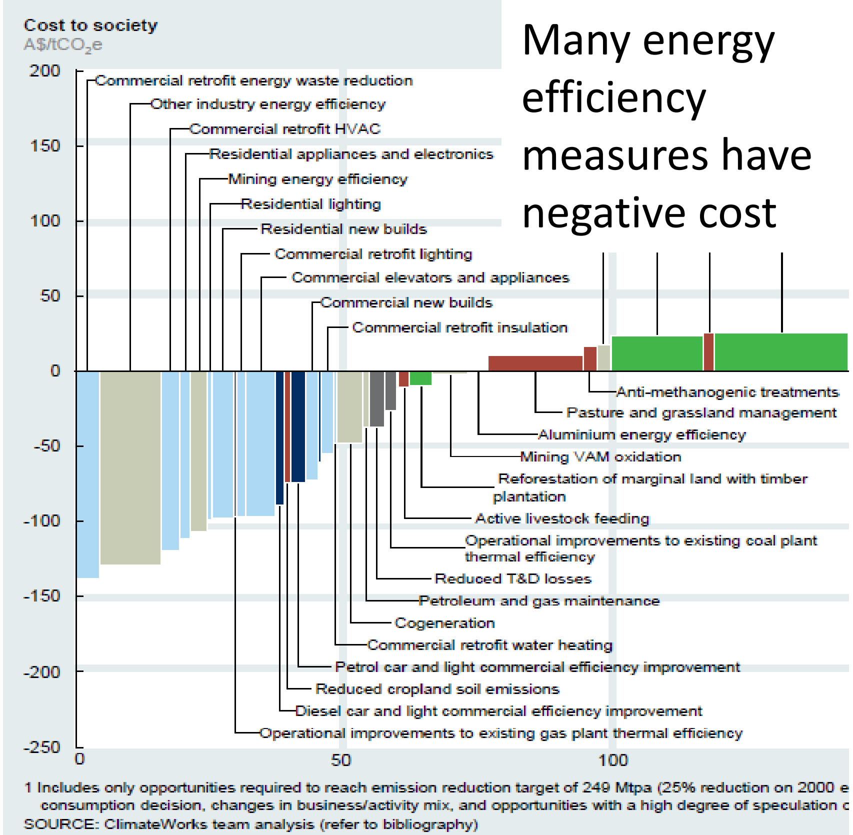
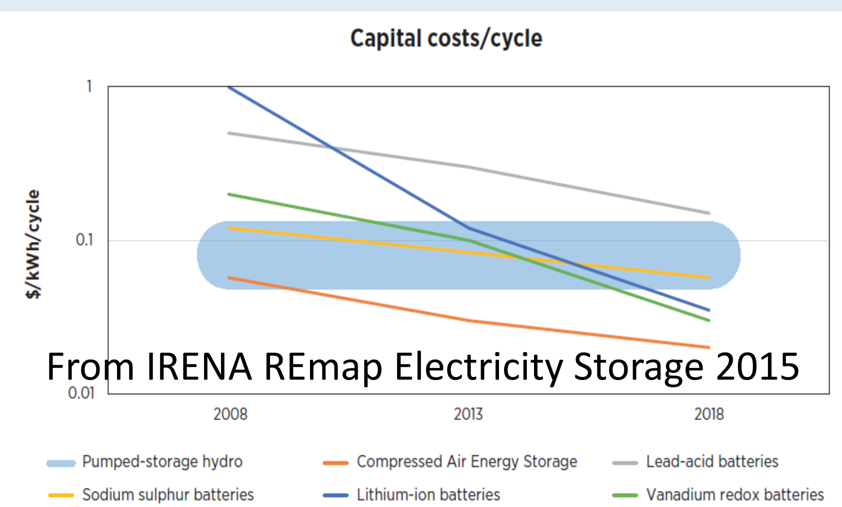


Figure 2: Cost assessments for electricity storage systems



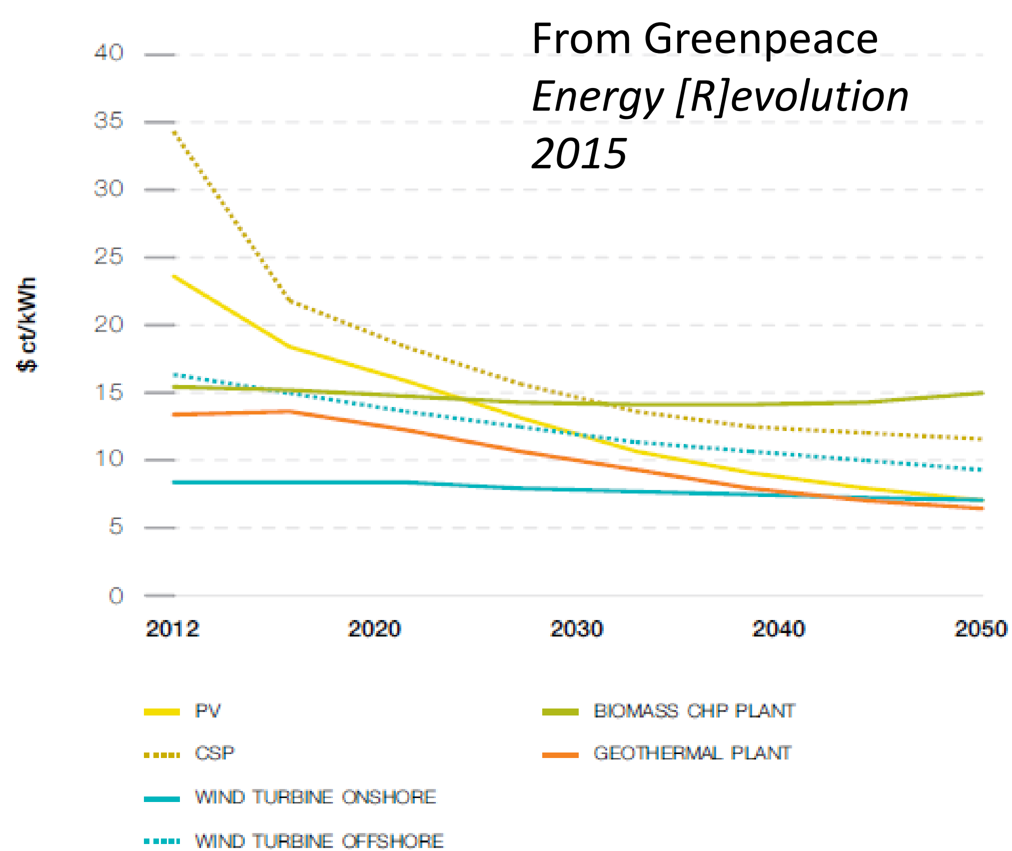
Source: The Brattle Group, 2014; Walawalkar, 2014.

Indicative technology cost trends:

NOTE: projected costs are very uncertain, but key trends are declining costs and more rapid roll-out than expected: typically 20% reduction for each cumulative doubling of production

FIGURE 5.2 | **EXPECTED DEVELOPMENT OF ELECTRICITY GENERATION COSTS FROM RENEWABLE POWER GENERATION IN THE ENERGY [R]EVOLUTION SCENARIOS**

DEPENDING ON THE ASSUMED DEVELOPMENT OF FULL LOAD HOURS PER YEAR, EXAMPLE FOR OECD EUROPE



Evaluation of Costs and Benefits

- Sophisticated evaluation of cost-effectiveness must consider many factors:
  - Local circumstances
  - What price does it compete with: wholesale, retail energy price? And what will those prices be?
  - For efficiency measures, what total service cost does it compete with?
  - What non-energy market(s) does it compete in?
  - What other costs does it avoid: avoided infrastructure costs; distribution/delivery costs and losses; peak loads
  - What other benefits: avoided blackouts; improved productivity, health, product quality etc (see IEA *Multiple Benefits of EE* report); benefits for rural and other disadvantaged groups
  - Impacts on total level of energy subsidies, energy security, social systems
  - Impact of likely future levels of carbon prices or equivalent policies on cost relative to competitors

Where to Now for APEC?

- No-one knows which options will be winners, so we need:
  - Flexible strategies, quality information and detailed monitoring of change
  - To encourage innovation, trials, knowledge sharing, creative finance models
  - To support emerging options to compete with powerful incumbent businesses
  - To manage disruption, inefficiencies and mistakes
- Different solutions will be best in different circumstances, depending on service requirements, available options and local cultures and policies
- There will be winners and (often powerful and noisy) losers
- Climate response and adaptation will be overarching drivers

APEC Actions?

- Encourage APEC members to develop and implement energy strategies that:
  - Are consistent with decarbonisation by 2050 or earlier
  - Are flexible and adaptable to unexpected changes, innovation
  - Factor into energy option evaluation factors such as reframing of ‘energy needs’, economies of scale, learning by doing, ‘multiple benefits’, innovation in and from other sectors, etc
  - Incorporate clean energy elements into policies across the economy and society (eg housing, social welfare, taxation)
- Work with member countries, IEA etc to:
  - Track and share actual costs, benefits, experience and progress of emerging technologies and underlying policies and measures
  - Develop, trial and implement planning methodologies, institutional arrangements and funding systems (eg through ABAC) that support integrated energy solutions
- Ensure emerging technologies are not blocked by institutional inertia or incumbent power

The international energy scene will change

Will new ‘energy giants’ emerge, eg countries leading in smart, efficient energy solutions; with major renewable energy resources such as solar, geothermal resources using advanced drilling techniques from the oil industry?

Source: http://pubs.usgs.gov/gip/dynamic/fire.html