An A2SE Industry collaboration with research partners:

Engines of Reform – Innovations to Triple Energy Productivity by 2030 To Stay <1.5-2 Degrees

Australian National University, Feb 24 2016 Presentation by Dr Michael Smith (ANU)

A project of the Australian Alliance to Save Energy

2xEP and the National Energy Productivity Plan

Introduction

2xEP Program Governance

Brief: Energy Productivity in Australia

Foundations Paper

Foundations Summary

2xEP
Doubling Australia's Energy Productivity

Agriculture

Built Environment

Mining facturing

Mining

Transport - Freight

Transport - Passenger

http://www.2xep.org.au/

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Engines of Reform – What's Next

- 1. A new productivity & innovation reform agenda
- 2. Quantifying how innovations in energy productivity unlock labour, capital productivity gains by sector.
- 3. Innovation/Tech – Mapping + Better Knowledge Sharing of new EP innovations available internationally and locally
- 4. Review of EP potential through transforming production-consumption systems (supply chain industrial ecology)
- 5. What is Technically Possible? Is Tripling EP by 2030 Possible & Needed to Stay Under 1.5/2 Degrees?
- 6. Post Paris COP – Energy efficiency is critical to achieving 1.5 degree target – ie Importance of energy efficiency targets.

2xEP Doubling Australia's Energy Productivity

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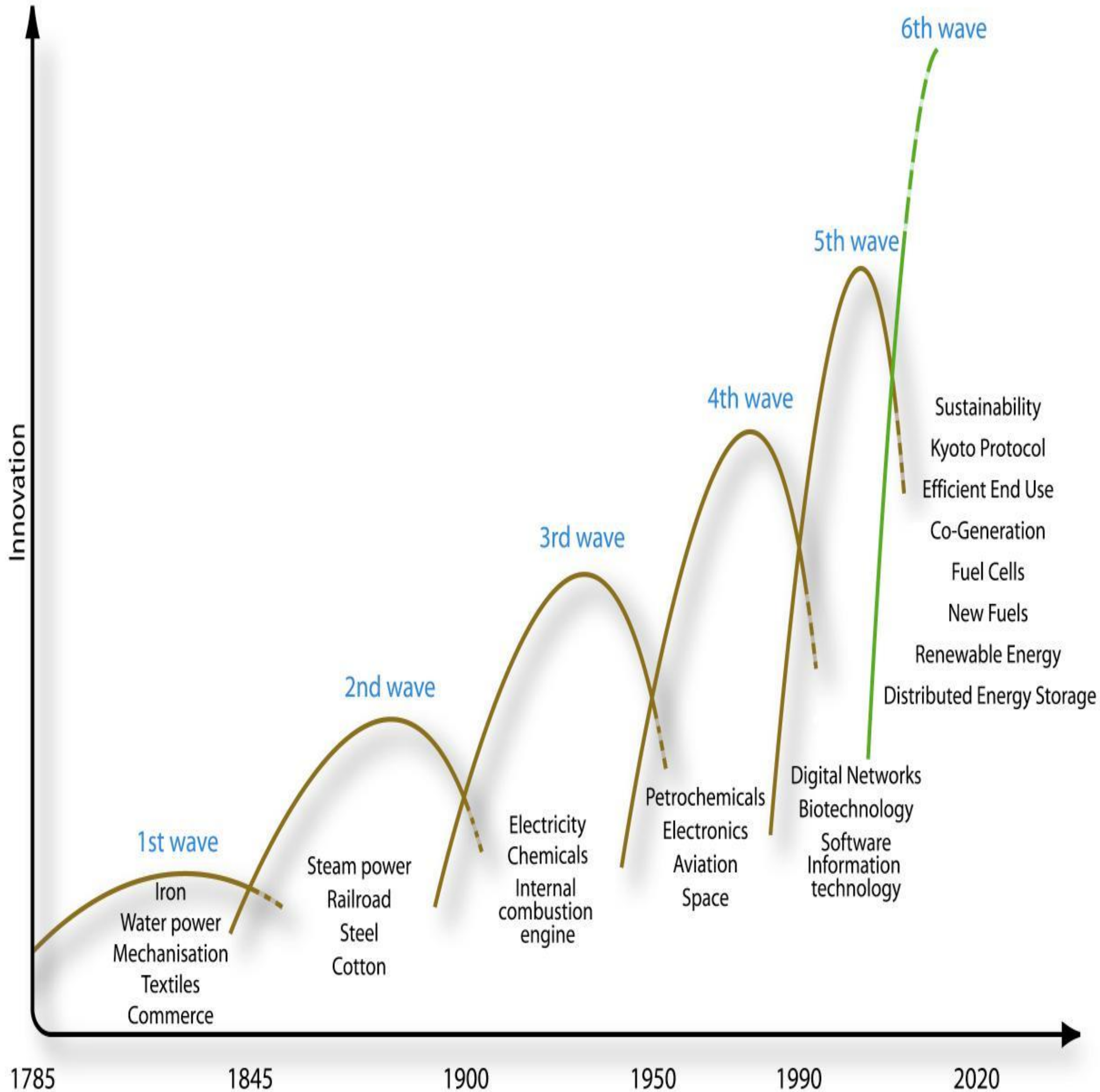

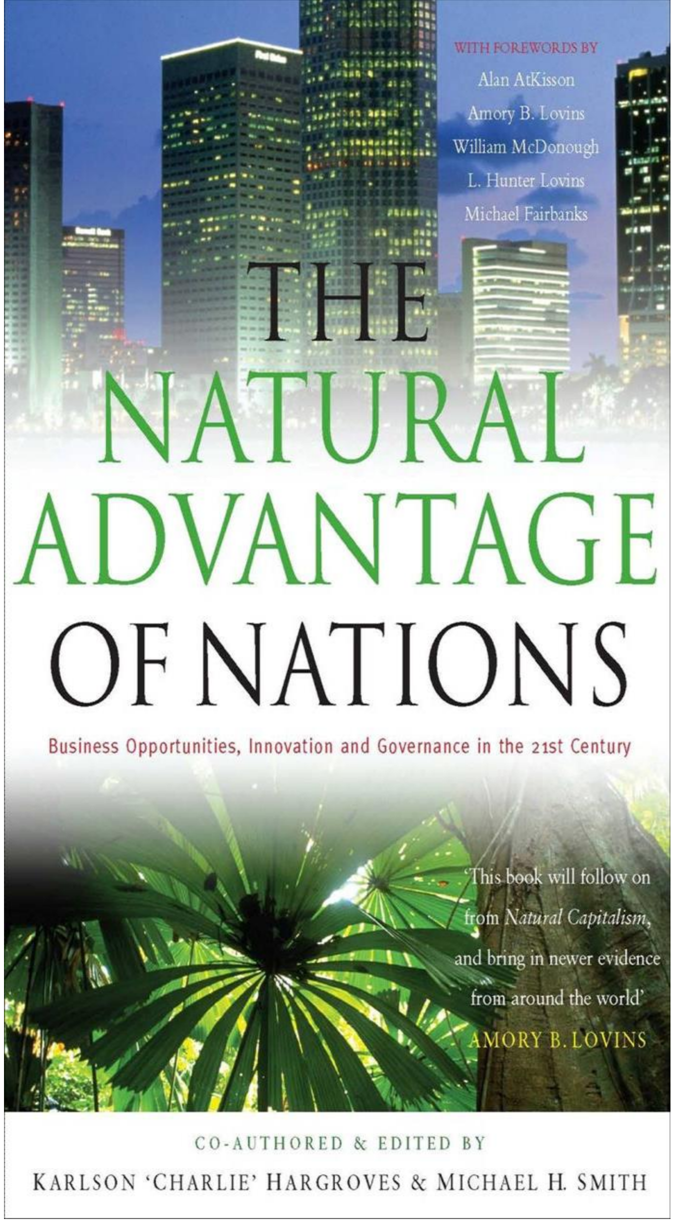

- *How government can build partnerships with the private sector and civil society to work together t… lead a new wave of innovation to achieve low carbo… efficient sustainable citi…*

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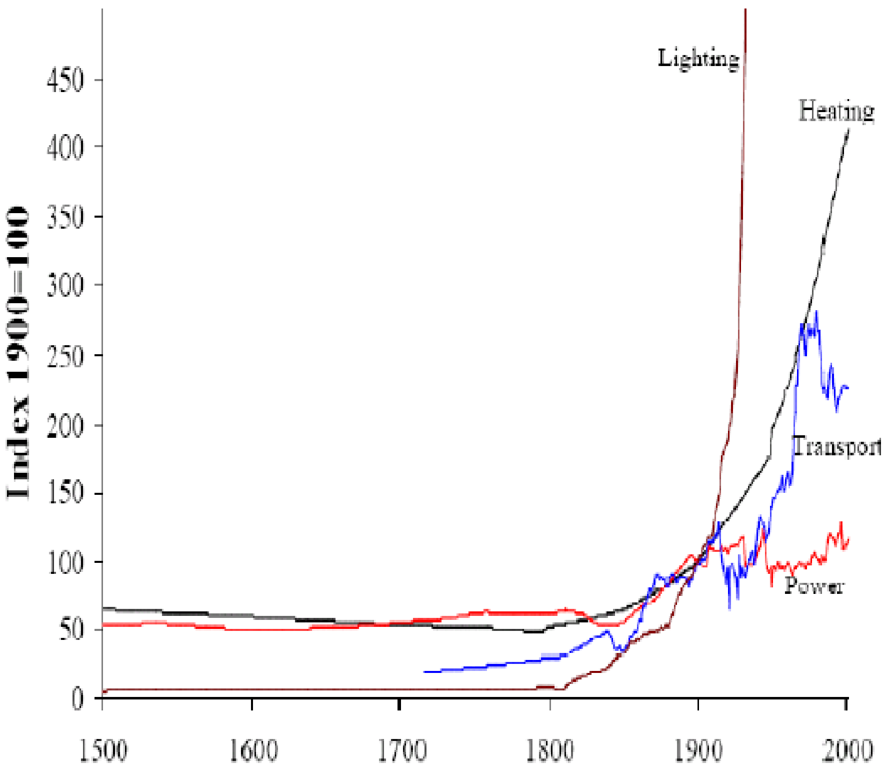
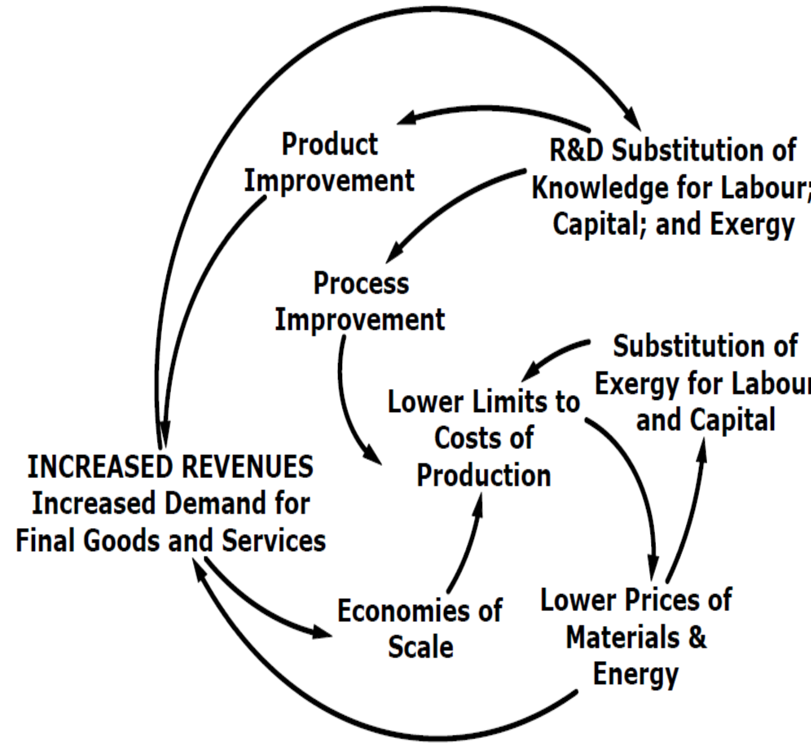
http://www.naturaledgeproject.net/NAON_ch17.aspx#one

First Industrial Revolution – 10+ X Increase in EP

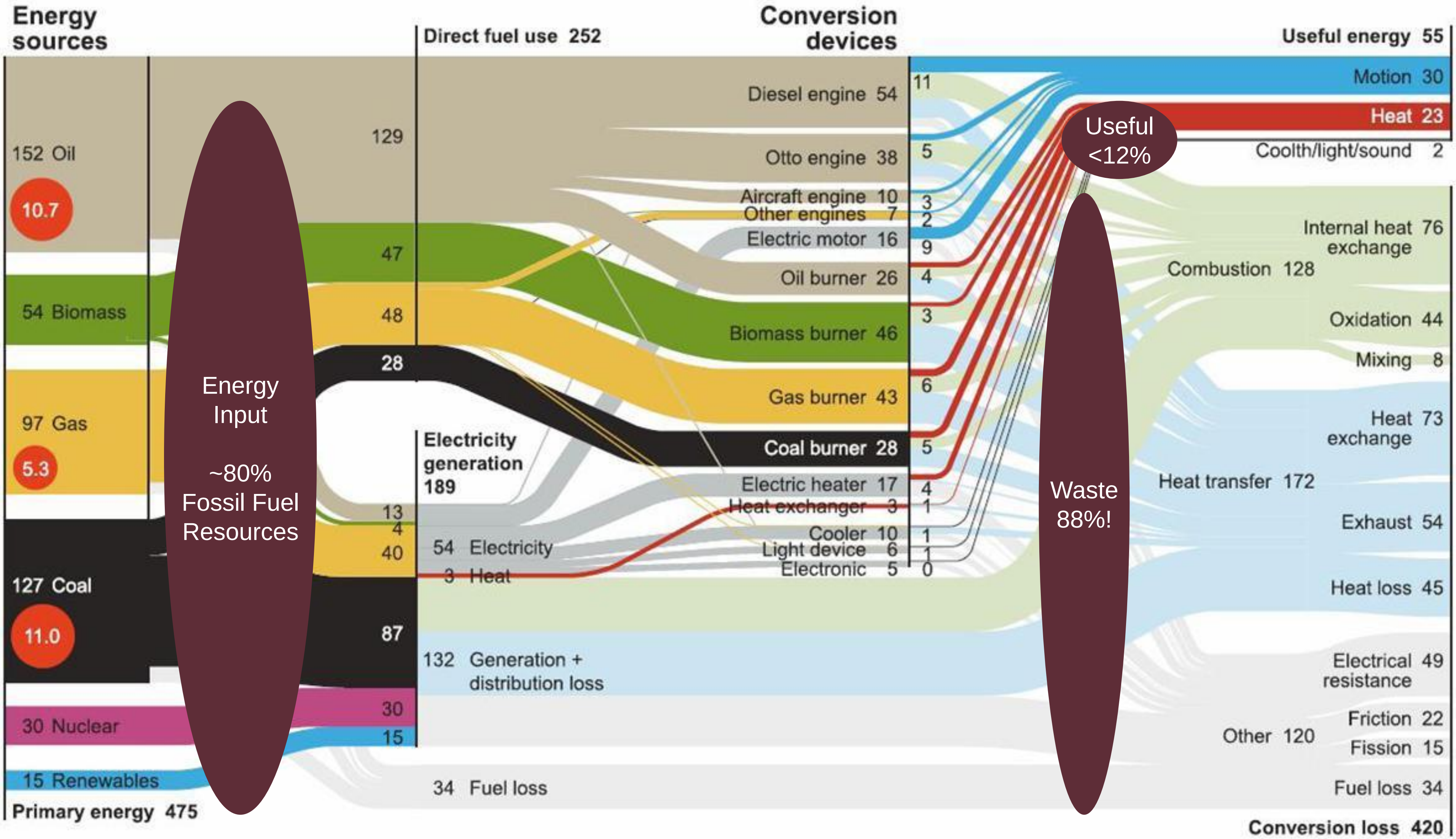


Efficiency of energy technologies, 1500-2000 (Source: Fouquet (2008), Heat, Power and Light, E. Elgar Publishing, UK)



Virtuous cycle driving and underpinning economic growth. (Ayres et al, 2006) cited in Smith (2014,2015)

1. Large scope for EP: **88% waste!**



Global energy demand in 2005, total = 475 EJ

Global carbon emissions in 2005, total = 27 Gt CO_2

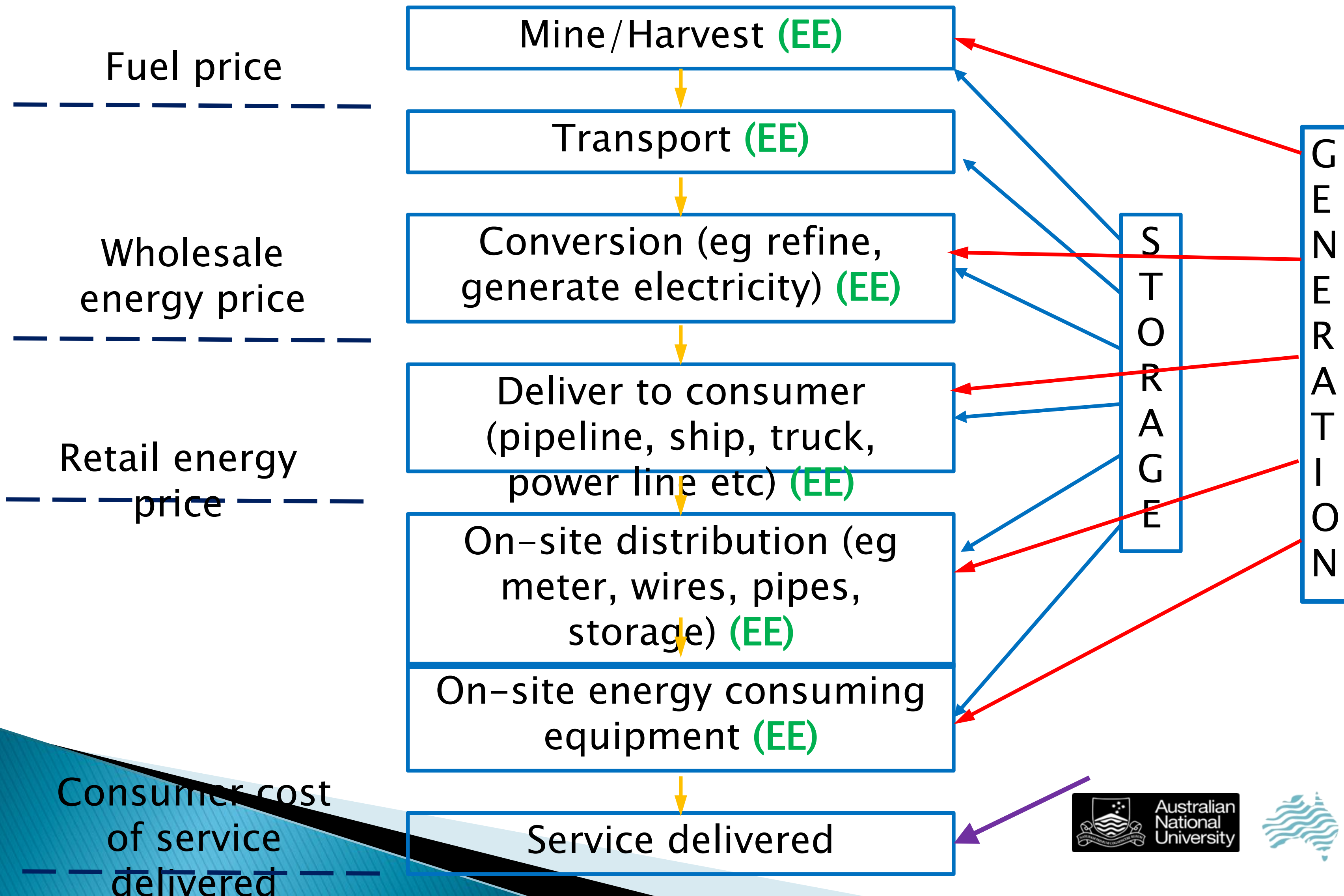
Submitted to *Energy*

UNIVERSITY OF CAMBRIDGE

2xEP Doubling Australia's Energy Productivity

The 'energy' service delivery system – innovations occurring in demand, supply and storage.

2xEP
Doubling Australia's Energy Productivity



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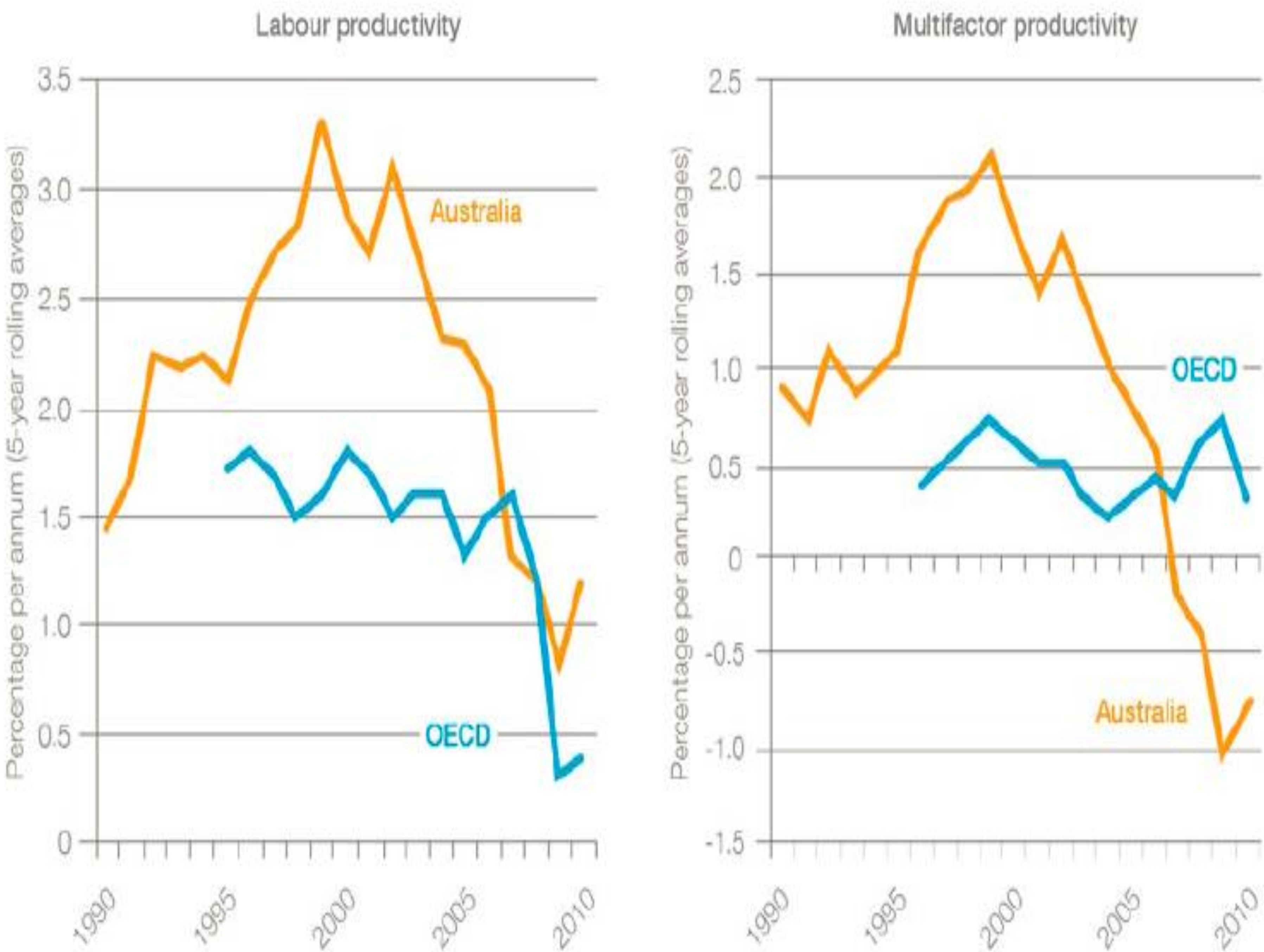
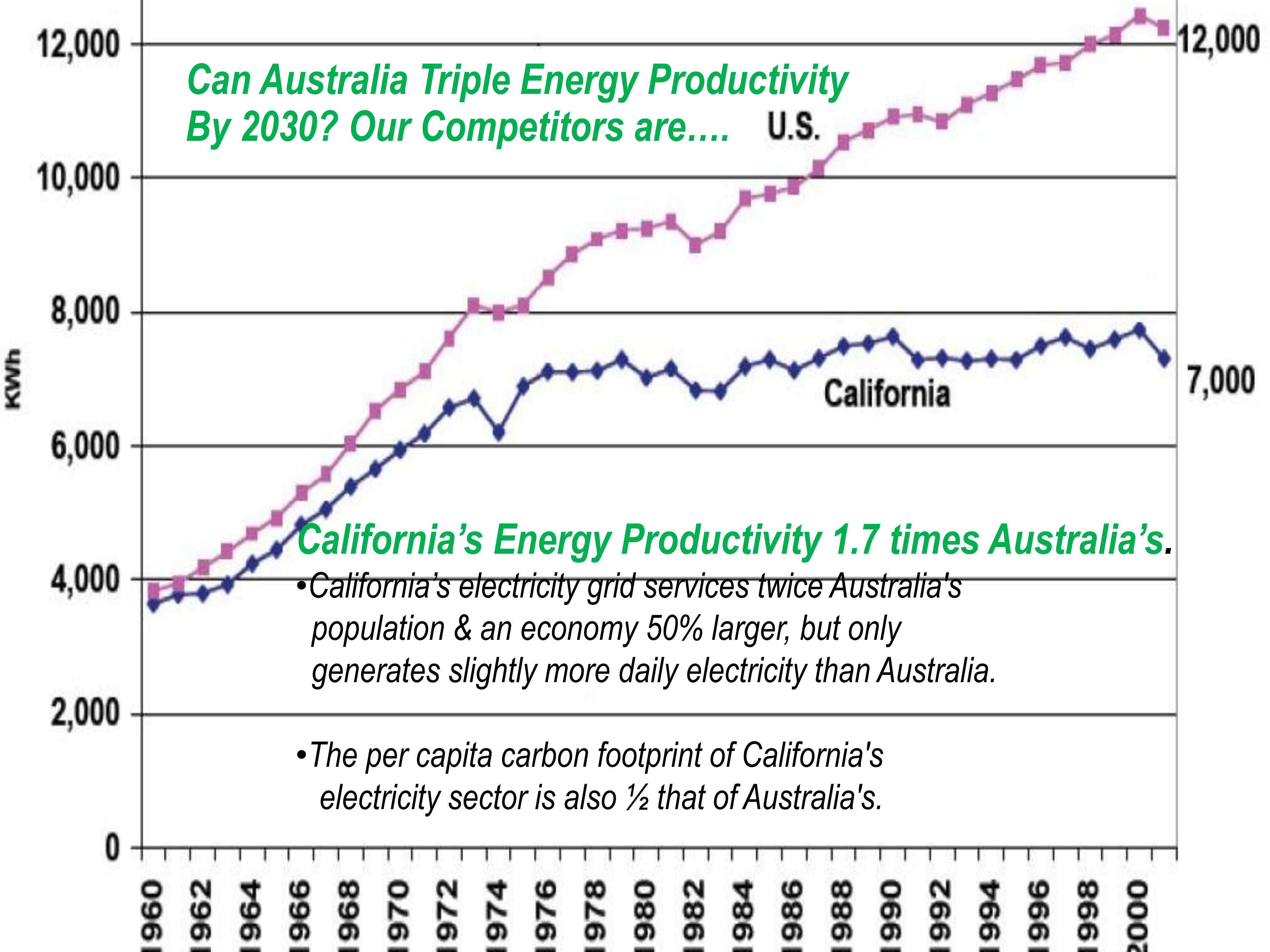

Labour productivity
Multifactor productivity
Percentage per annum (5-year rolling averages)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
Australia
OECD
1990
1995
2000
2005
2010

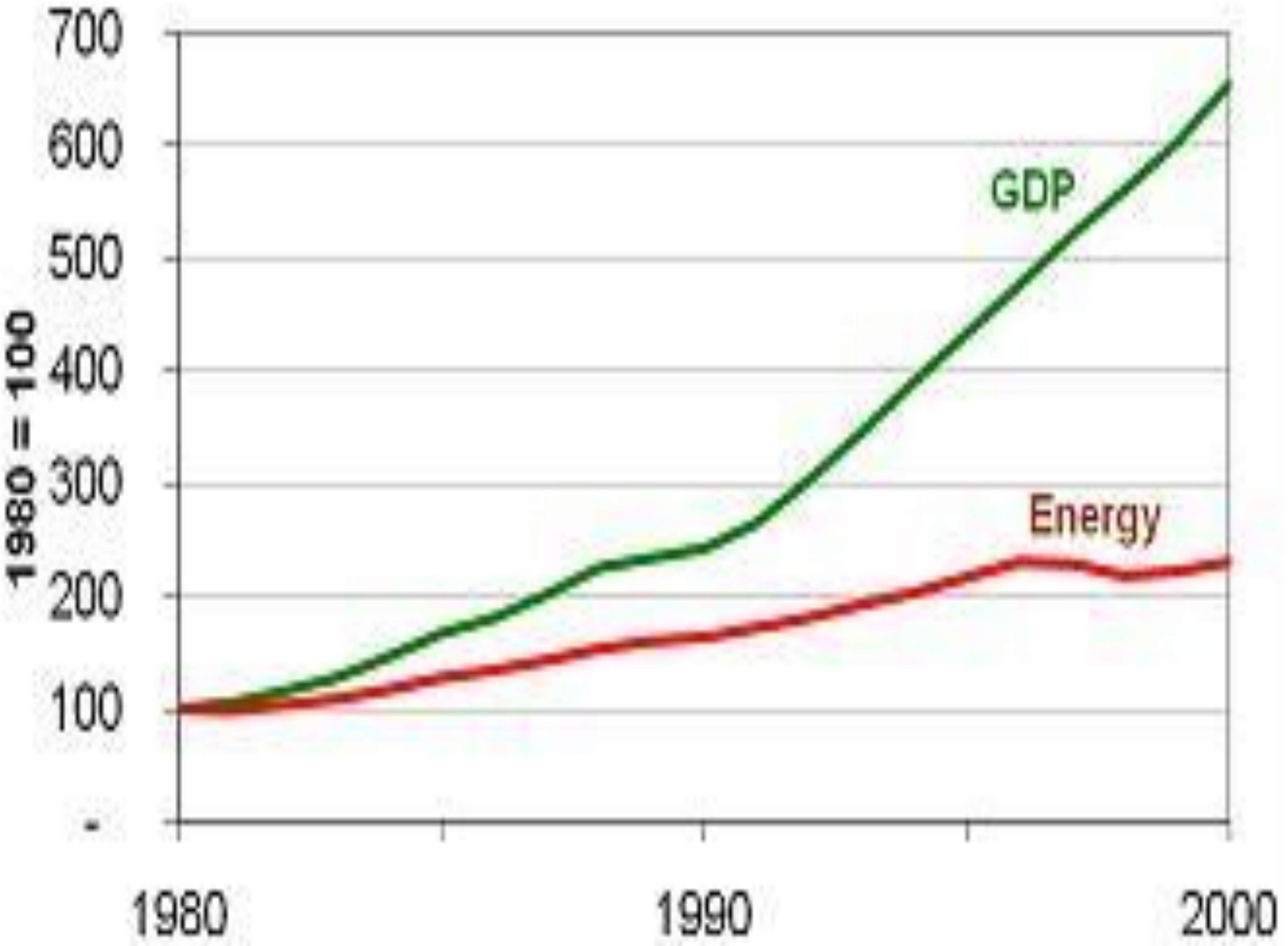
Can Australia Triple Energy Productivity By 2030? Our Competitors are….

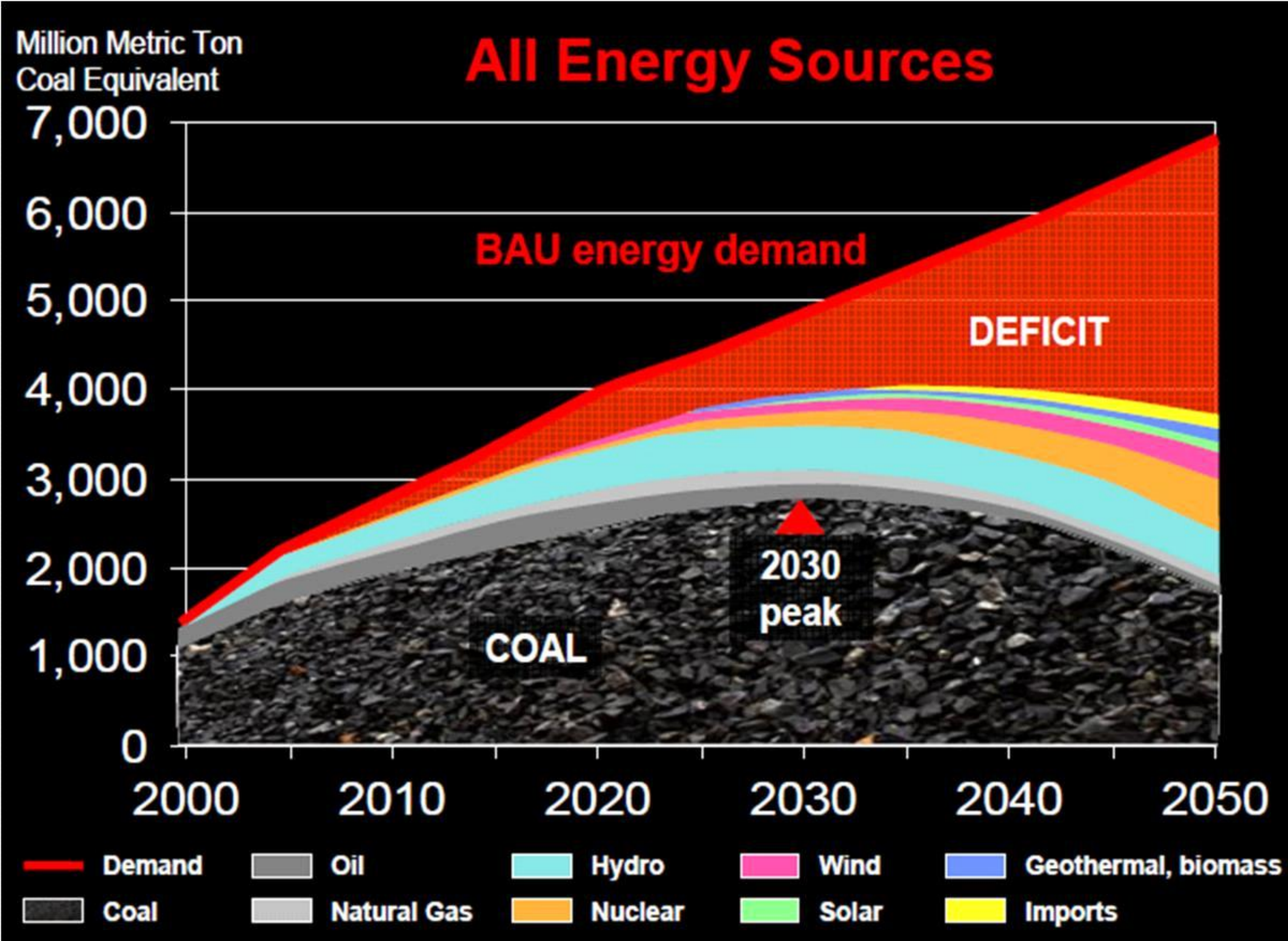


California's Energy Productivity 1.7 times Australia's.

- *California's electricity grid services twice Australia's population & an economy 50% larger, but only generates slightly more daily electricity than Australia.*

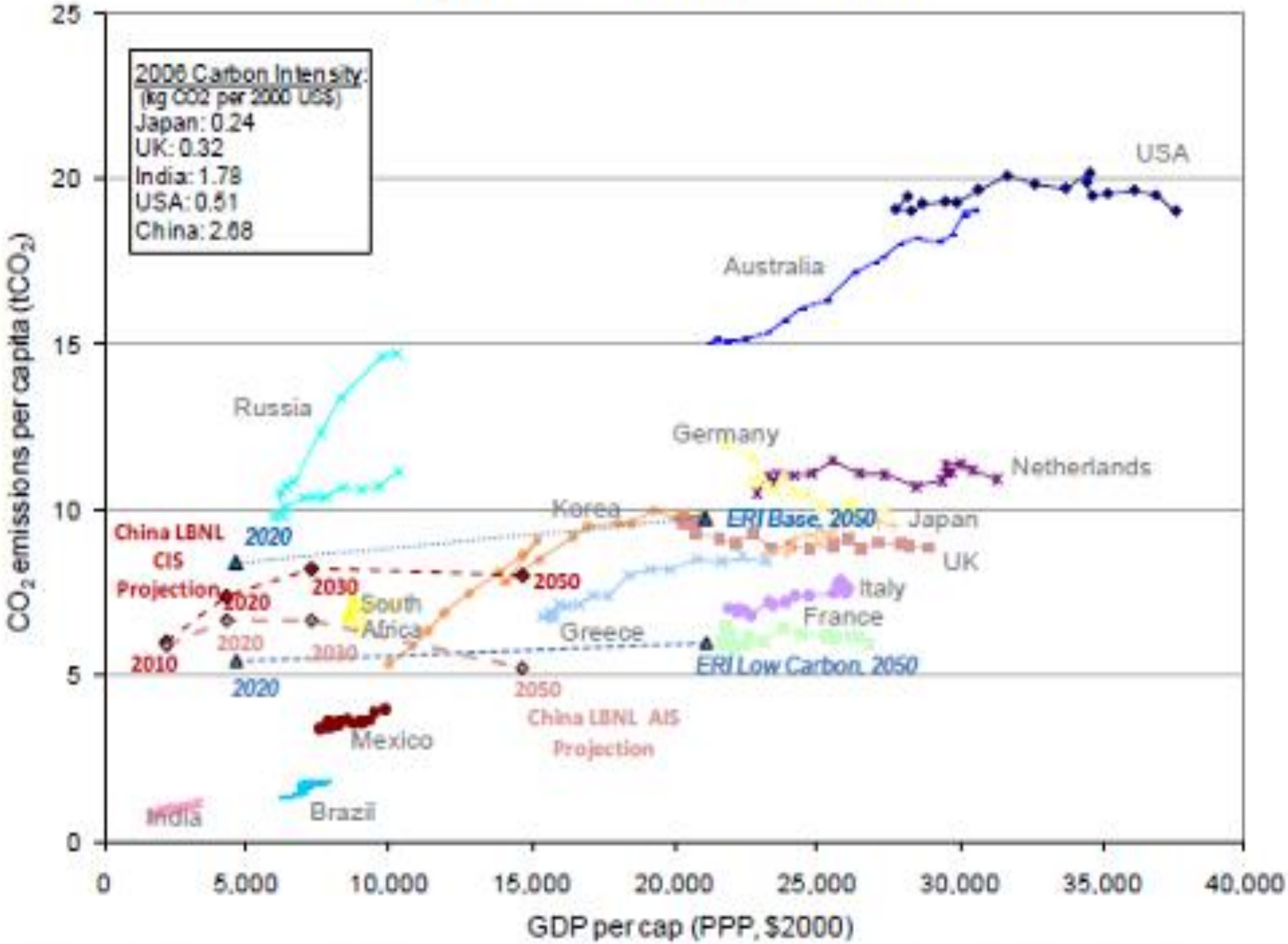
- *The per capita carbon footprint of California's electricity sector is also ½ that of Australia's.*

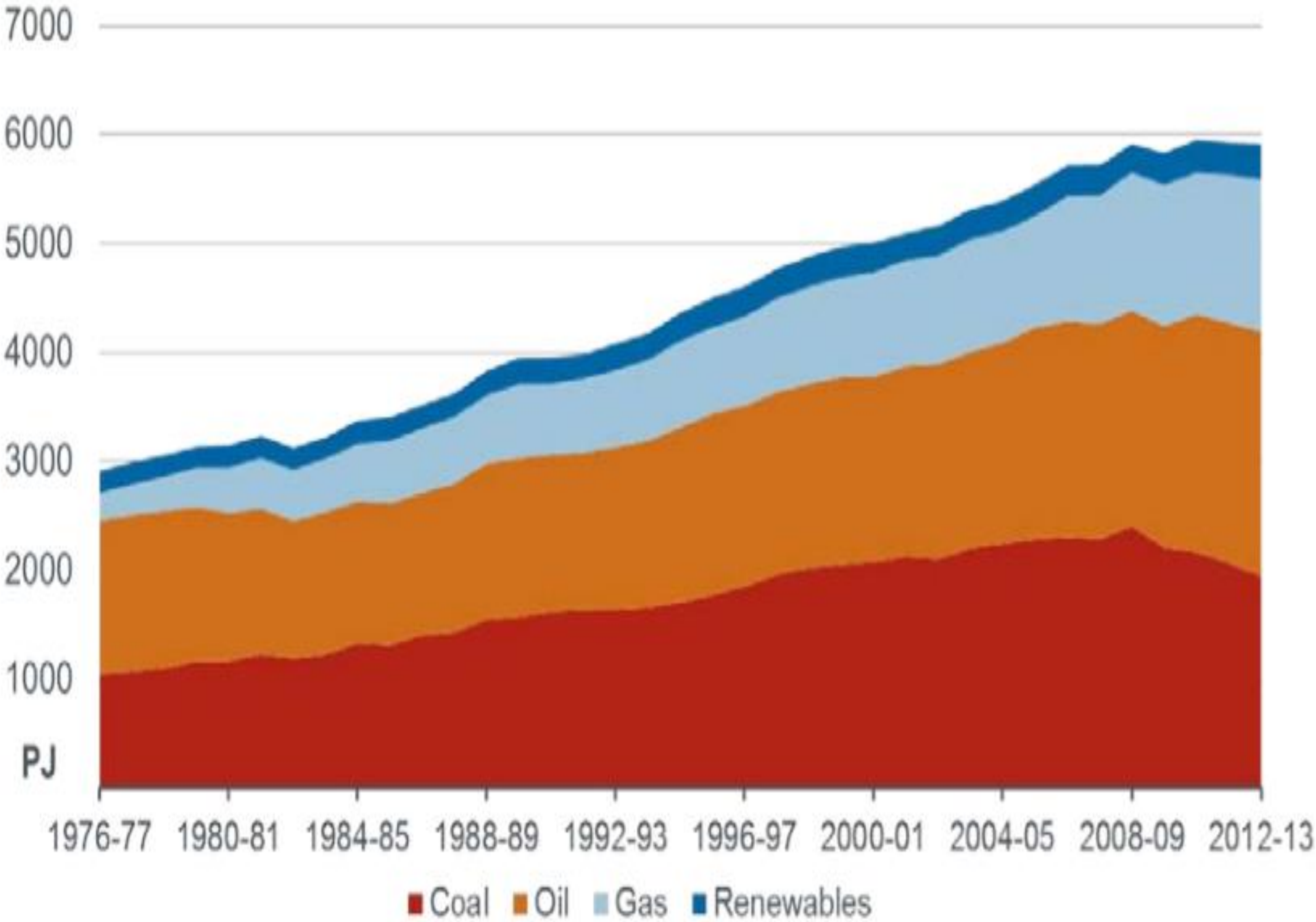

700
600
500
400
300
200
100
1980 = 100
GDP
Energy
1980
1990
2000



Million Metric Ton
Coal Equivalent
All Energy Sources
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
BAU energy demand
DEFICIT
2030
peak
COAL
2000
2010
2020
2030
2040
2050
Demand
Oil
Hydro
Wind
Geothermal, biomass
Coal
Natural Gas
Nuclear
Solar
Imports

CO_2 Emissions of Selected Countries





Source: BREE 2014a, Table C.

Years	USA GDP (US$ Billions)	Chinese GDP (US$ Billions)	Japanese GDP (US$ Billions)	German GDP (US$ Billions)	Australia GDP (US$ Billions)
1970	1075.9	89.6	209.1	215	41 (18, 1960)
1980	2862.5	302.9	1087	946.7	140
1990	5979.6	396.6	3103.7	1764.9	407
2000	10284.8	1208.9	4731.2	1950	669
2010	14964.4	6005.4	5498.7	3417.1	1,141 billion
2015	17348.1	10430.6	4602.4	3868.3	1554.68 billion (1700-1800 by 2020)

1.A New Productivity Agenda – A New Wave of Innovation

Did you know that Doubling Energy & Resource Productivity by 2030 = > $25 Trillion Increase to GDP by 2030 above BAU?

- **Energy efficiency could cumulatively add ~US$18 Trillion to GDP by 2035 above BAU &** cut energy supply capital investment requirements & fuel costs by US$7 Trillion each + congestion +air-pollution. (IEA World Energy Outlook+ 6 other studies)

- **Water productivity measures, that also save energy and cut emissions, to add $2-4 Trillion cumulatively to GDP Growth by 2030**: Reducing urban water leakage globally could add US$165 Billion to GDP per annum by 2030 whilst water efficiency globally adds ~ US$120 Billion per annum to global GDP by 2030. (New Climate Economy, 2014 + McKinsey + other studies)

- **Circular Economy – Improving Resource Productivity in ways that improve energy efficiency and cut emissions** – to add $5-7 Trillion cumulatively to GDP Growth by 2030.

- **Doubling Rate of Renewable Energy Investment to Double Renewable Energy Capacity by 2030** - $1.2 Trillion per annum by 2030 (IRENA, 2016)

- Smith, M (2015) Doubling Energy and Resource Productivity by 2030 @ http://www.2xep.org.au/doubling-energy-and-resource-productivity-by-2030.html

- *2. Energy Productivity investments also enhance traditional measures of productivity in a myriad of ways. For instance,*

2xEP
Doubling Australia's Energy Productivity

- **Labour Productivity (LP)** – Newer, more energy and resource efficient equipment often provides labour productivity co-benefits. Also energy efficient "green buildings", which have better quality lighting, air and reduced indoor air pollution increases LP. Improving energy productivity can also lead to jobs growth and greater labour participation which also boost LP.

- **Capital Productivity (CP)** – Investment in energy productivity can improve capital productivity by providing a quicker return on investment (through the operational energy cost savings), improving capital asset values and thus the contribution of capital assets to the value of the business.

- **Multi-Factor Productivity (MFP)** – Improving energy productivity directly correlates closely with improving MFP.

- Smith, M (2015) Doubling Energy and Resource Productivity by 2030 @ http://www.2xep.org.au/doubling-energy-and-resource-productivity-by-2030.html

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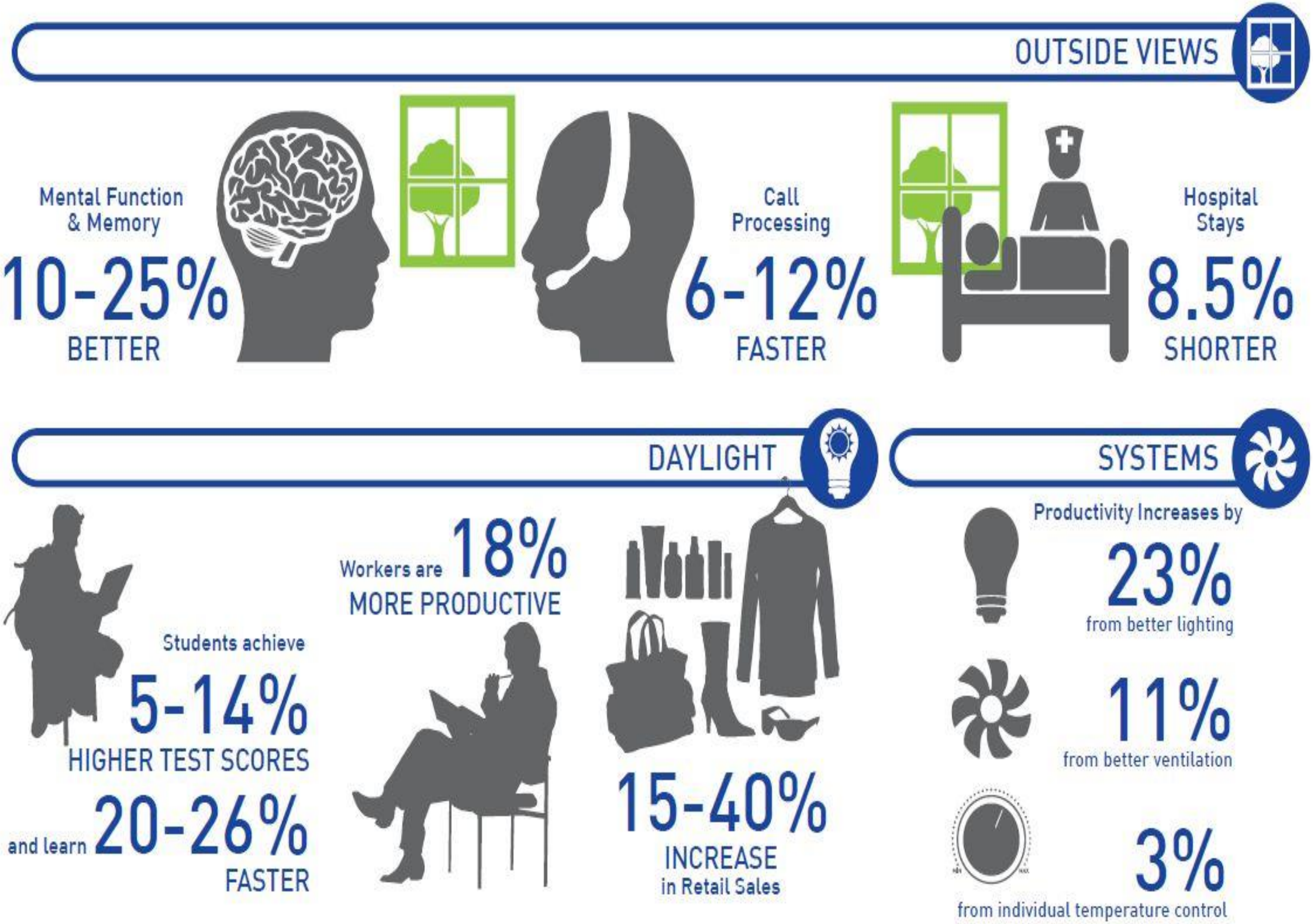
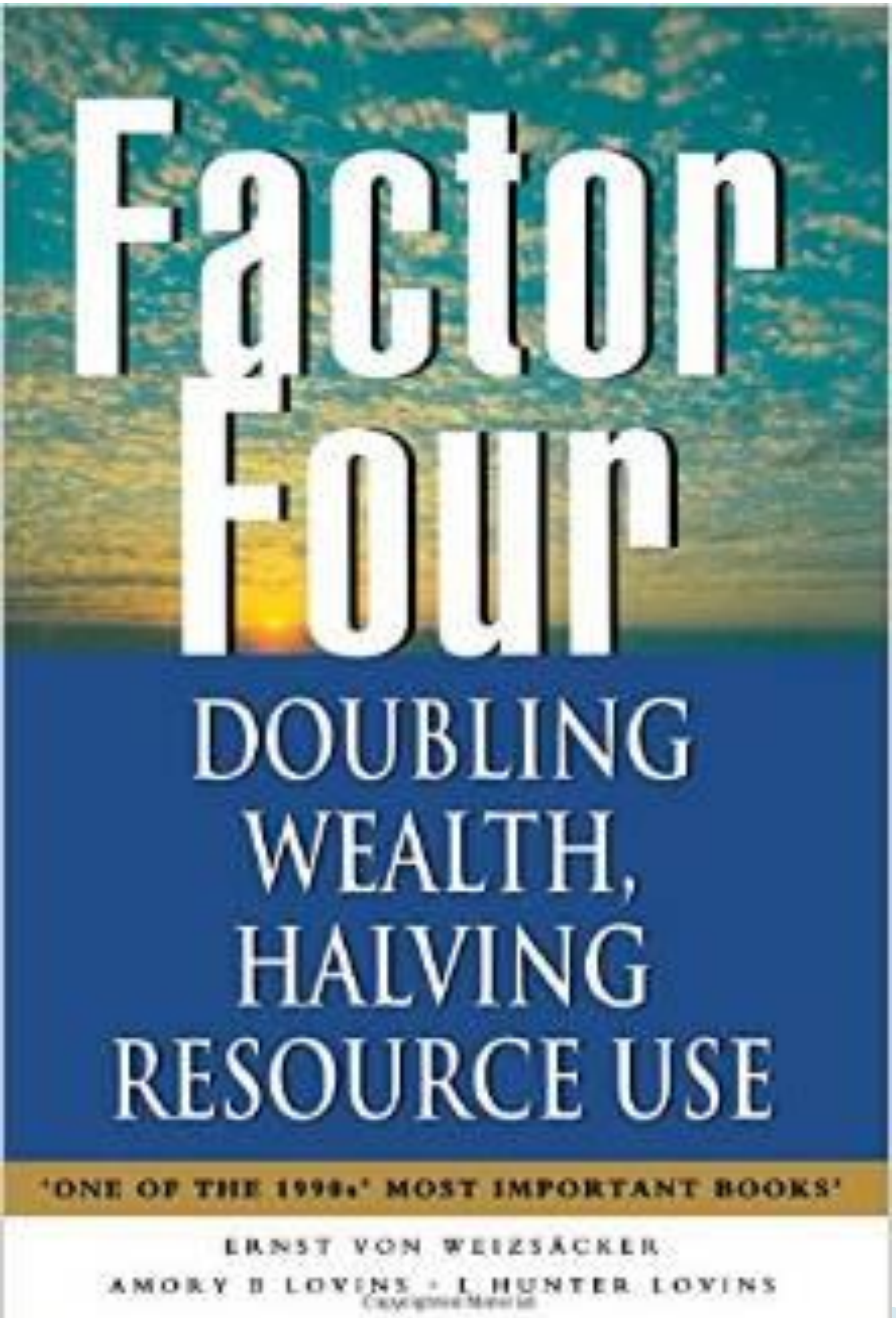

OUTSIDE VIEWS
Mental Function & Memory
10-25%
BETTER
Call Processing
6-12%
FASTER
Hospital Stays
8.5%
SHORTER
DAYLIGHT
Students achieve
5-14%
HIGHER TEST SCORES
and learn 20-26%
FASTER
Workers are 18%
MORE PRODUCTIVE
15-40%
INCREASE
in Retail Sales
SYSTEMS
Productivity Increases by
23%
from better lighting
11%
from better ventilation
3%
from individual temperature control

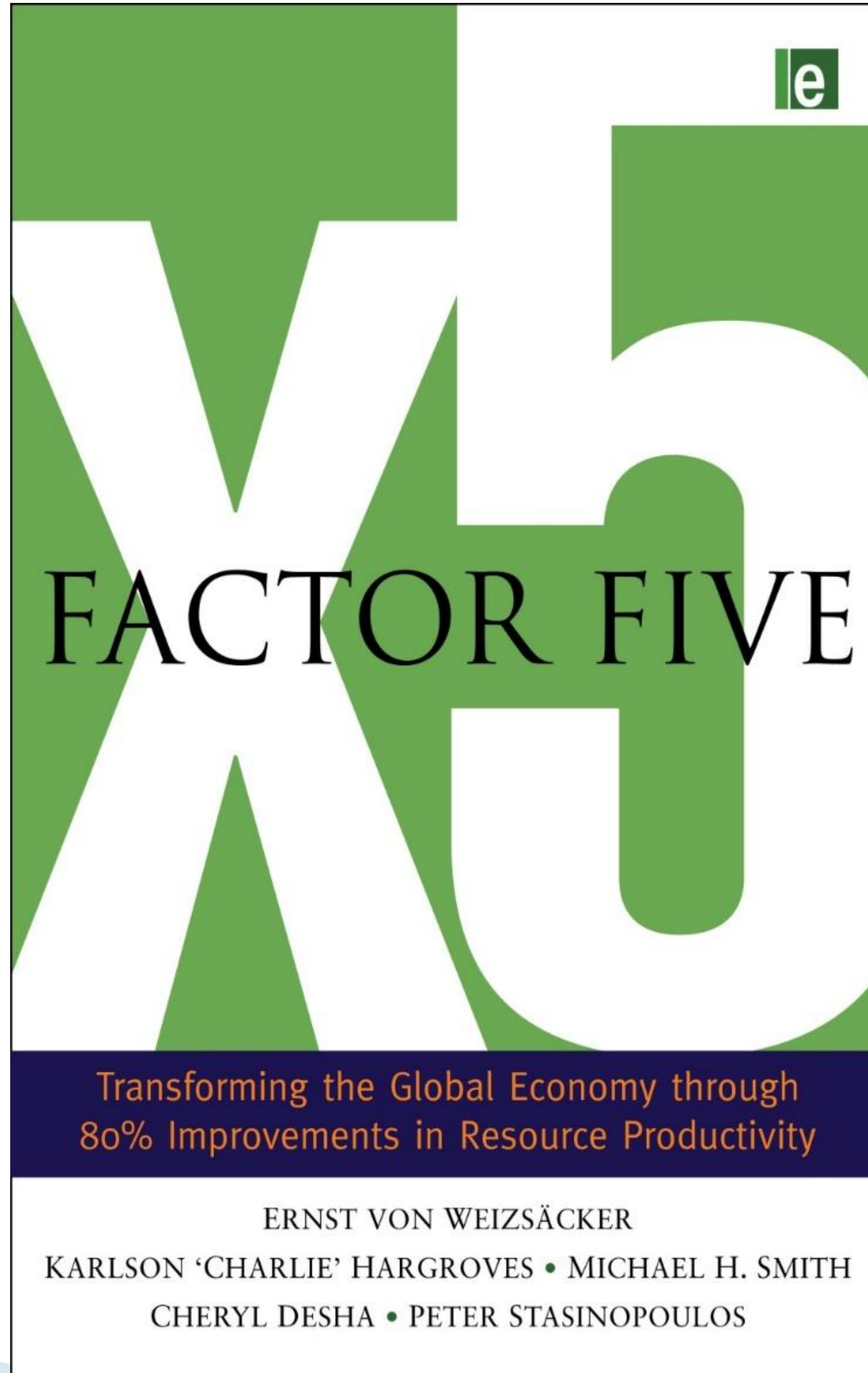
Productivity Co-benefits of Energy Efficiency/Energy Productivity.

Production Efficiency to Improve Labour Productivity	**Working Environment Improvements to Improve Labour productivity**	**Other Productivity Benefits**
Increased product output/yields	Reduced heat stress	A more innovative workplace
Faster rates of production / product output	Reduced need for personal protective gear	Improved energy/water efficiency of products to build market share
Improved equipment performance	Improved lighting	Delaying or reducing capital expenditures
Shorter process cycle times	Reduced noise levels	Improved public image
Improved product quality/purity	Improved temperature control	Decreased liability and insurance
Reduced Inputs and Waste Costs	**Reduced Emissions and Related Costs**	**Improved Rates of Operation**
Use of waste fuels, heat, gas	Reduced dust emissions	Reduced need for engineering controls
Reduced product waste	Reduced CO, CO2, NOx, Sox emissions	Lowered cooling requirements
Reduced water use	Reduced Maintenance Costs	Increased facility reliability
Materials Reduction	Equipment upgrades reduce maintenance	Reductions in labour requirements

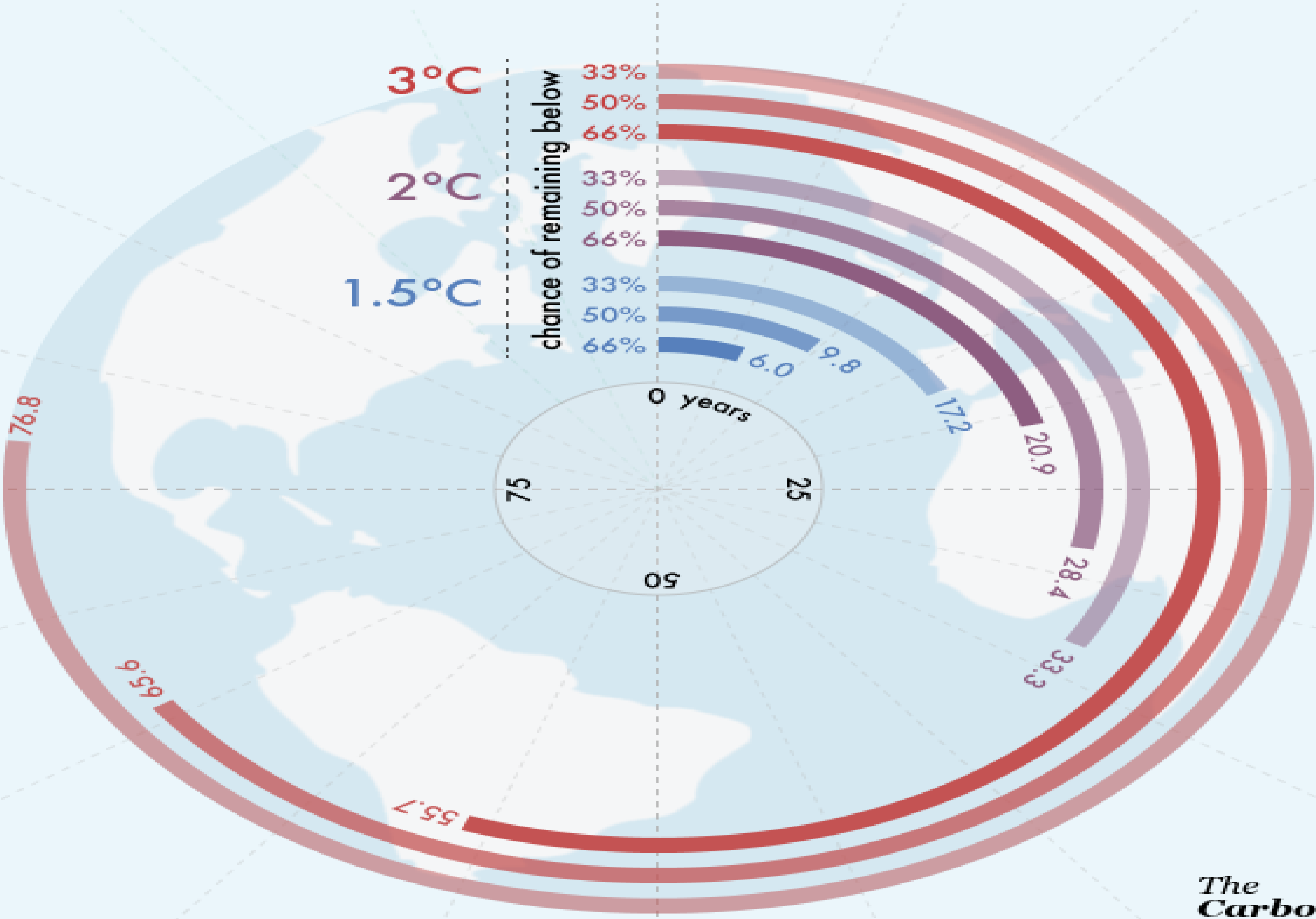
Resources Sector - Energy Productivity – Labour Productivity Co-benefits

BHPBilliton announced in 2012 that it would move to truckless mines by investing in “in-pit crushers and conveyors”(IPCC) to address rising operational costs from labour /diesel/carbon. IPCCs are much more energy efficient than haul trucks. “*'When you run a truck, it takes 10 to 11 employees for every truck. ...If you go autonomous you get rid of half of those. If you go truckless, (and invest in IPCCs), you get rid of all of them. You do this at a time when you see increasing diesel prices, carbon taxes, a number of reasons why getting rid of trucks or using fewer trucks is desirable.'*“...


Factor
Four
DOUBLING
WEALTH,
HALVING
RESOURCE USE
'ONE OF THE 1990s' MOST IMPORTANT BOOKS'
ERNST VON WEIZSÄCKER
AMORY B LOVINS • L HUNTER LOVINS


e
x5
FACTOR FIVE
Transforming the Global Economy through
80% Improvements in Resource Productivity
ERNST VON WEIZSÄCKER
KARLSON 'CHARLIE' HARGROVES • MICHAEL H. SMITH
CHERYL DESHA • PETER STASINOPOULOS

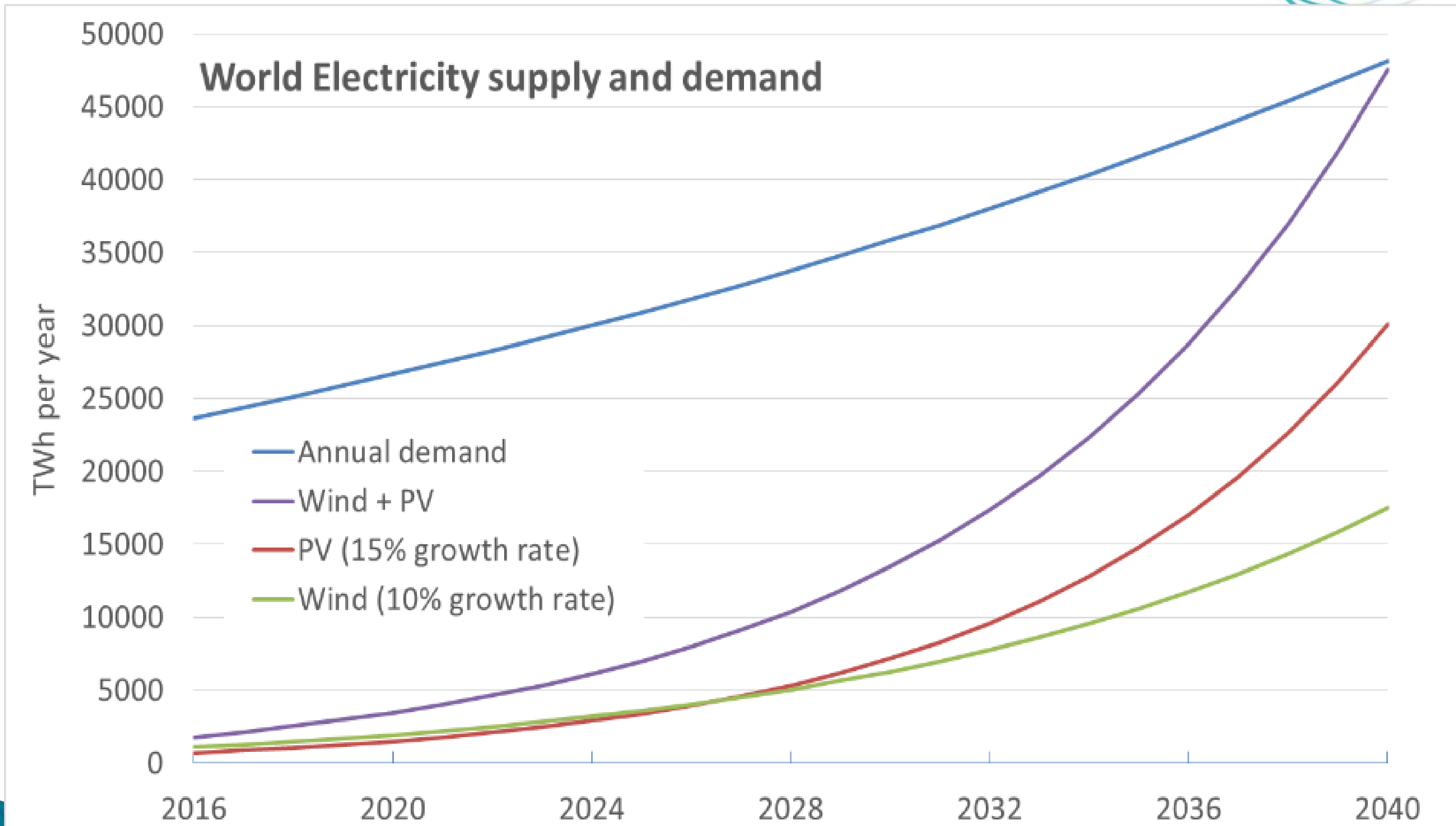
How many years of current emissions would use up the IPCC's carbon budgets for different levels of warming?



http://bit.ly/carboncountdown

The Carbon Brief

Path to 100% renewables



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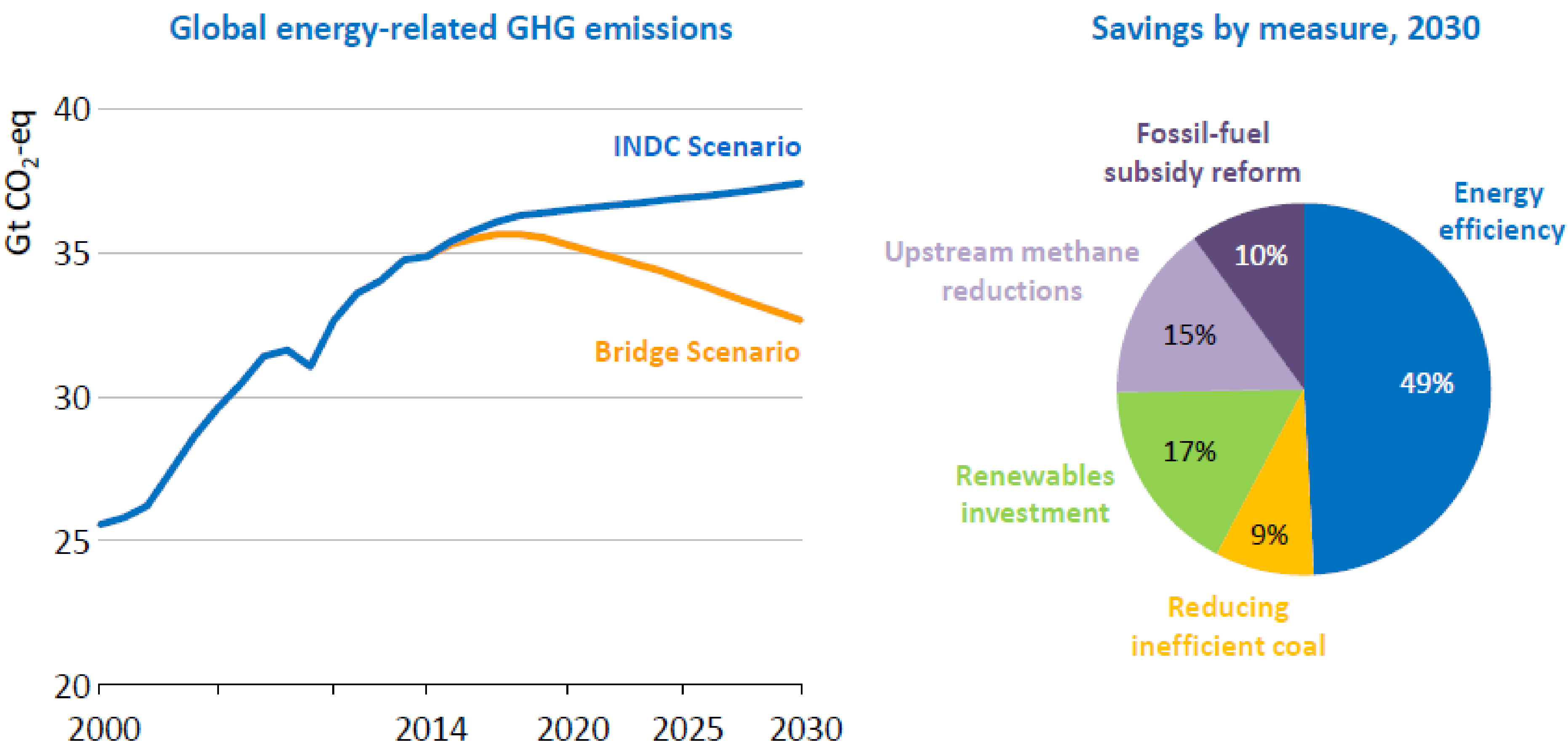
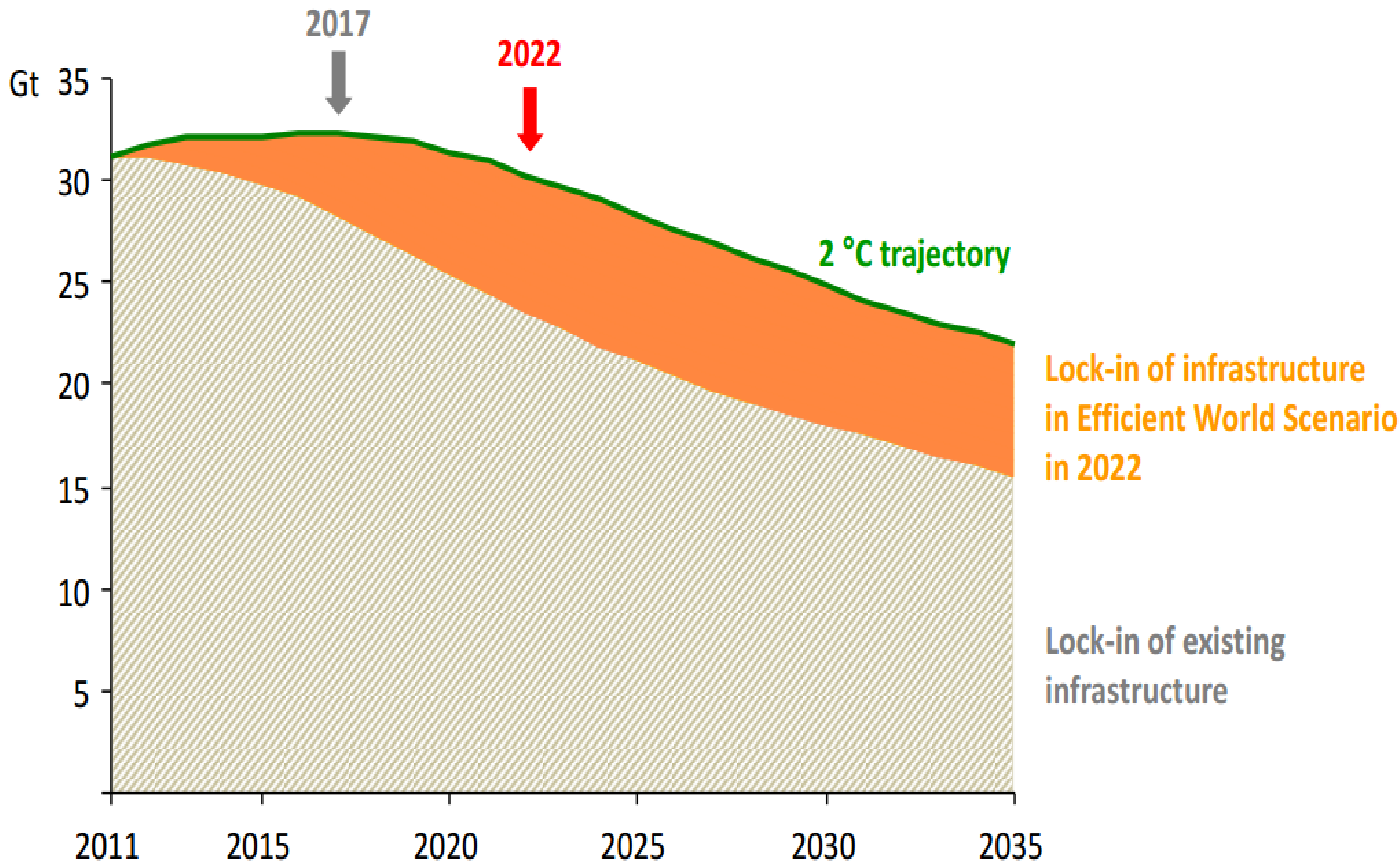
1. Peak in emissions:
IEA strategy to raise climate ambition

WEO Special Report on
Energy & Climate Change

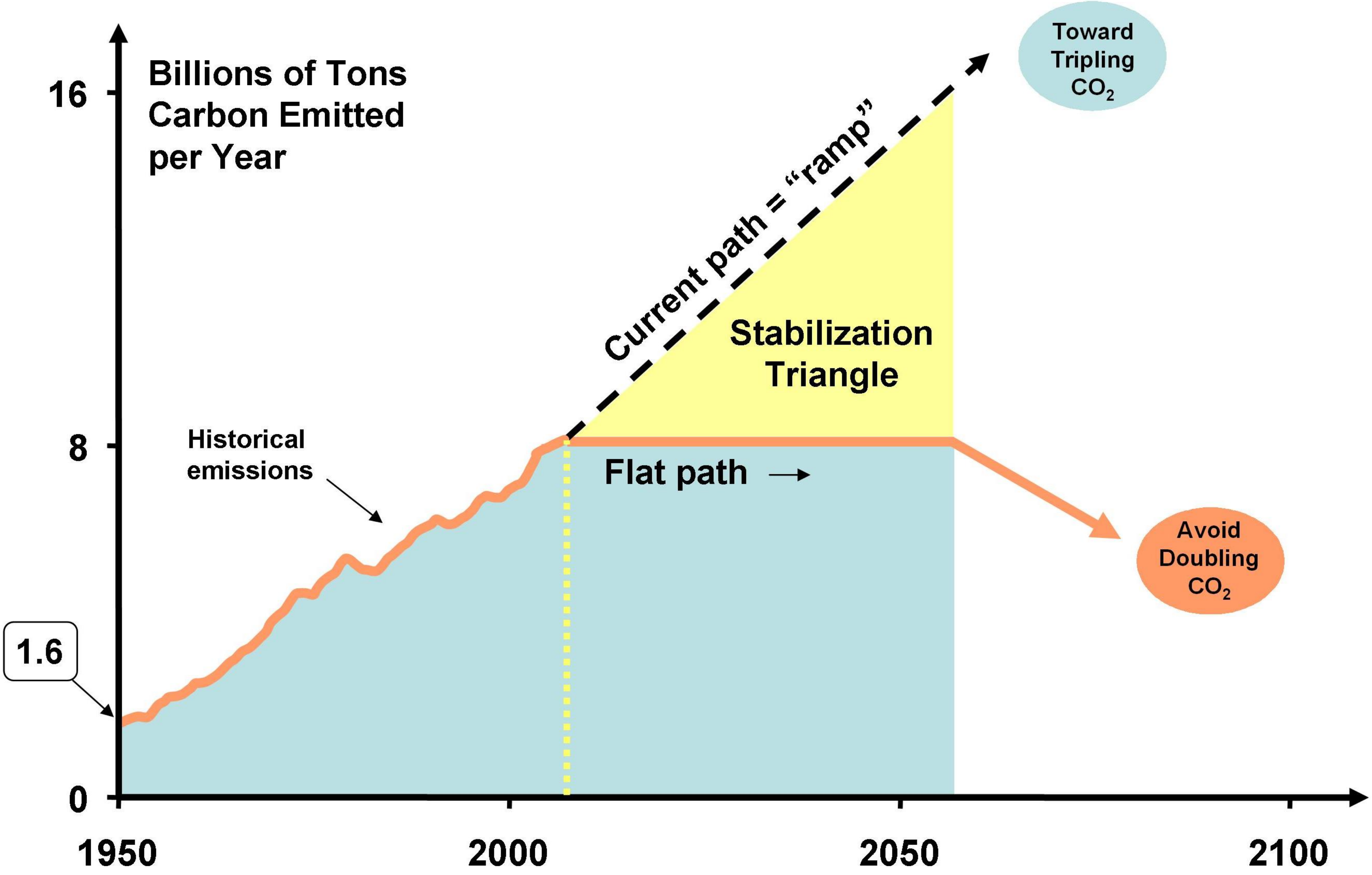


Five measures – shown in a "Bridge Scenario" – achieve a peak in emissions around 2020, using only proven technologies & without harming economic growth

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



Energy efficiency can delay "lock-in" of CO_2 emissions permitted under a 2 °C trajectory – which is set to happen in 2017 – until 2022, buying five extra years



Pacala and Socolow (2004) Stabilisation Wedges. Science at http://www.princeton.edu/mae/people/faculty/socolow/Science-2004-SW-1100103-PAPER-AND-SOM.pdf

Socolow and Pacala's Stabilisation Wedges	Underestimated the potential of energy efficiency to contribute to cutting emissions.
(1) Efficient Vehicles – Double Fuel Efficiency	(10) Wind – 2 million MW (50 times current)
(2) Reduced Use of Vehicles – By Half	(11) PV – 2000 GW (700 times current)
(3) Efficient Buildings and Appliances – Cut GHGs by ¼	(12) Wind generated hydrogen – to power hydrogen fuel cell cars.
(4) Efficient Base-load Coal Plants – Double Conversion Efficiency to 60%	(13) Biomass for fuel – 100 times current Brazil and US cropland
(5) Replace inefficient coal plants with gas plants (four X the current production of gas-based power)	(14) Reduced deforestation, plus reforestation, afforestation, and new plantations
(6-8) Carbon Capture and Storage (3 wedges)	(15) Conservation Tillage
(9) Nuclear Power – Double Current Global Output	

Additional Stabilisation Wedges – End Use Energy Efficiency by 2030	Areas of Large Potential for Rapid Greenhouse Gas Reductions
#1 – Residential and Commercial Buildings. Retrofit lighting, appliances, office equipment.	**#8 Reducing Urban Sprawl** - Whilst using low embodied energy building materials
#2 – Industry - Upgrade Motor Driven Technologies to cut global electricity use by 10%.	**#9 Energy/Water Efficiency Opportunities –** Reduce urban water leakage, improve urban water efficiency
#3 - Investment In Co-generation - avoids the need for 10% of new generation by 2030 saving $950 billion per annum by 2030. (IEA,2011)	**#10 Circular Economy** - Product Stewardship, Materials Efficiency and Recycling.
#4 – Energy Efficient Street Lighting – Shift to efficient lighting could save up to $650 Billion	**#11 Product Design Standards** - to be more energy/water efficient
#5 – Transition to More Efficient Transport Options: ~40% trips in OECD cities are <5 km.	**#12 Reduce Global Food Waste** in half.
#6 - Fuel Efficient Freight Transport Options including modal shifts. IEA and OECD show potential to halve transport fuels by 2030.	**#13 Behaviour Change** (ie diet, energy, travel)
#7 - Reducing Urban Heat Island Effect - Increasing urban albedo + investing in green urban development	**#14 Reducing Black Carbon –** from moving to cleaner energy sources for households and transport.

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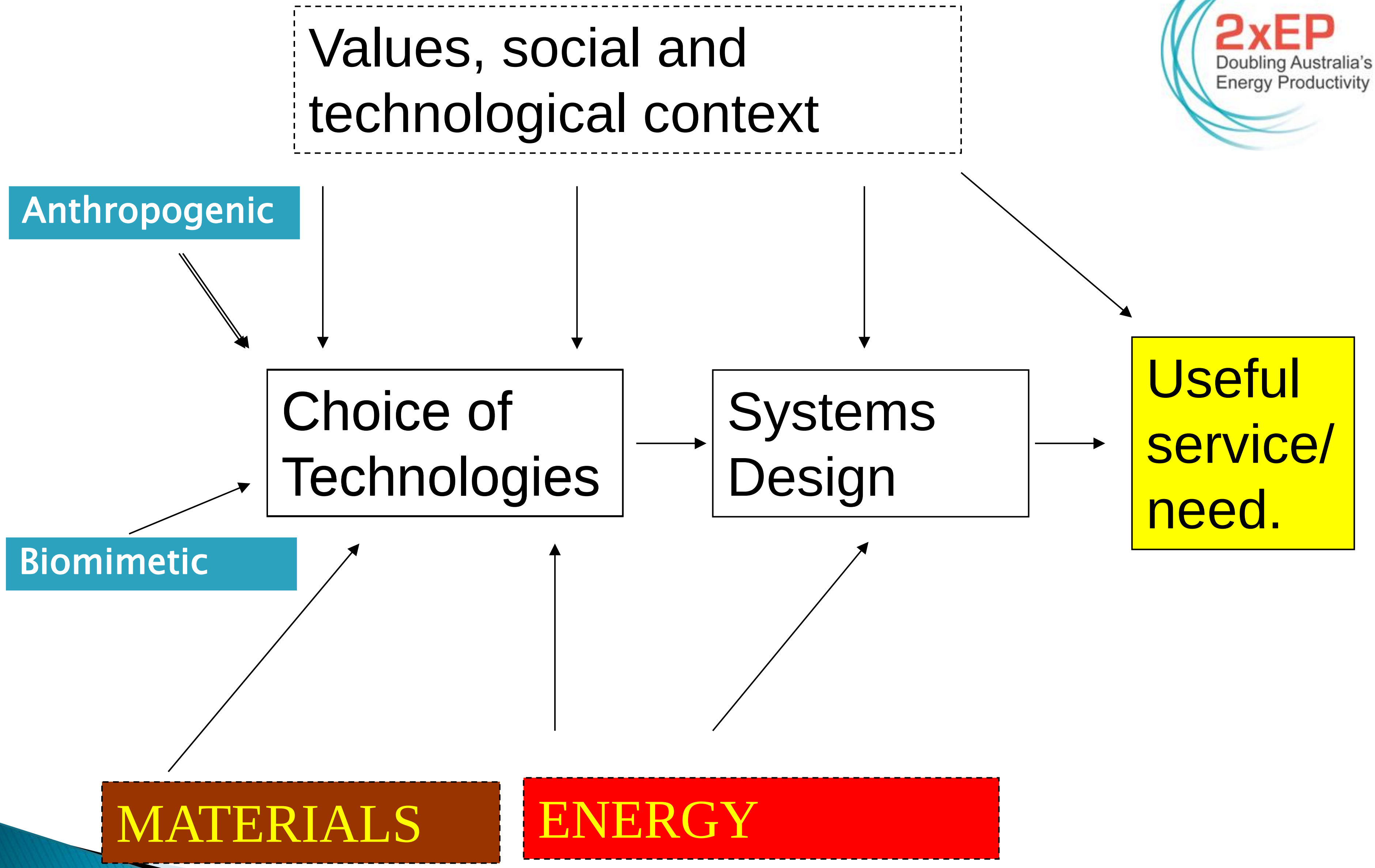
Doubling Australia's Energy Productivity



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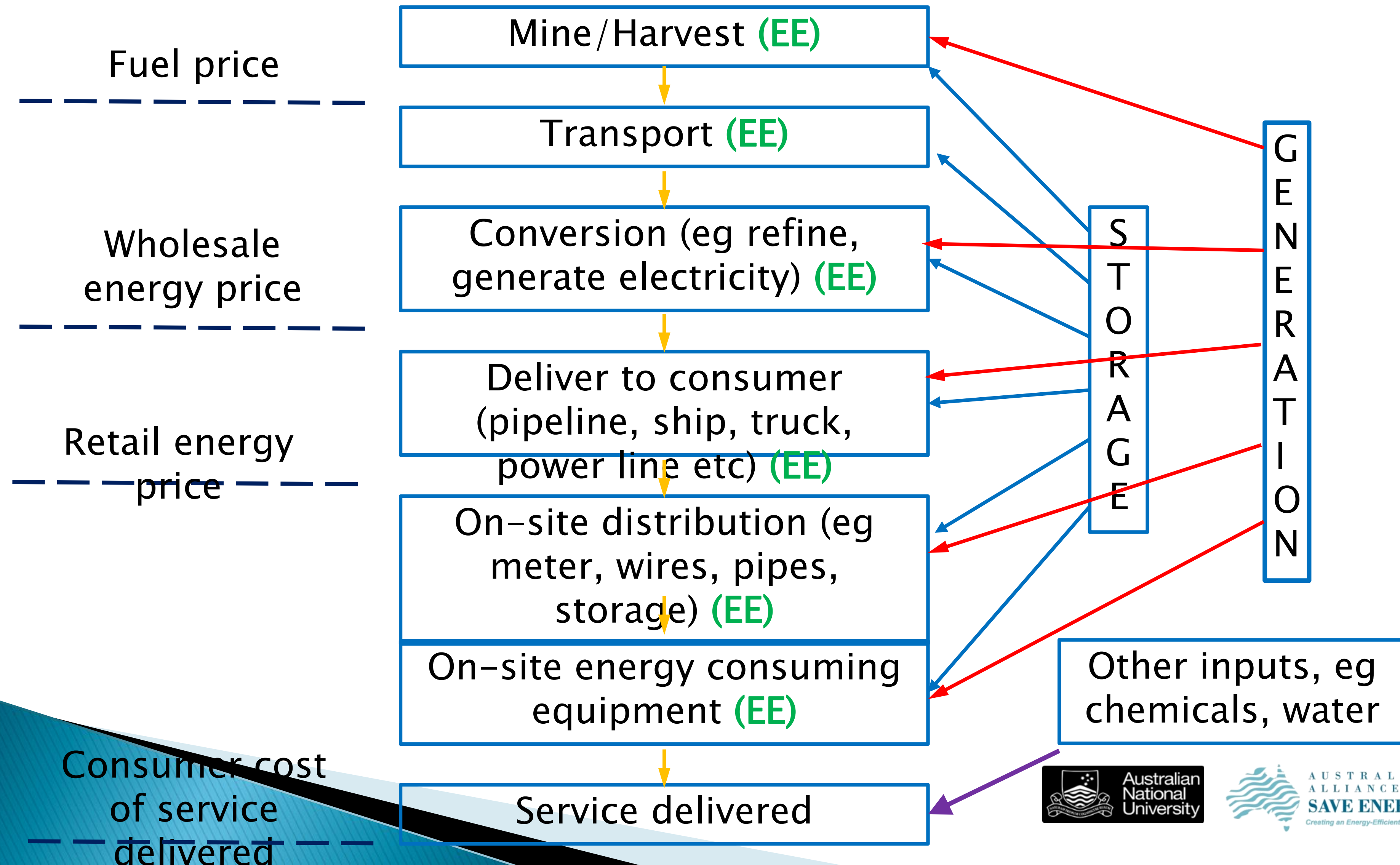
The ‘energy’ service delivery system – many options now exist.



Do we need high temperature industrial process heat & co-generation processes?

Step 1: minimise energy input per unit of useful work output generated

- Zeobond cement

Source: The Zeobon… up (n.d.)

Chemicals Industry – Redesigning Reactions along Green Chemistry Principles.

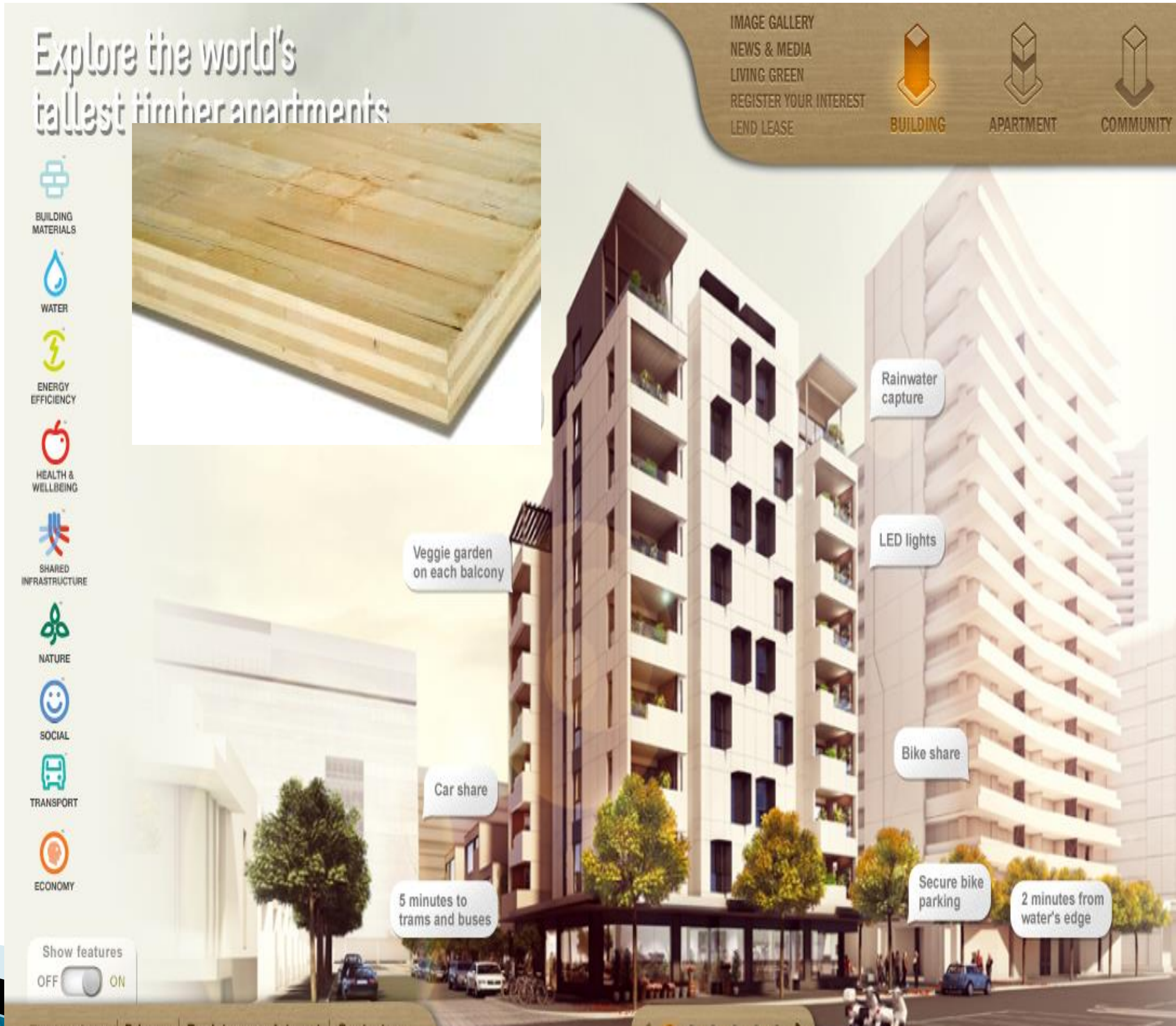
Argonne National Labs has developed new non-toxic, environmentally friendly 'green solvents' to replace the millions of toxic solvents currently used in industry. The new process makes low-cost, high-purity ester-based solvents, such as ethyl lactate, using advanced fermentation, membrane separation, and chemical conversion technologies. *Overall, the new process uses 90 % less energy and produces ester lactates at about 50 % of the cost of conventional methods.*

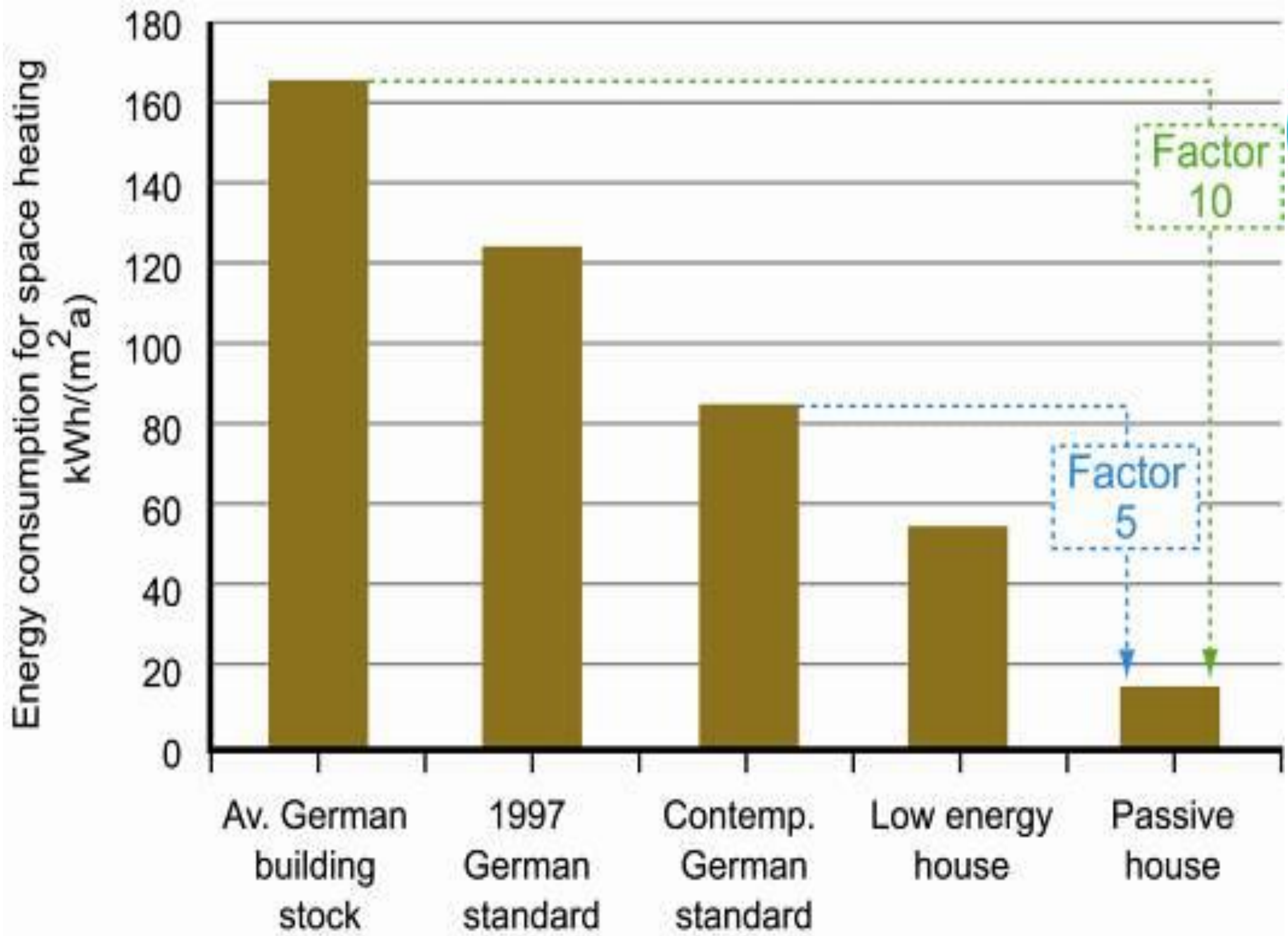
- NTEC Versol Inc - selling these in the US under trademarks Versol and Versol Gold.

- Argonne National Lab (1998) 'Green Solvent Process Gets Presidential Honor', *Argonne News*. Available at www.anl.gov/Media_Center/Argonne_News/news98/an980629.html.

Embodied energy in new build could use up 30-60% of the remaining global carbon budget by 2050 – *if new buildings are built with traditional high embodied energy cement, steel and aluminium*

Embodied energy: Forte building by LendLease in Melbourne Docklands, Aust: world's tallest timber apartment building – uses cross-laminated timber to reduce embodied energy





http://www.laros.com.au/our-projects/

Australian Buildings Can be 50-80% more energy efficient for heating and cooling

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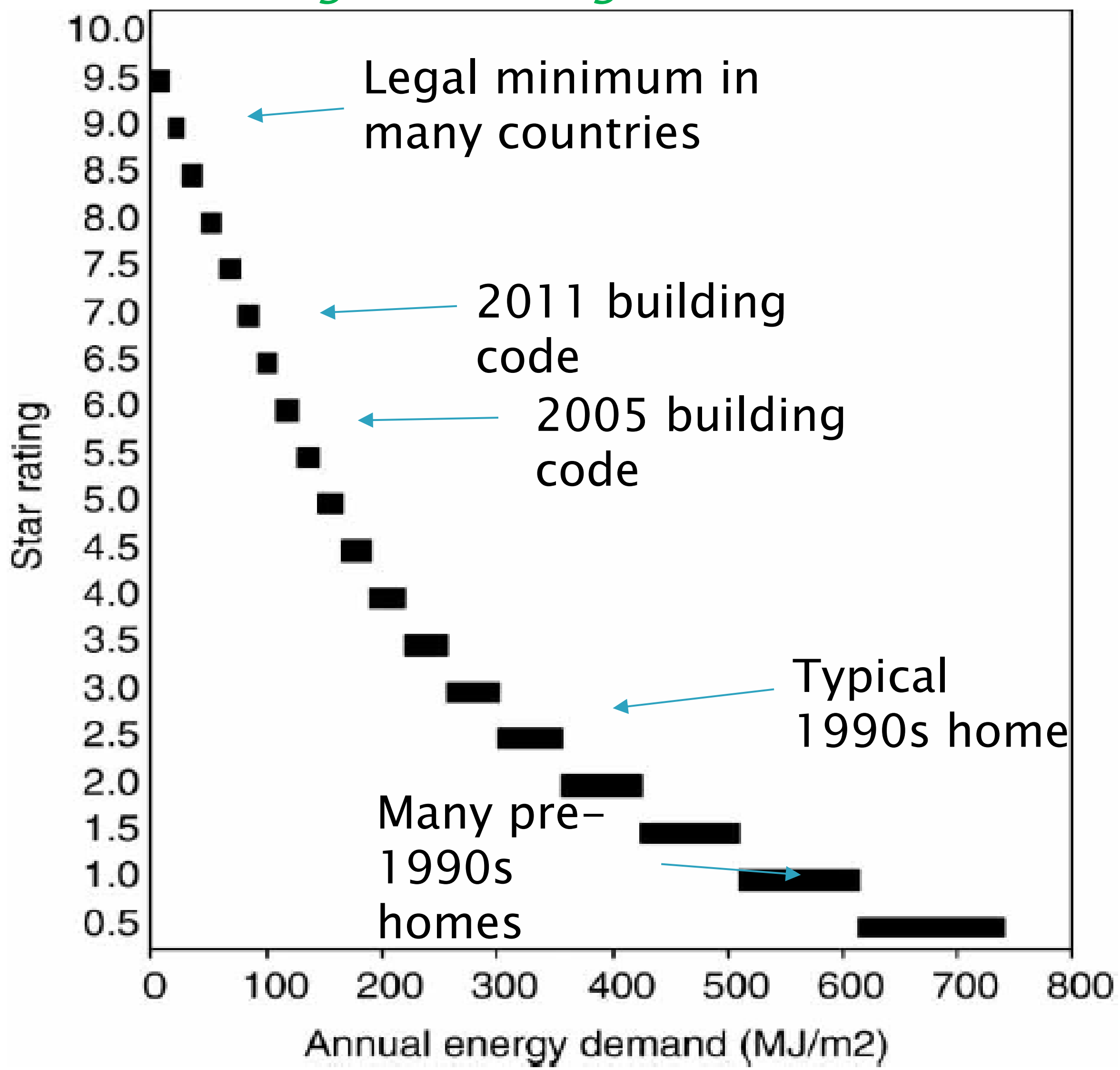

Figure 1 Residential heating and cooling Star ratings for Melbourne in Victoria, Australia

CONTEXT: building

As building envelope performance improves, annual energy requirement for heating and cooling declines dramatically

NOTE: these are thermal energy flows, ignoring equipment efficiencies

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Residential: Technology transformation

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

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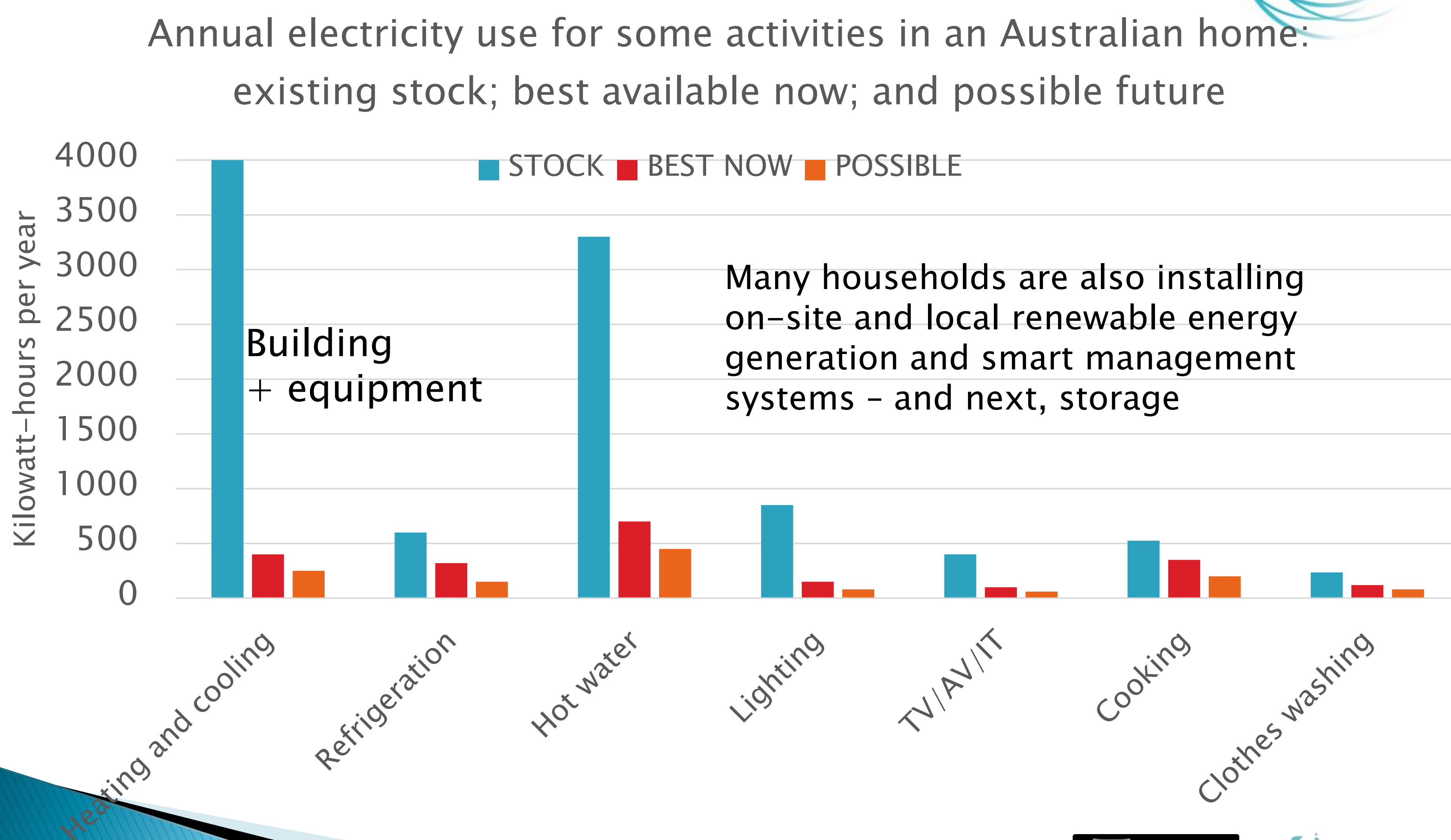

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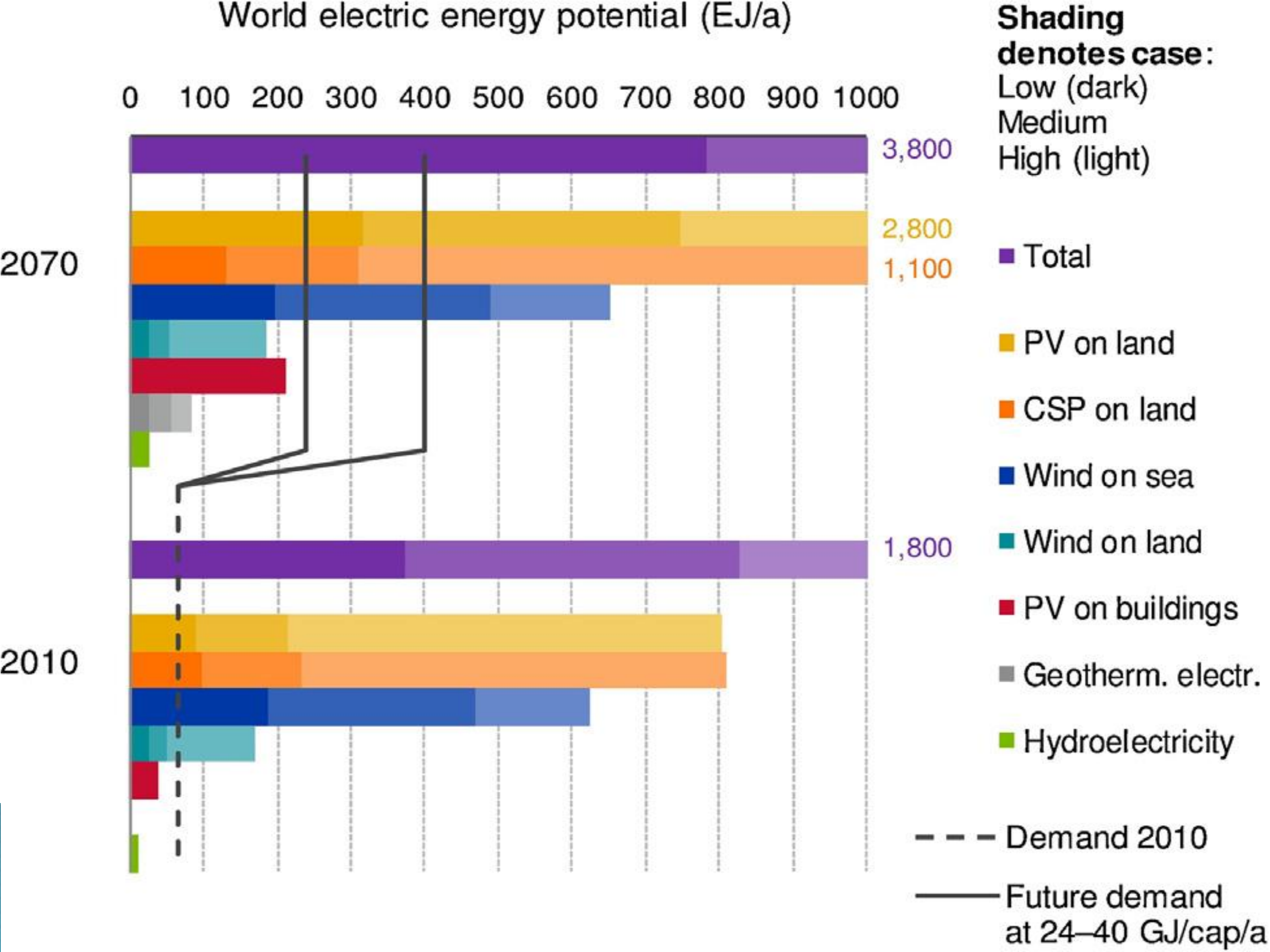
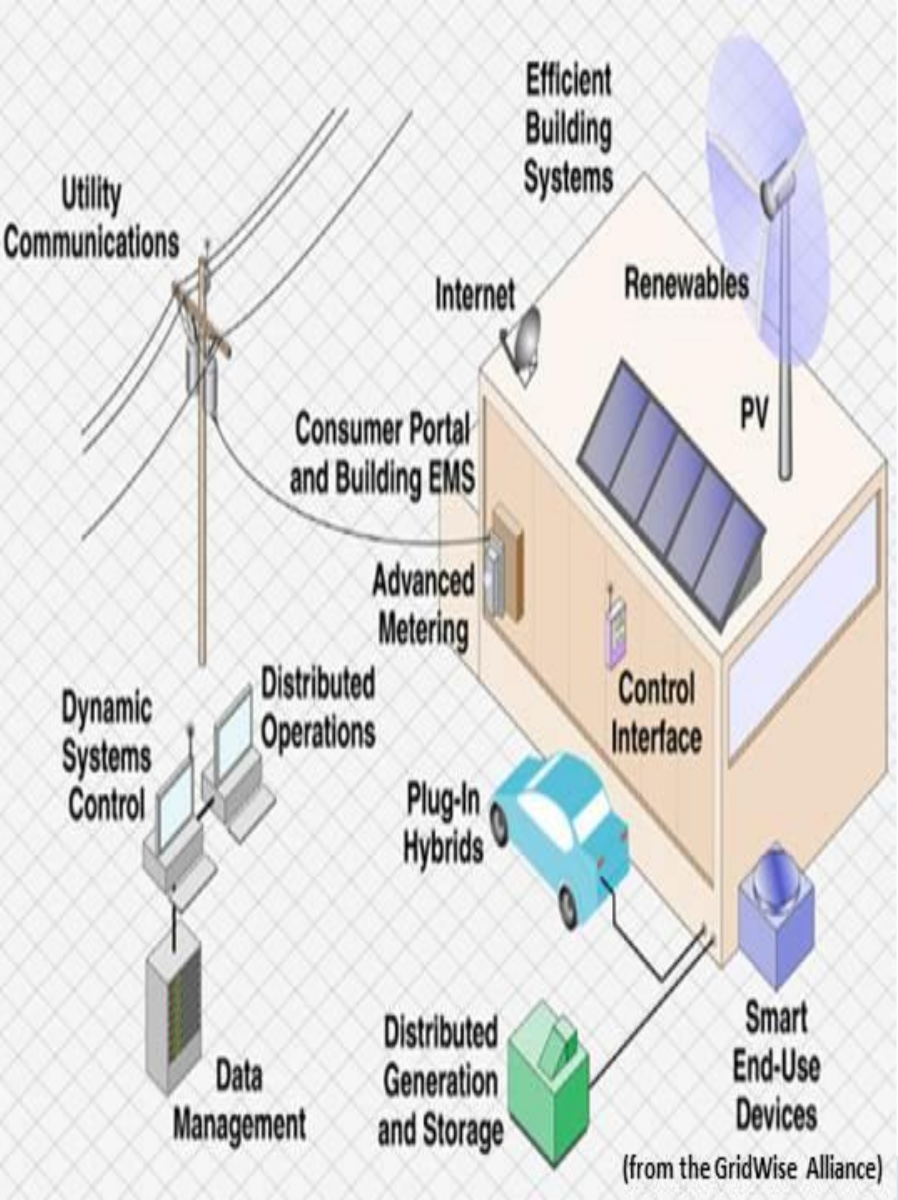

World electric energy potential (EJ/a)
0
100
200
300
400
500
600
700
800
900
1000
3,800
2,800
1,100
1,800
2070
2010
Shading denotes case:
Low (dark)
Medium
High (light)
Total
PV on land
CSP on land
Wind on sea
Wind on land
PV on buildings
Geotherm. electr.
Hydroelectricity
Demand 2010
Future demand at 24–40 GJ/cap/a

Innovations Enable A Step Change in EP: Energy/Transport/Building Sectors



- Buildings – 50-80% more efficient
- Innovations in High Density Living and Compact Transport Options (https://www.ted.com/talks/kent_larson_brilliant_designs_to_fit_more_people_in_every_city?language=en)
- Smart control innovations for LED lighting cut energy by a further 50%
- Solartube lighting – http://solatube.com.au/
- Solar PV panel, wind & energy storage innovations to help Australia replace existing energy supply infrastructure by 2050 (http://www.teslamotors.com/powerwall)
  (http://reneweconomy.com.au/2014/pumped-hydro-the-forgotten-storage-solution-47248)
- Transport demand management innovation
- Electric vehicle (2,3,4 wheeler) innovations
- Electric scooters on track to reach100 million by 2018 in http://www.navigantresearch.com/newsroom/electric-scooters-in-asia-pacific-will-increase-nearly-tenfold-from-2012-to-2018

EP Potential in Transport

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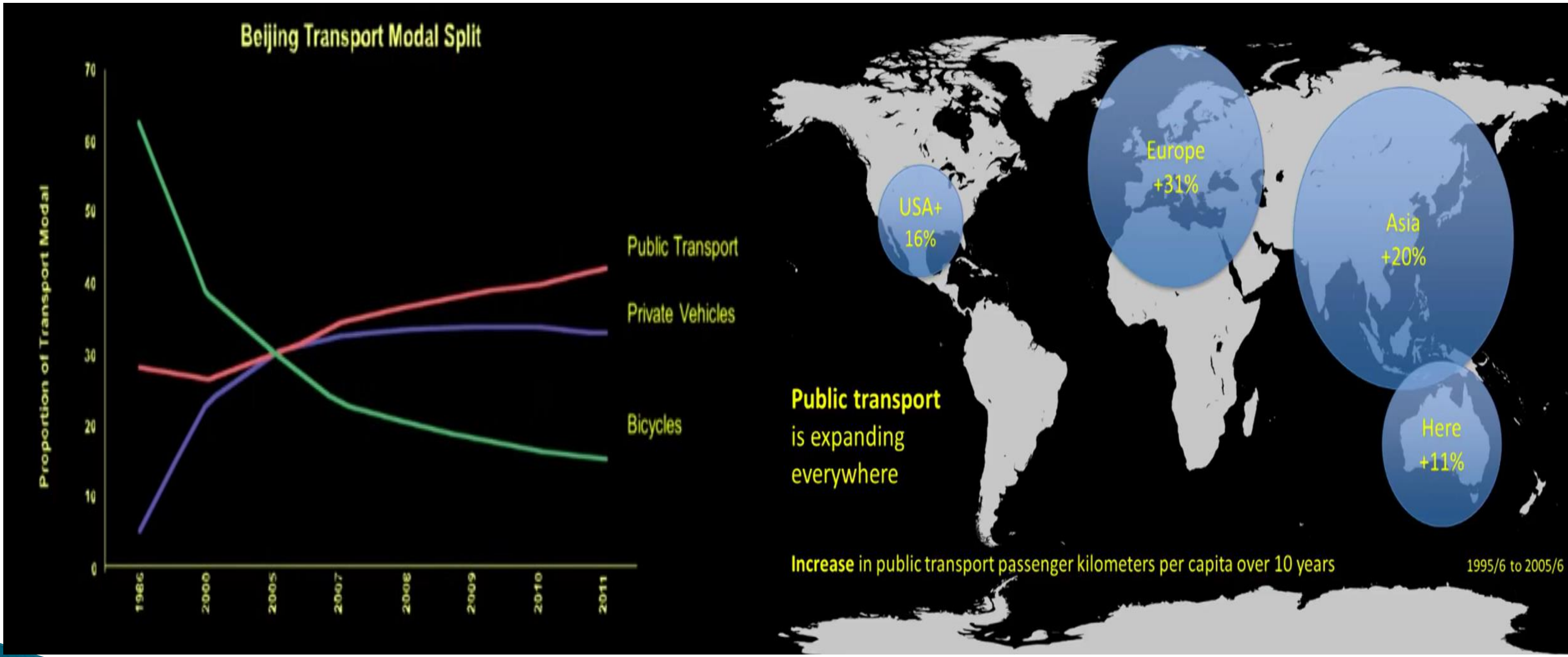
IEA/OECD – has found that demand for transport fuels could be halved by 2030.
http://www.euractiv.com/energy-efficiency/iea-transport-fuel-use-halve-203-news-514919



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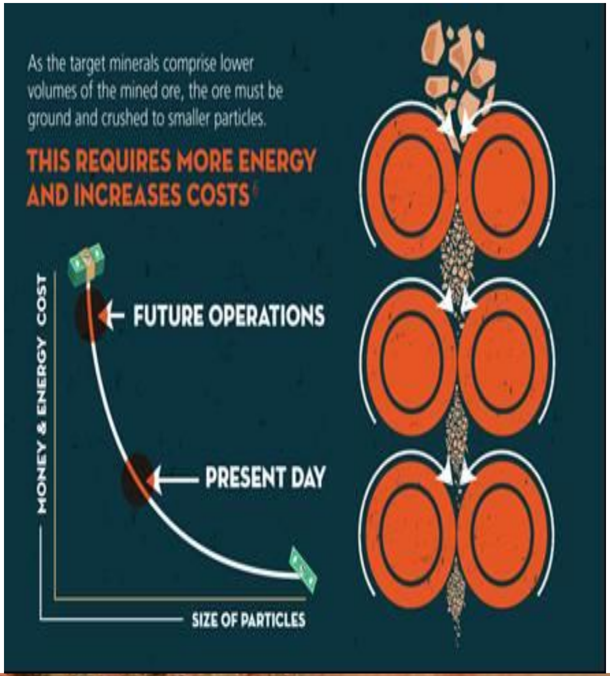
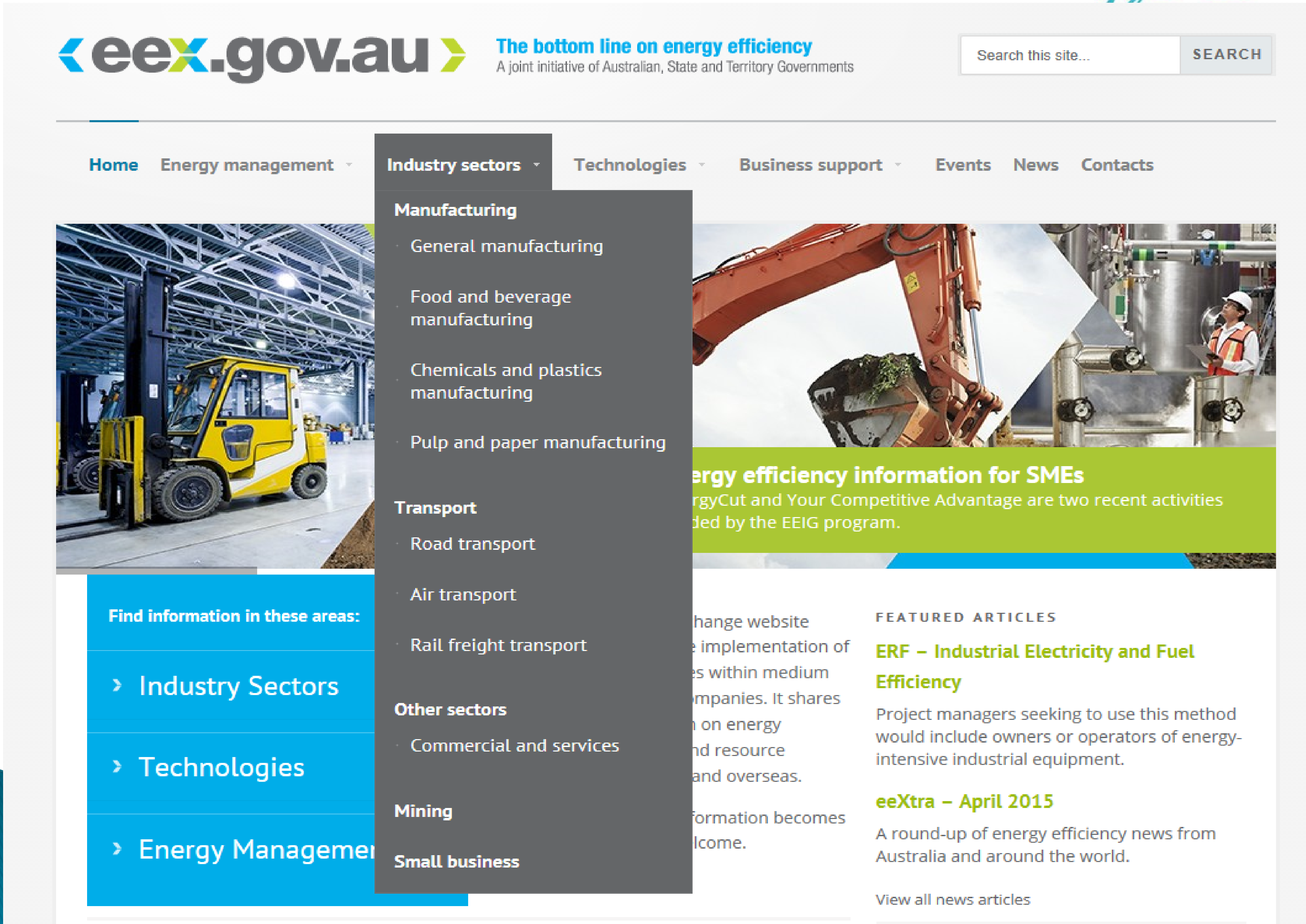
Source – Peter Newman – TED Talk – Susta lity

Innovations can enable a Step Change in EP in the Mining Sector.

- Technologies to improve ore characterisation (UQ, CRC Ore)
- Smart blasting - ultra-high intensity blasting (up to 40% improvement) (Orica – CEEC Medal, 2014)
- Energy efficient materials movement (eg IPCC)
- Energy efficient comminution tech innovations
- Flexible mill circuit design
- Onsite renewable energy and co-generation (>20 R&D renewable projects re mining with ARENA)
- Long term – Prof Jamieson (University of Newcastle) – innovations in froth floatation



What's Next


eex.gov.au
The bottom line on energy efficiency
A joint initiative of Australian, State and Territory Governments
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Manufacturing
General manufacturing
Food and beverage manufacturing
Chemicals and plastics manufacturing
Pulp and paper manufacturing
Transport
Road transport
Air transport
Rail freight transport
Other sectors
Commercial and services
Mining
Small business
ergy efficiency information for SMEs
rgyCut and Your Competitive Advantage are two recent activities
ded by the EEIG program.
Find information in these areas:
Industry Sectors
Technologies
Energy Managemen
hange website
implementation of
s within medium
mpanies. It shares
on energy
nd resource
and overseas.
ormation becomes
lcome.
FEATURED ARTICLES
ERF – Industrial Electricity and Fuel Efficiency
Project managers seeking to use this method would include owners or operators of energy-intensive industrial equipment.
eeXtra – April 2015
A round-up of energy efficiency news from Australia and around the world.
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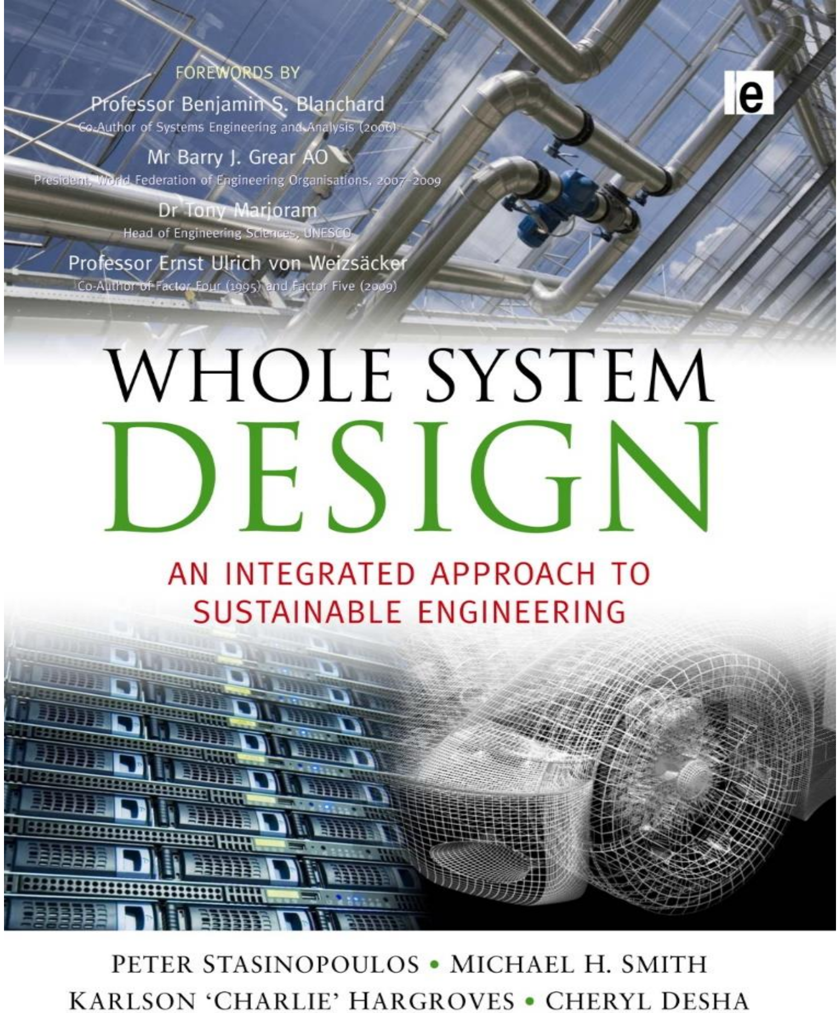
Key Messages

- Our 'need' for energy is derived from 'needs' for services like nutrition, shelter, entertainment, economic output etc
- Recent innovation has dramatically increased the range of options to satisfy 'needs' instead of traditional energy systems
- These involve *integrated* use of combinations of:
  - More efficient energy and resource use
  - Smart management of demand
  - Storage of energy in many forms (heat, coolth, electricity, chemical, gravitational potential, movement)
  - Distributed energy production or conversion
  - Innovative reframing of what our needs are (eg virtual solutions)
- Costs of many emerging energy options are falling due to:
  - Rapid innovation from many directions and 'learning by doing'
  - Capture of economies of scale from flexible mass production
- Distributed solutions that seem to have higher costs can be cheaper overall because they avoid/reduce losses and costs in the supply chain and offer non-energy benefits



What is the energy and resource efficiency technical potential of systems? Is it possible to deliver the same or better services whilst using 70-80% less energy? If so, How? What policy measures are needed?

Australian National University

AUSTRALIAN ALLIANCE TO SAVE ENERGY
Creating an Energy-Efficient Australia

Further Reading

- Stadler, A., Jutsen, J., Pears, A., & Smith, M. (2014). 2xEP: Australia's energy productivity opportunity. Australian Alliance to Save Energy http://a2se.org.au/files/2XEP_Foundation.pdf
- IEA (2012) World Energy Outlook. IEA
- International Energy Agency. (2014). *Capturing the multiple benefits of energy efficiency: Roundtable on industrial productivity and competitiveness* (Discussion Paper). Paris: Author. http://www.iea.org/media/workshops/2014/eeu/industry/IEA_Industrialnonenergybenefitsbackgroundpaper_FINAL.pdf
- ClimateWorks Australia (2015) Australia's Energy Productivity Potential. CWA. Monash University.
- Smith, M. (2014, 2015 updated). *Green growth: Unlocking new sources of productivity, profits and growth in the 21st century*. Sydney: United States Studies Centre, University of Sydney Email – michaelh.smith@anu.edu.au
- Smith, M. (2014, 2015 updated). *Green growth: Doubling Energy and Resource Productivity by 2030 – A How to Guide for Policy Makers* . Sydney: United States Studies Centre, University of Sydney Email – michaelh.smith@anu.edu.au
- Smith, M. (2014, 2015 updated). *Green growth: Improving Business Productivity and Competitiveness.* Sydney: United States Studies Centre, University of Sydney Email – michaelh.smith@anu.edu.au
- Smith, M (2014) Energy and Resource Productivity – Direct Action that Could Save the Global Economy. Sydney Morning Herald. http://www.canberratimes.com.au/national/public-service/energy-and-resource-productivity-direct-action-that-could-save-the-global-economy-20140901-3en76.html
- Smith, M. Hargroves. K. Desha, C (2010) Cents and Sustainability – Securing Our Common Future by Decoupling Economic Growth from Environmental Pressures. Routledge. London
- Stasinopoulos, P. Smith, M et al (2010) Whole of System Design. UNESCO, WFEO, TNEP at http://www.naturaledgeproject.net/whole_system_design.aspx