Centre for Energy and Environmental Markets

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Is the future renewable? *International and Australian perspectives on renewable energy*

Dr Iain MacGill
Research Coordinator, CEEM

CEEM established …

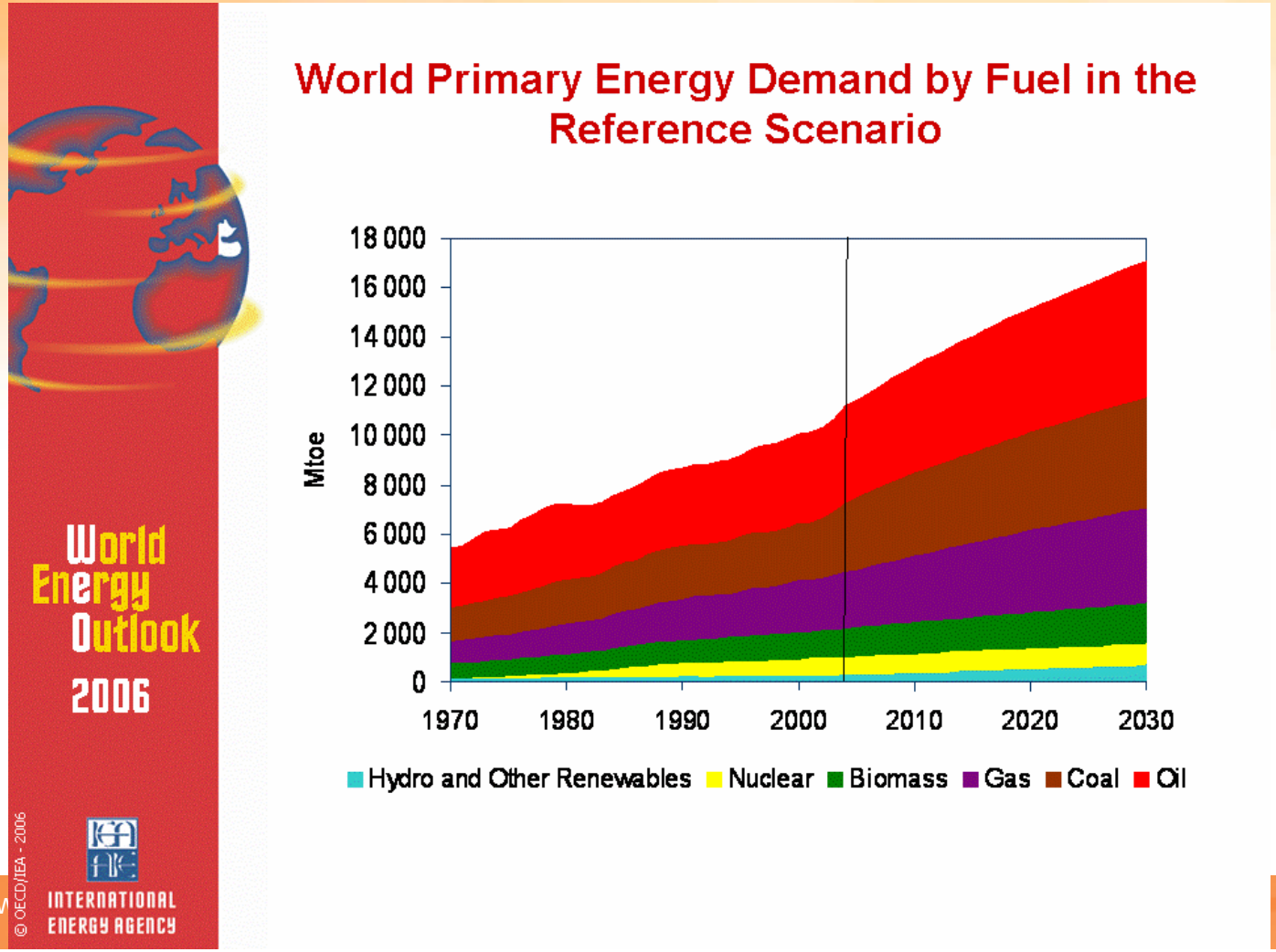
- *to formalise* growing shared research interests + interactions between UNSW researchers
  - Faculties of Engineering, Business (Economics and Management), Arts and Social Sciences, Science, Institute for Env. Studies...
- *through UNSW Centre* aiming to provide Australian research leadership in interdisciplinary analysis + design of energy and environmental markets
- *focussing in the areas* of
  - Energy markets – spot, ancillary and derivatives – within restructured electricity industries
  - Related environmental markets – emissions trading, renewable obligations, Greenpower…
  - Wider policy frameworks and instruments for achieving overall energy and environmental objectives

Some current CEEM research efforts

- Facilitating wind integration in the NEM
  - 2 strands: forecasting and control of wind energy, and market design to facilitate wind energy
- Renewable energy policy support options in restructured industries
  - MRET, Victorian RET, proposed NSW RET
- Modelling participant behaviour in elec. markets
  - Interactions between spot and derivative markets
- Emissions Trading Schemes + options for Australia
  - Experimental economics studies on market design
- Technology assessment for sustainable energy policy frameworks
  - Energy efficiency, gas and cogeneration, renewables, CCS, nuclear options
- Economic modelling of Distributed Energy
- Energy efficiency policy – regulation, financial mechanisms
- Policy frameworks for technology innovation
  - Emerging renewables, Carbon Capture + Storage (CCS)

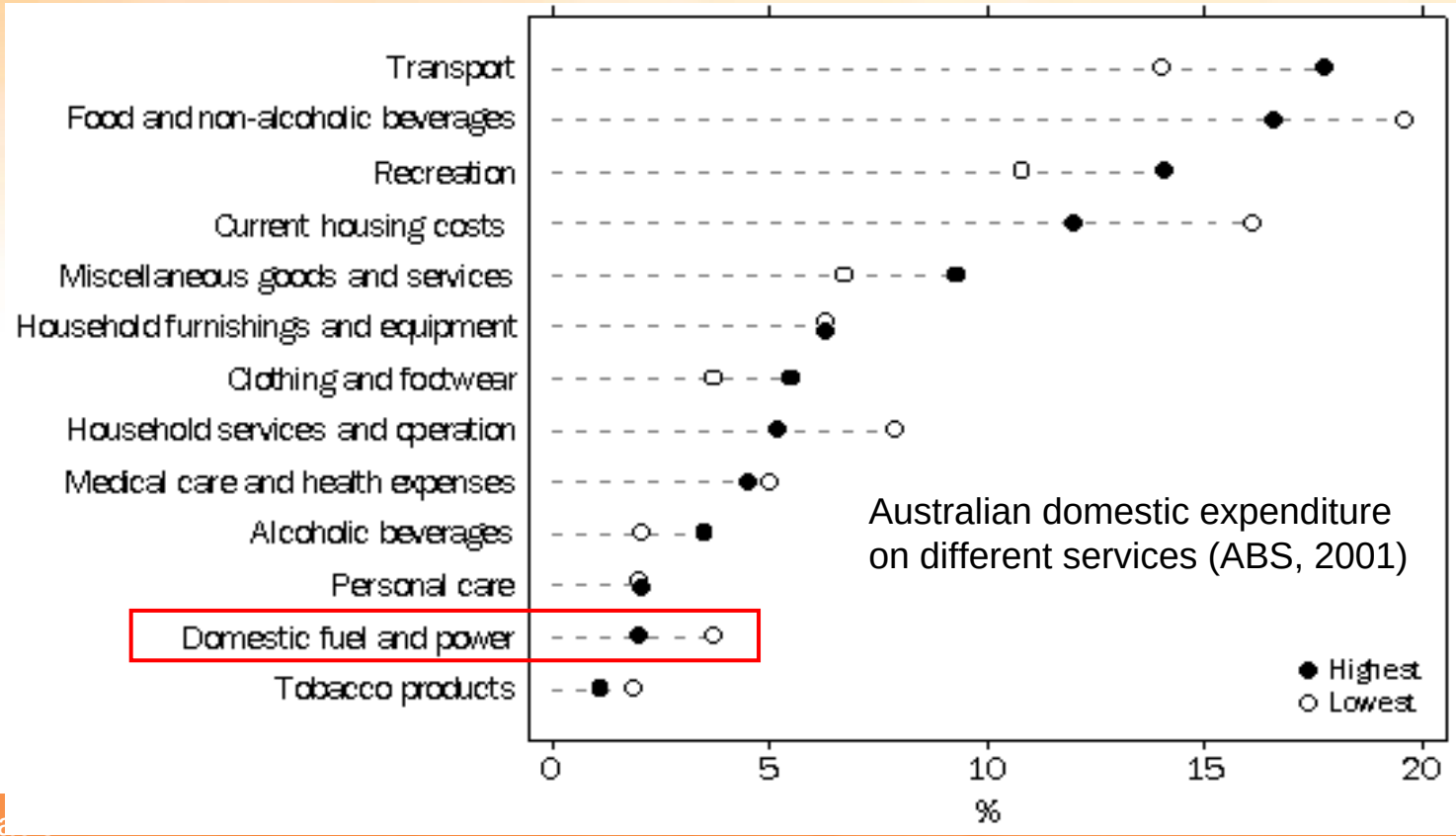
The current incumbents…

- **Fossil fuels dominate the global energy mix although renewables have key role in some, mainly developing, countries**



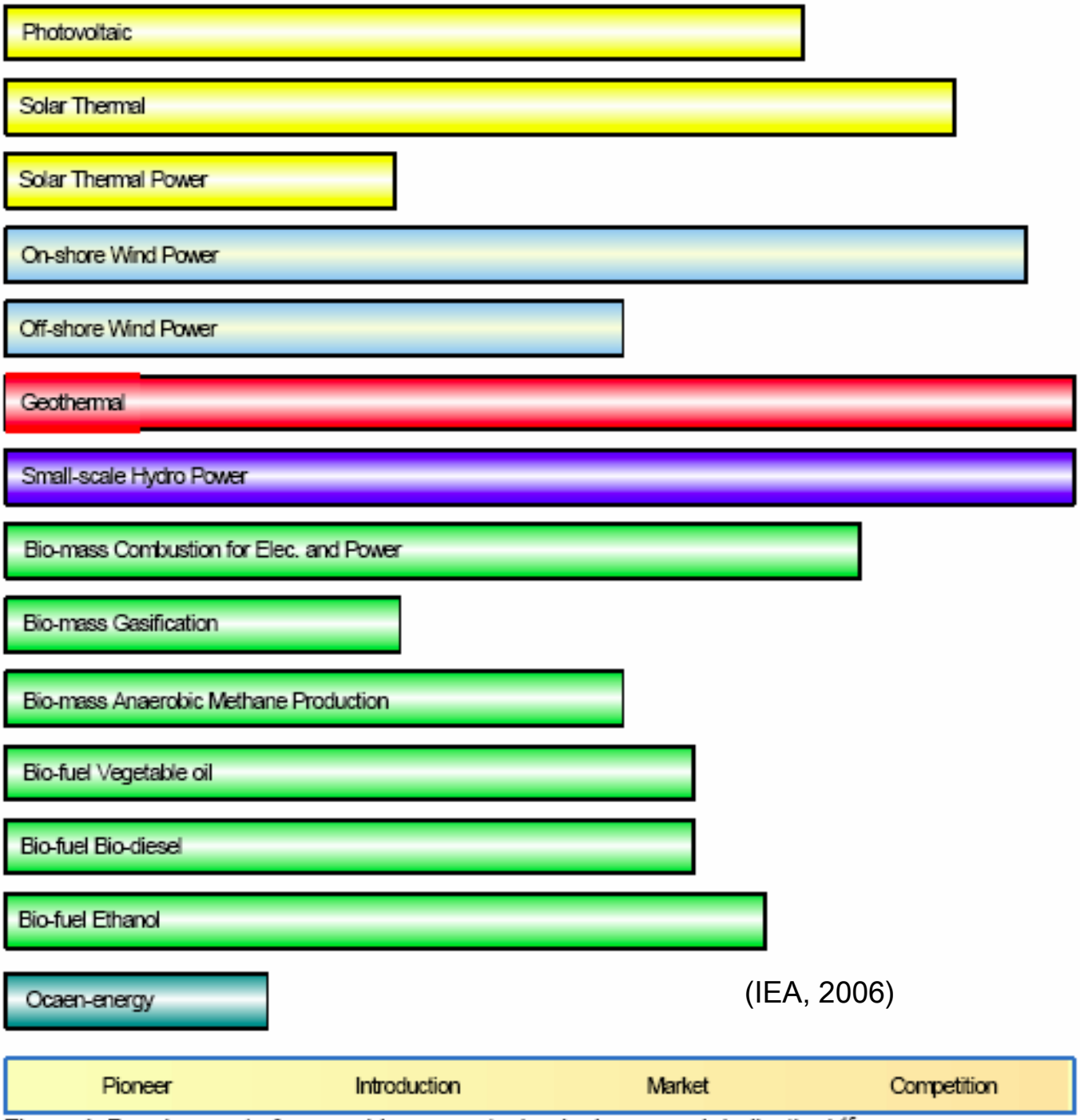
…dominate for a reason

- **For the 'golden billion(s)', never have so many had so much energy so cheaply**
  finding fossil fuels equivalent to winning the 'energy' lottery



Australian domestic expenditure on different services (ABS, 2001)

Wide range of RE technologies but varying technical status
(IEA, 2006)



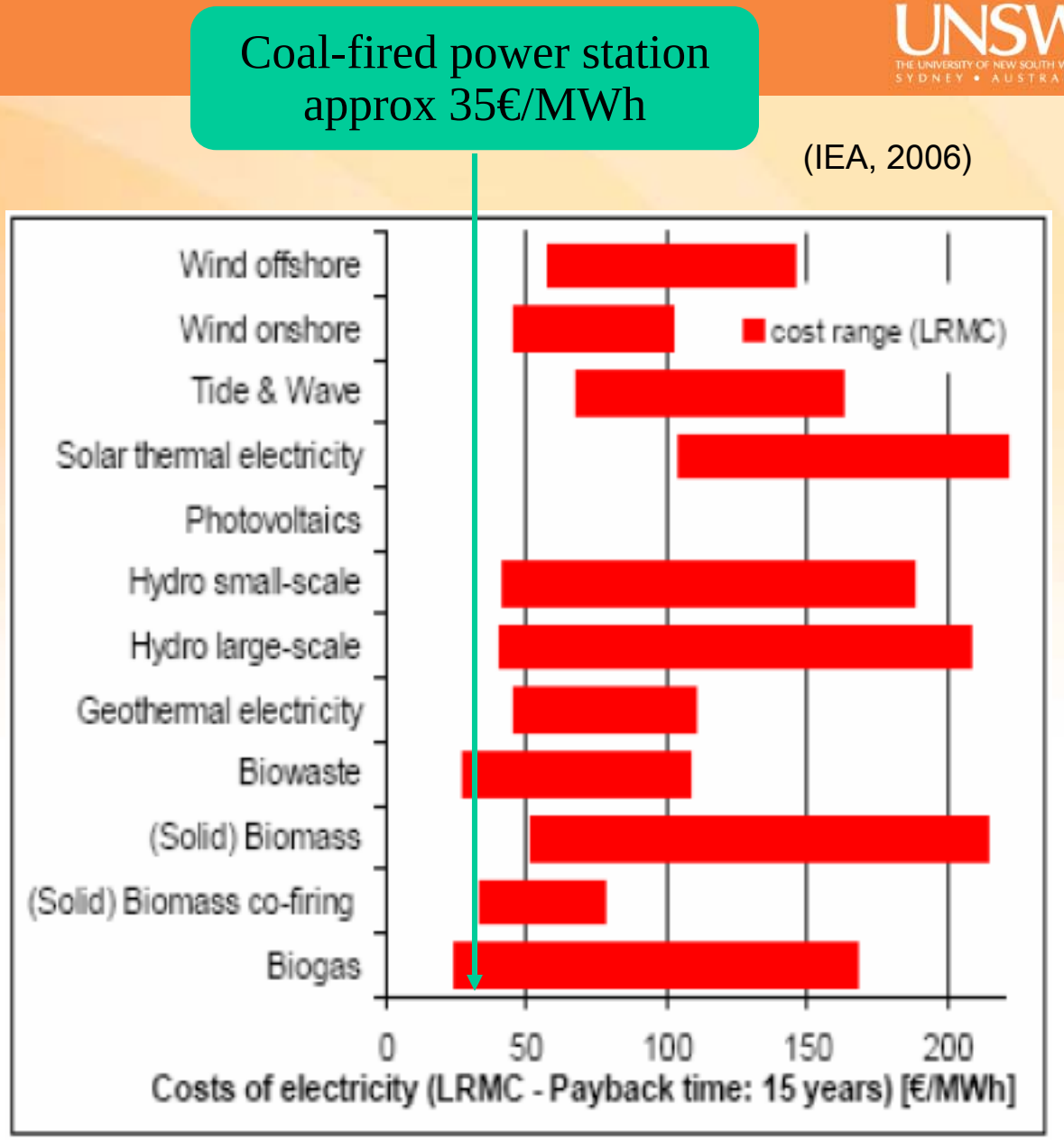
(IEA, 2006)

Figure 4: Development of renewable energy technologies – rough indication! [16]

While renewable energy direct costs generally higher than fossil fuels

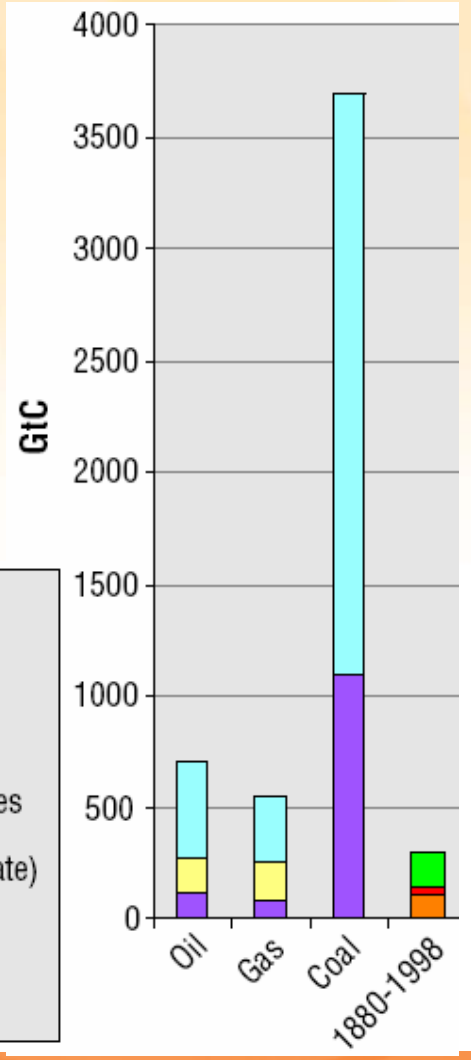
eg. Renewable energy & coal comparison for Europe

Note that Australia's fossil-fuel power is considerably cheaper than in Europe



Energy security concerns grow…

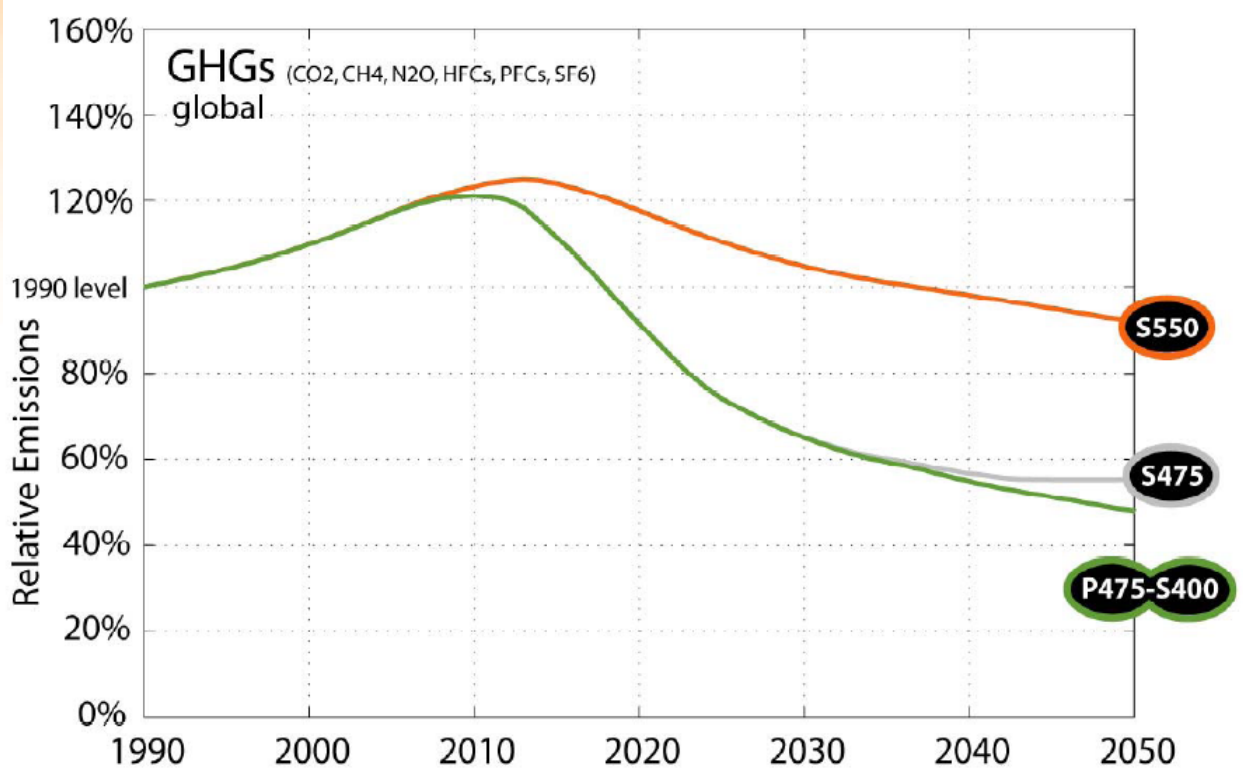
- …but we are unlikely to run out of fossil fuels in global context for some time
- at least while energy wealth continues to be concentrated among the 'golden billion'
  - universal energy consumption at current rates of the energy rich would increase global use 3-5 times and quickly drawdown reserves
- However, some countries and regions have significant concerns about oil + gas import dependency
- while Australia is an "energy superpower"



…but climate change the real driver away from BAU

(Meinshausen, Avoiding Dangerous Climate Change, 2005)

- A reasonable chance of keeping warming less than 2 deg.C may require stabilisation at 400-475ppm
- … requiring major global reductions by 2050
- while any delays in taking action greatly increase necessary rate of reduction
  - 20 year delay means 3-7 x faster fall required



The Australian energy context

- Large, low cost + high quality coal, gas and U reserves
  - A major energy exporter – World #1 Coal, #2 Uranium, #5 LNG
  - An energy intensive economy c.f. other industrialised nations
  - Amongst the world's highest per-capita greenhouse emissions

% of Global...	Population	GDP	Energy Production	Energy Consumption	Fossil-fuel GHG emissions
Australia	*0.3*	*1.3*	*2.3*	*1.0*	*1.3*
China	21	5.4	14	15	18
India	17	1.7	4.2	5.1	4.1
United States	4.6	31	15	21	22
Japan	2.0	14	0.9	4.8	4.6
Korea	0.8	1.8	0.3	1.9	1.7
Germany	1.3	5.6	1.2	3.1	3.2

(IEA, *World Energy Statistics 2006*)

Australia's high coal dependence for elec. gen

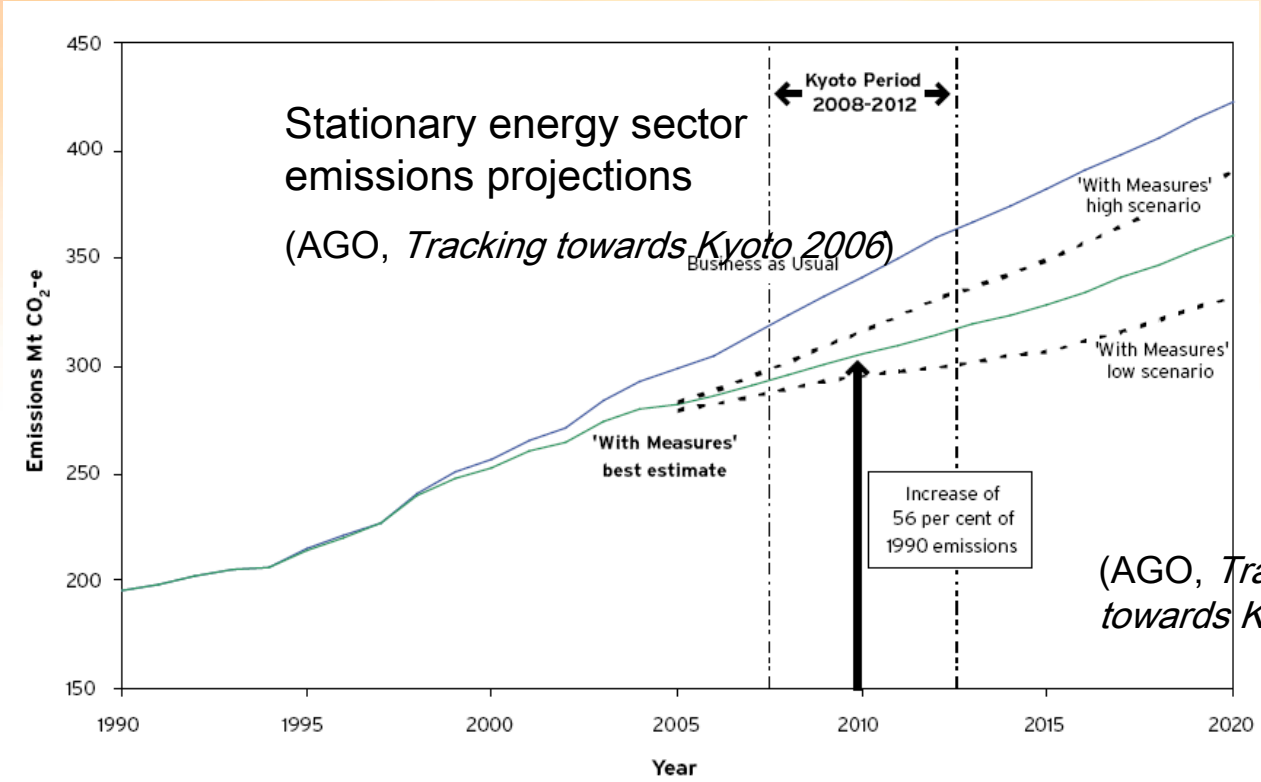
Table 1: Percentage of electricity generated from coal in selected countries

Country	Year	Percent of electricity from coal	Trend since 1990
Poland	2000	96	Steady at saturation
South Africa	2000	about 92	rising slightly towards saturation
Australia	2000	78	Steady
PR China	1999	75	small increase over the decade
India	1999	75	small increase
Czech Republic	2000	73	Steady
Germany	2000	53	fallen slightly
USA	2000	52	Steady
Denmark	2000	47	big decline as gas and wind increase
Korea	2000	42	big increase
UK	2001	37	big decline since 1986
Japan	2000	22	big increase
Thailand	1999	18	small decrease
Vietnam	1999	12	big decrease

(WWF, *Coal-fired electricity and its impact on global warming*, 2003)

Australia's challenging context for climate policy

- Energy-related emissions – 70% of total (stationary energy 50%)
  - Estimated +35% over 1990–2004, projected +56% over 1990–2010



(AGO, *Tracking towards Kyoto, 2006*)

- Growing volume + value of energy exports

Our global climate change energy options

A range of power generation options of varied status and promise for reducing greenhouse emissions

- Current coal-fired base-load and gas-fired peak-load
- Improved end-use energy efficiency
  - Wide range of end-use technologies + hence opportunities
- Lower emission and distributed fossil fuel technologies
  - eg. CCGT, CHP
- Nuclear power
- Emerging lower emission fossil fuel techs through Carbon Capture and Storage (CCS)
- Other emerging technologies - eg. fuel cells
- **Range of renewable technologies**

Q. How to assess the potential role of these options?
A. With risk-based, sustainability focussed, assessment

- *Technical status*
  - unproven => mature, emerging => widespread
- *Delivered energy services and benefits*
  - **GHG emission reductions**, flexibility, integration
- *Present costs* where known + possible future costs
  - Often wide disagreement on costs of established technologies, let alone emerging technologies
- *Potential scale of deployment*
  - possible physical, technical + cost constraints
- *Potential speed of deployment*
  - time and effort required to achieve scale
- *Other possible societal outcomes*
  - eg. other environmental impacts, energy security

Assessing renewables

A wide range of technologies of varied status and promise

- *Technical status*
  - Well proven (eg. SHW, wind, PV) to emerging (eg. Hot Rock)
- *Delivered energy services and benefits*
  - Low emission although life-cycle q's, integration challenges for some
- *Present costs* where known + possible future costs
  - Wide variation, higher direct costs than fossil fuels, potential for major cost reductions with some techs
    A range of externalities – good and bad
- *Potential scale of deployment*
  - large but various technical + economic constraints
- *Potential speed of deployment*
  - Relatively fast for proven techs but new industries take time to build
- *Other possible societal outcomes*
  - energy security potential, regional development, low env. impacts

Some global renewable energy indicators

- Impressive growth of some technologies but from generally small base
- Growing policy efforts particularly in liquid fuels

Selected Indicators	2004		2005
Investment in new renewable capacity (annual)	$30	▶	$38 billion
Renewables power capacity (existing, excl. large hydro)	160	▶	182 GW
Renewables power capacity (existing, incl. large hydro)	895	▶	930 GW
Wind power capacity (existing)	48	▶	59 GW
Grid-connected solar PV capacity (existing)	2.0	▶	3.1 GW
Solar PV production (annual)	1150	▶	1700 MW
Solar hot water capacity (existing)	77	▶	88 GWth
Ethanol production (annual)	30.5	▶	33 billion liters
Biodiesel production (annual)	2.1	▶	3.9 billion liters
Countries with policy targets	45	▶	49
States/provinces/countries with feed-in policies	37	▶	41
States/provinces/countries with RPS policies	38	▶	38
States/provinces/countries with biofuels mandates	22	▶	38

(REN, *Renewable Energy Report, 2006*)

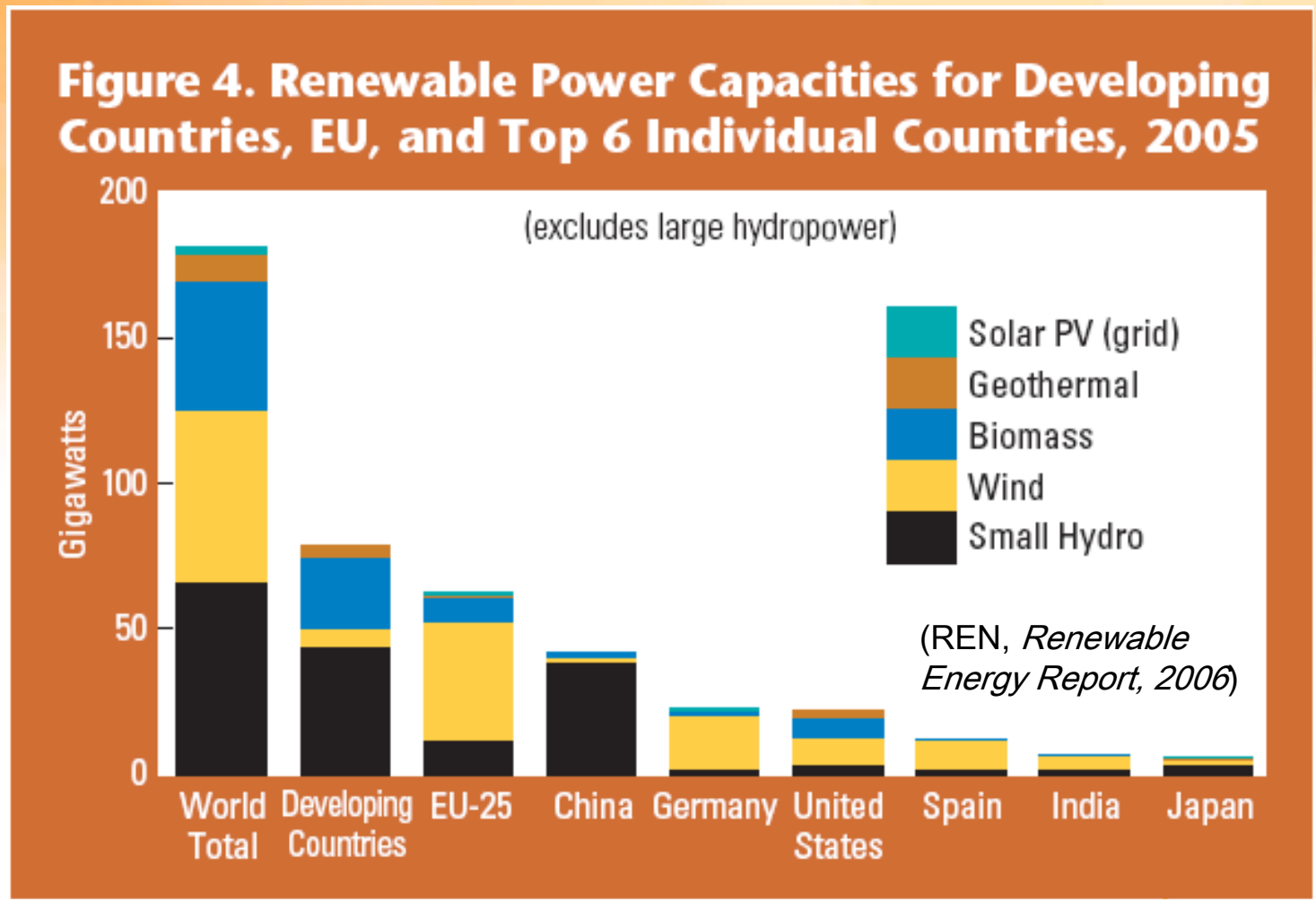
…and leading countries

- Reflecting a combination of national endowments, innovation *yet primarily policy*

Top Five Countries	#1	#2	#3	#4	#5
Annual amounts or capacity additions in 2005					
Annual investment	Germany/China (equal)		United States	Japan	Spain
Wind power	United States	Germany	Spain	India	China
Solar PV (grid-connected)	Germany	Japan	United States	Spain	France
Solar hot water	China	Turkey	Germany	India	Austria/Greece/ Japan/Australia
Ethanol production	Brazil/United States		China	Spain/India	
Biodiesel production	Germany	France	Italy	United States	Czech Republic
Existing capacity as of 2005					
Renewables power capacity (excl. large hydro)	China	Germany	United States	Spain	India
Large hydro	United States	China	Brazil	Canada	Japan/Russia
Small hydro	China	Japan	United States	Italy	Brazil
Wind power	Germany	Spain	United States	India	Denmark
Biomass power	United States	Brazil	Philippines	Germany/Sweden/Finland	
Geothermal power	United States	Philippines	Mexico	Indonesia/Italy	
Solar PV (grid-connected)	Germany	Japan	United States	Spain	Netherlands
Solar hot water	China	Turkey	Japan	Germany	Israel

(REN, *Renewable Energy Report, 2006*)

‘new’ renewable energy contributions for some key countries



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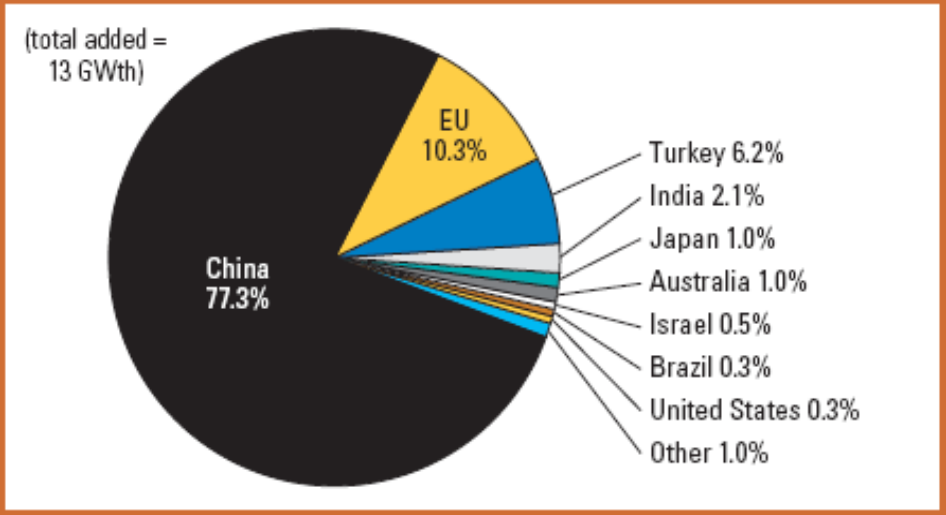
Solar Hot Water

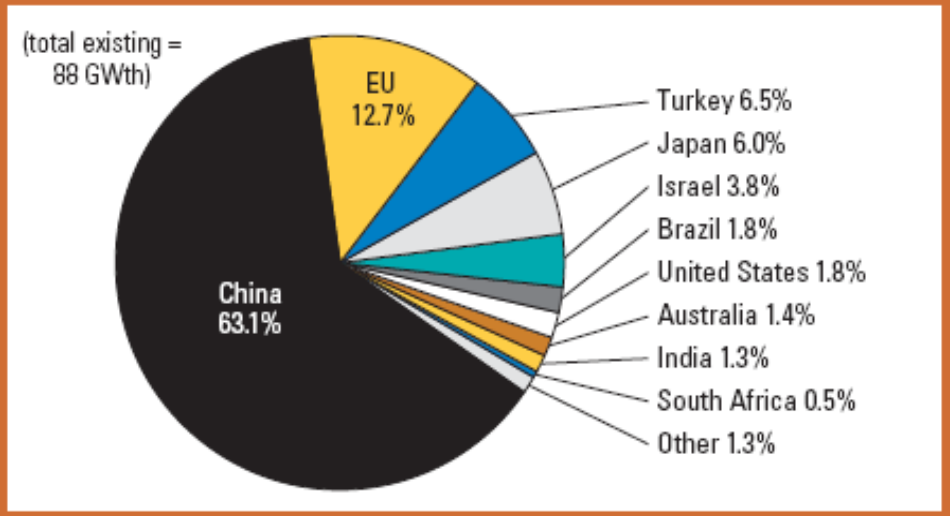
- China now dominates the world market
- Australia was formerly a key player

Figure 5. Solar Hot Water/Heating Capacity Added in 2005



(REN, *Renewable Energy Report, 2006*)

Figure 6. Solar Hot Water/Heating Capacity Existing in 2005



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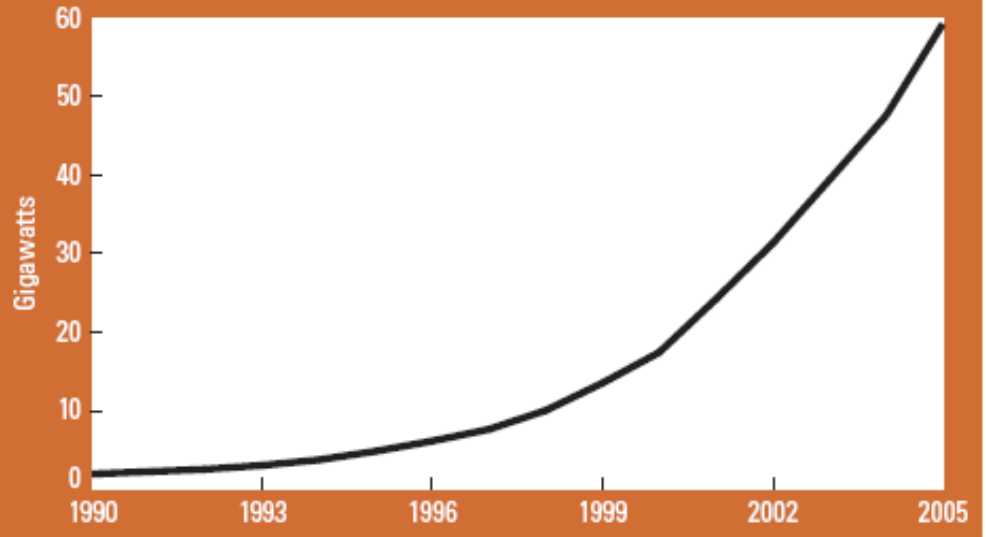
Wind power

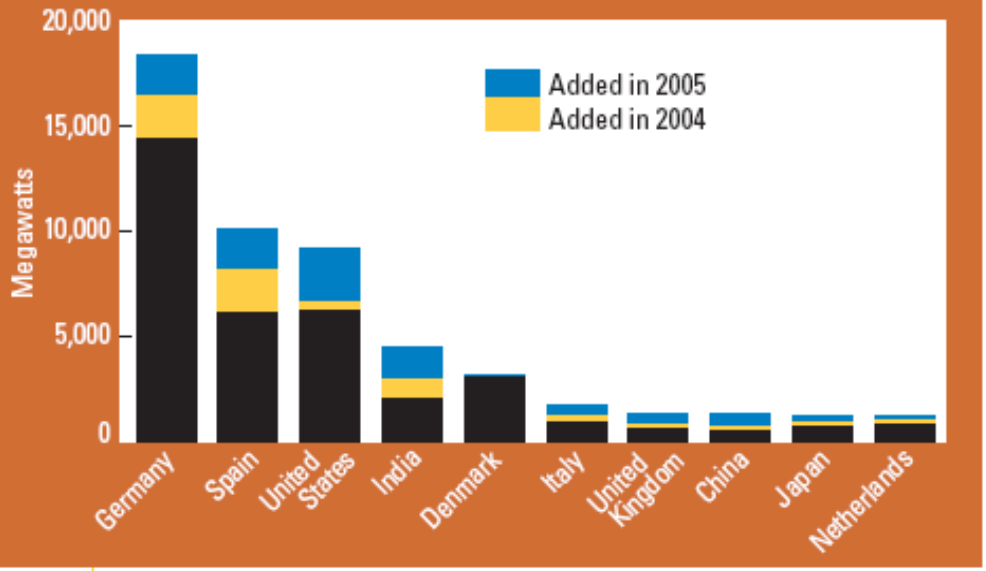
- One of the energy success stories of the last decade
  Much more new wind than nuclear now being installed each year
- Australia has a very significant wind resource yet only limited industry development at present

Figure 1. Wind Power, Existing World Capacity, 1990–2005



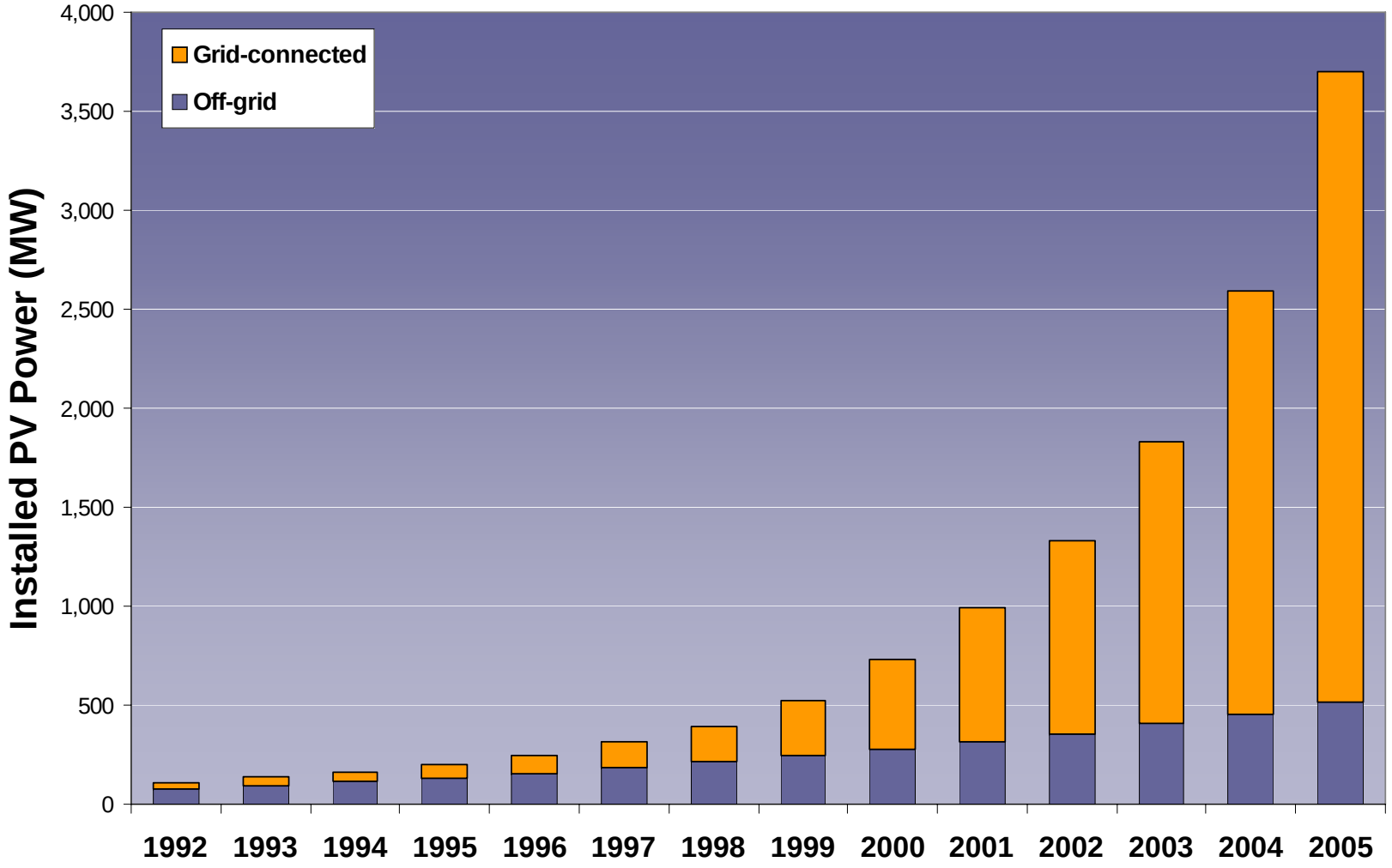
(REN, *Renewable Energy Report, 2006*)

Figure 2. Wind Power Capacity, Top 10 Countries, 2005



PV Market in IEA countries,1992-2005 (IEA PVPS, 2006)

Figure 1 Cumulative installed grid-connected and off-grid PV power in the reporting countries – Years 1992-2005



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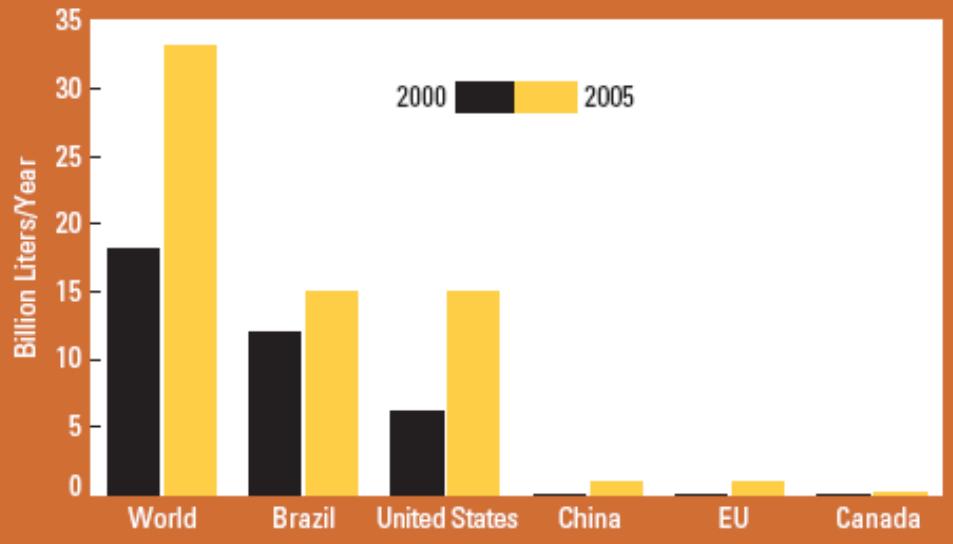
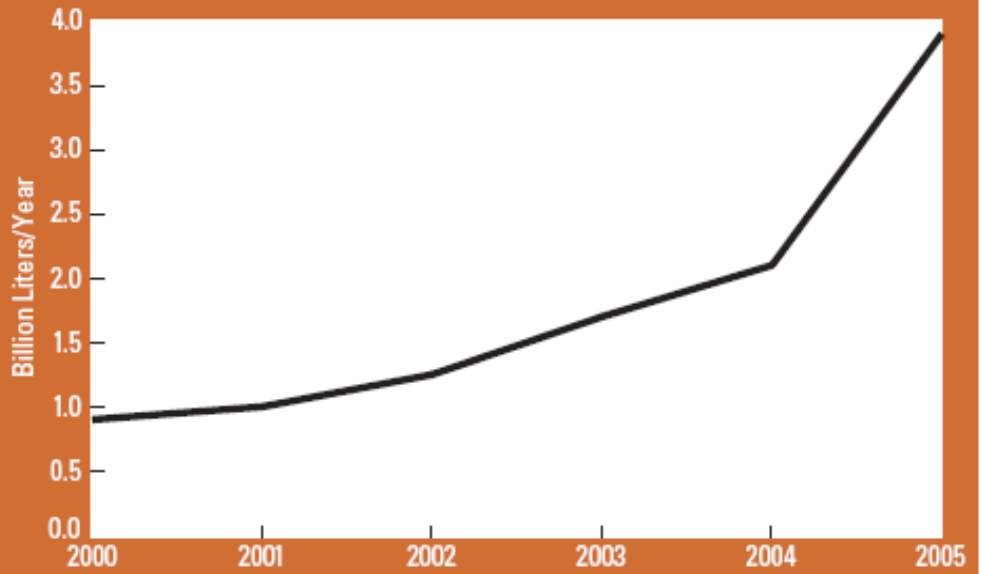
Liquid fuels

Figure 7. World Fuel Ethanol Production, 2000 and 2005



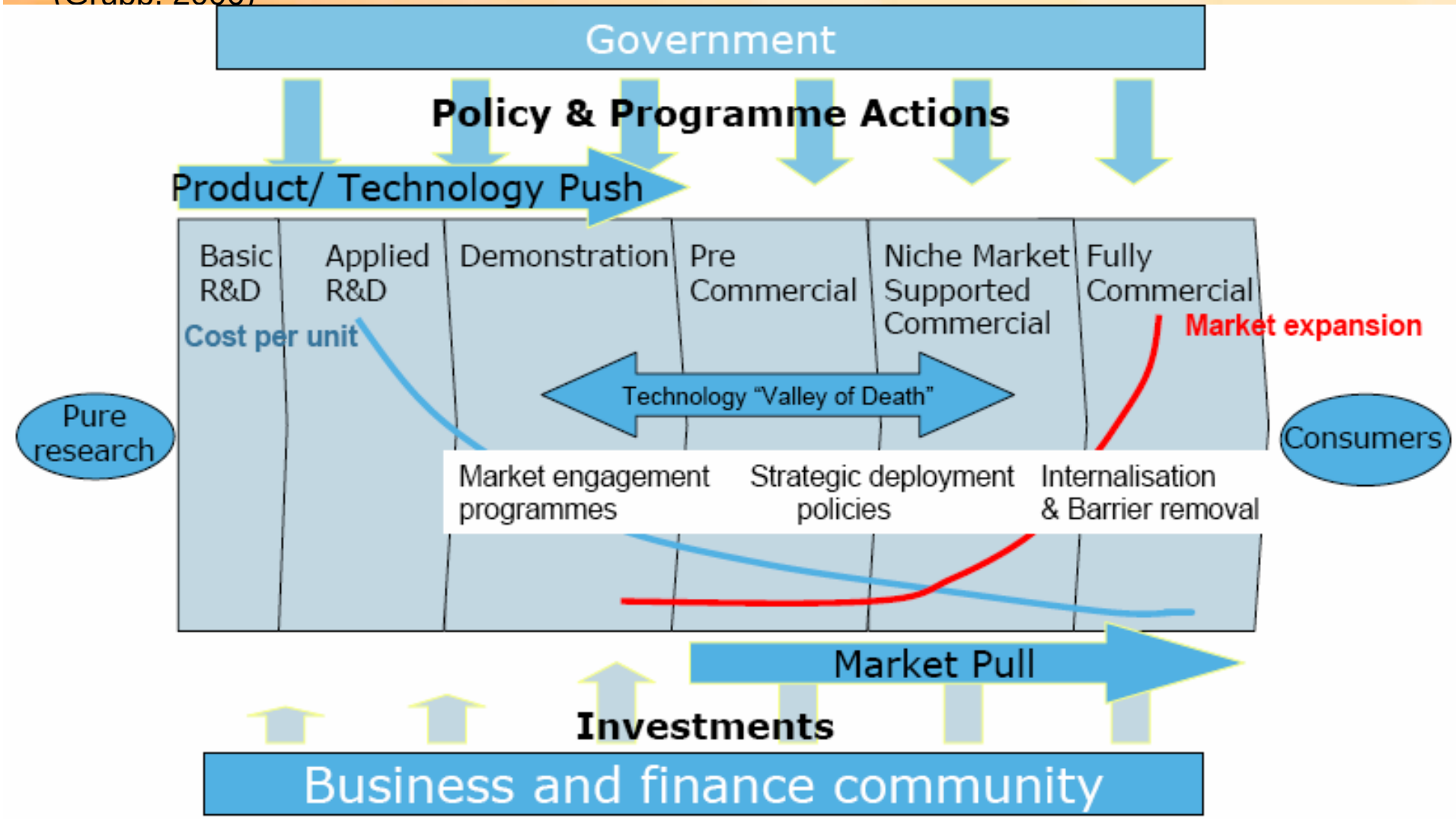
(REN, *Renewable Energy Report, 2006*)

Figure 8. World Biodiesel Production, 2000–2005



Renewable energy policy

Successful innovation requires both technology push & market pull policies (Grubb, 2006)



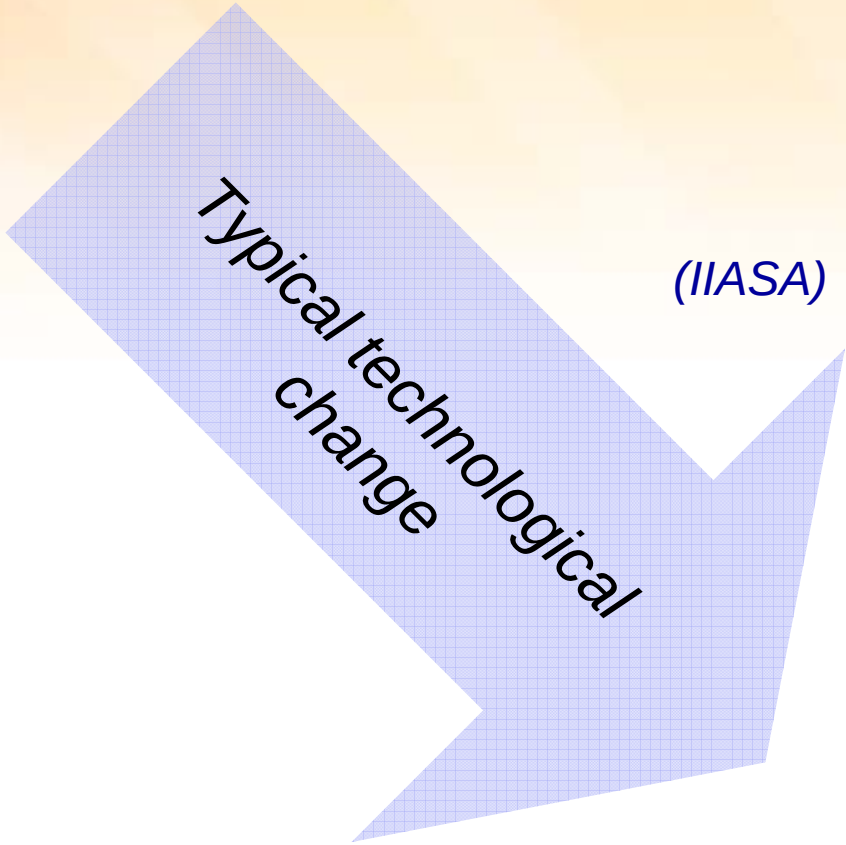
… and technology innovation involves uncertainties and hence risks – *Key Government roles*

Technology

'hardware' + 'software' + 'orgware'

Technological innovation

Invention
↓
Commercial-isation
↓
Diffusion/ adoption



Deployment and institutional 'orgware' are the keys for socio-technical transformation

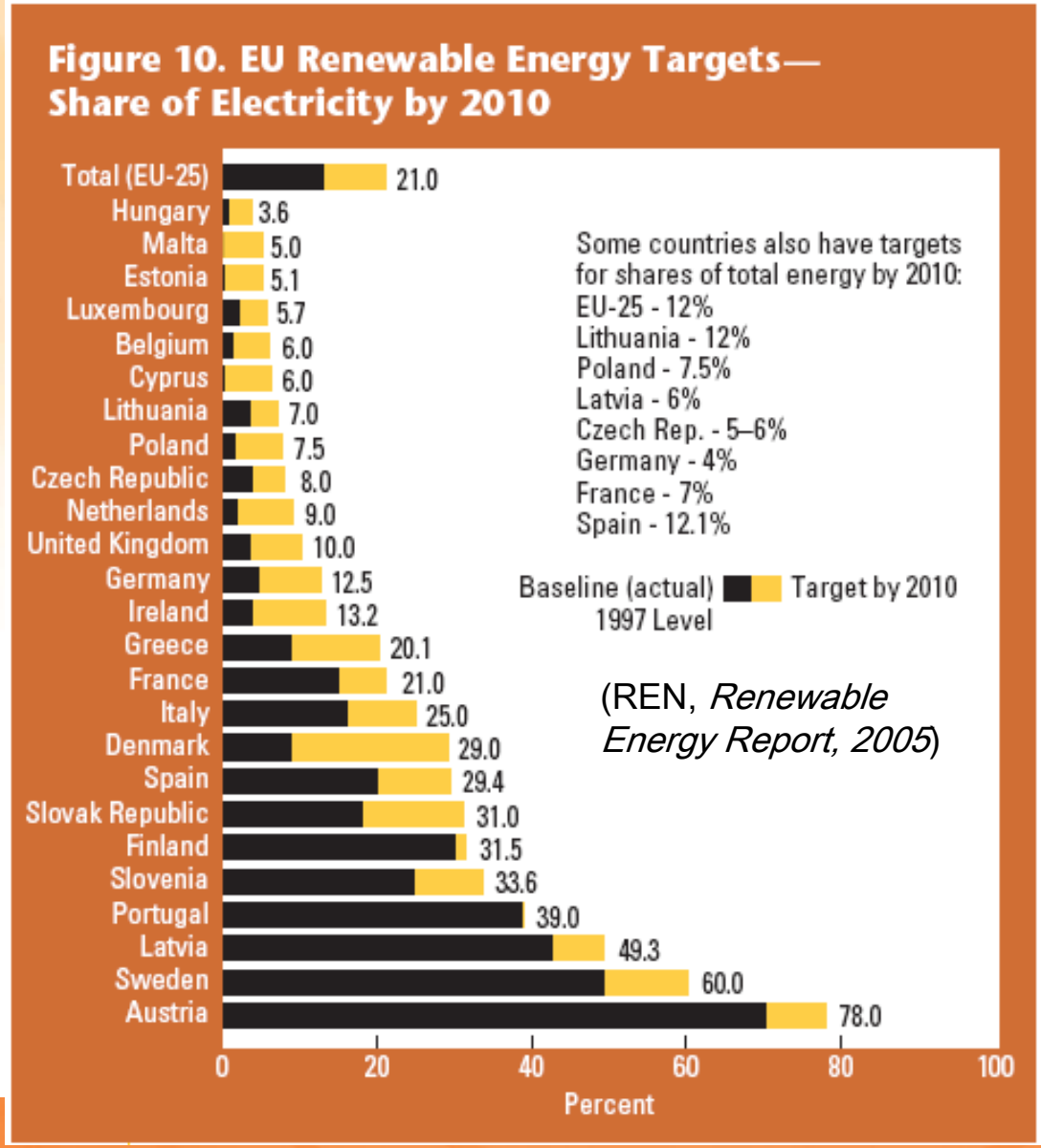
- Energy industry incumbents
  - Have economies of scale
  - Generally dominate institutions + strongly influence policy process
- Energy markets
  - Are 'designer' markets: governments make + can change rules
  - Currently don't price many of the enormous externalities – good and bad – of our energy sytems
  - Are only ever a part of energy policy framework

=> Policy priorities

  - Drive deployment of sustainable energy technologies through appropriate regulatory + market-based mechanisms
  - Strengthen institutional capacity to facilitate these technologies, and those new entrants deploying them

Renewable energy targets

- A key driver for market deployment policies
- Major targets in many countries
  The EU in particular, but also a growing number of developing countries
- However, Australia has only a very modest target
  projected to be <1% for new renewables in 2020



(REN, *Renewable Energy Report, 2005*)

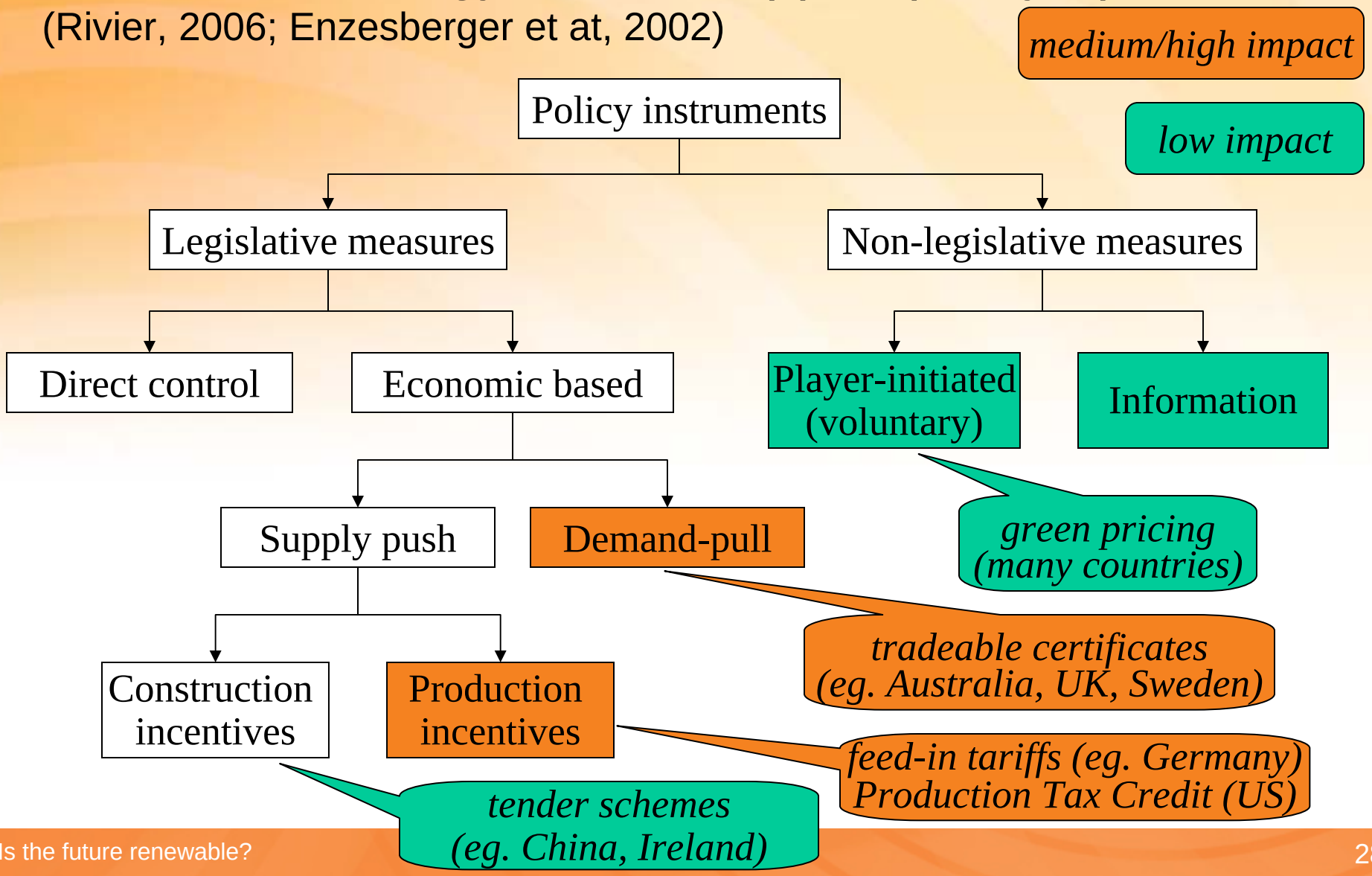
Now strengthening targets in many countries

- "The European Council reaffirms the Community's long-term commitment to the EU-wide development of renewable energies beyond 2010, underlines that all types of renewable energies, when used in a cost-efficient way, contribute simultaneously to security of supply, competitiveness and sustainability, and is convinced of the paramount importance of giving a clear signal to industry, investors, innovators and researchers. For these reasons, taking into consideration different individual circumstances, starting points and potentials, it endorses the following targets:
  - a binding target of a 20 % share of renewable energies in overall EU energy consumption by 2020;
  - a 10 % binding minimum target to be achieved by all Member States for the share of biofuels in overall EU transport petrol and diesel consumption by 2020, to be introduced in a cost-efficient way."

- China – 20% renewable electricity target for 2020 (currently ~8%)
- Growing number of US states with Renewable Energy Portfolio Standards (RPS)

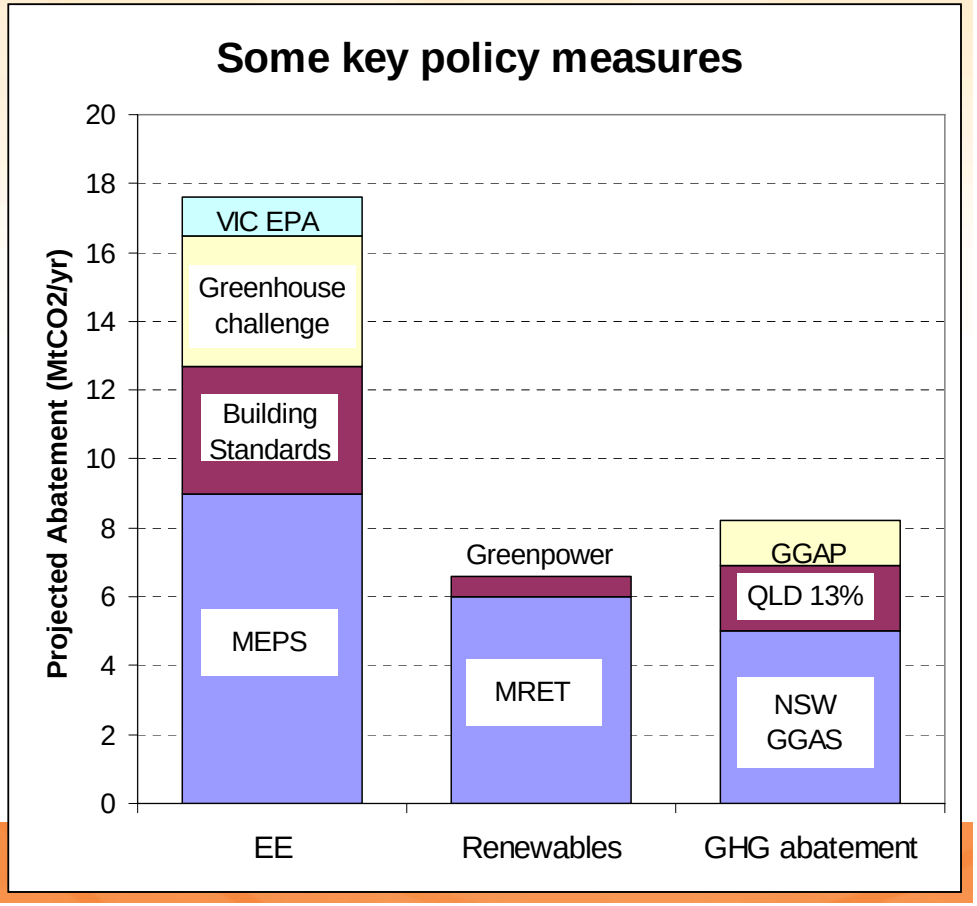
Renewable energy market support policy options

(Rivier, 2006; Enzesberger et at, 2002)



Current Australian Renewable Energy Policy

- Significant proportion of expected policy driven abatement from very modest Federal renewable energy target (MRET)
- State Govts now mandating additional renewable energy targets in absence of Federal action
- Some R&D & Demonstration 'technology push' support for emerging technologies
  but note very minor short-term emission reductions



Mandatory Renewable Energy Target

Renewable Energy (Electricity) Act 2000

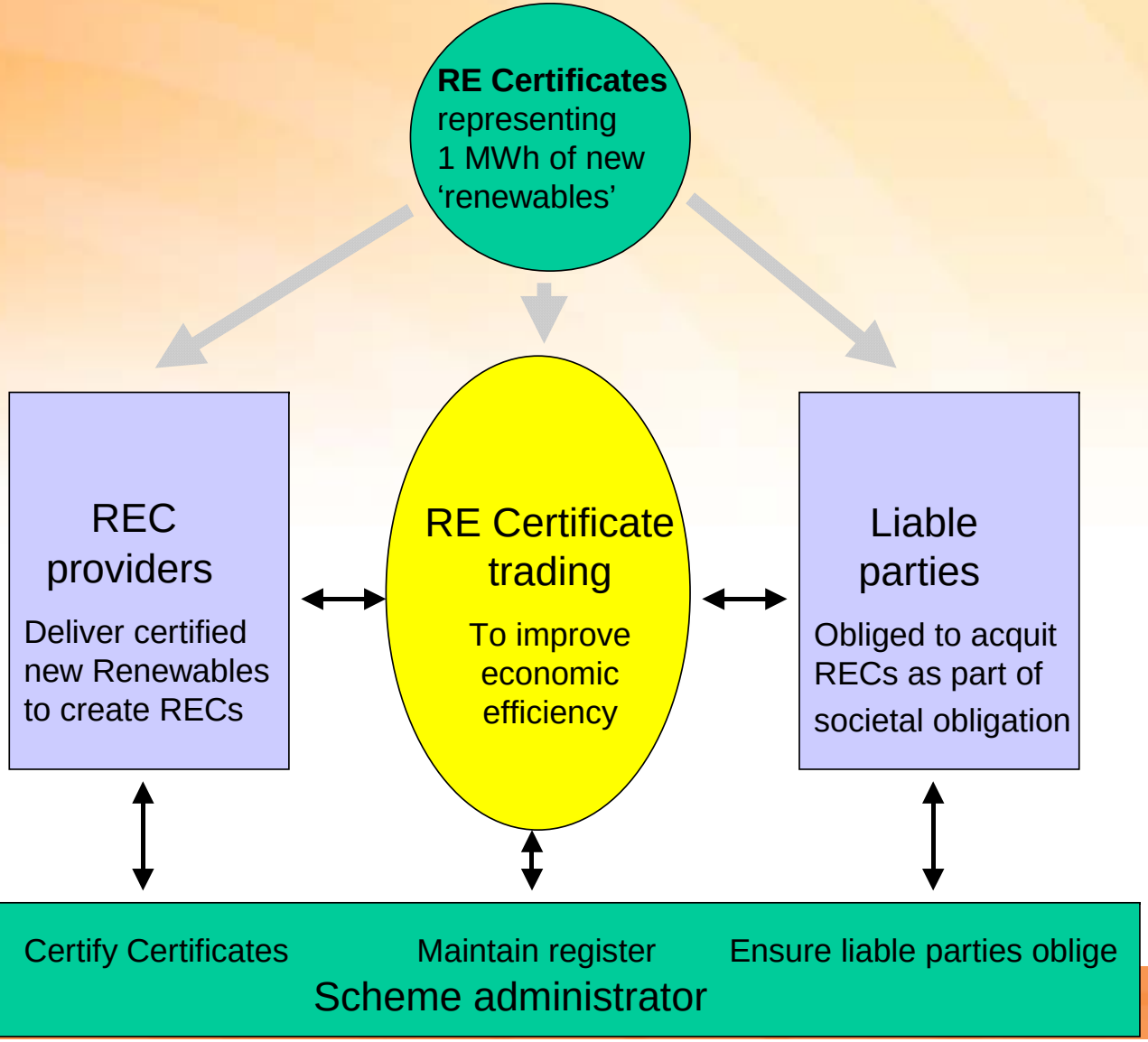
The objects of this Act are:

(a) to encourage the additional generation of electricity from renewable sources; and

(b) to reduce emissions of greenhouse gases; and

(c) to ensure that renewable energy sources are ecologically sustainable.

MRET – a 'designer' environmental market



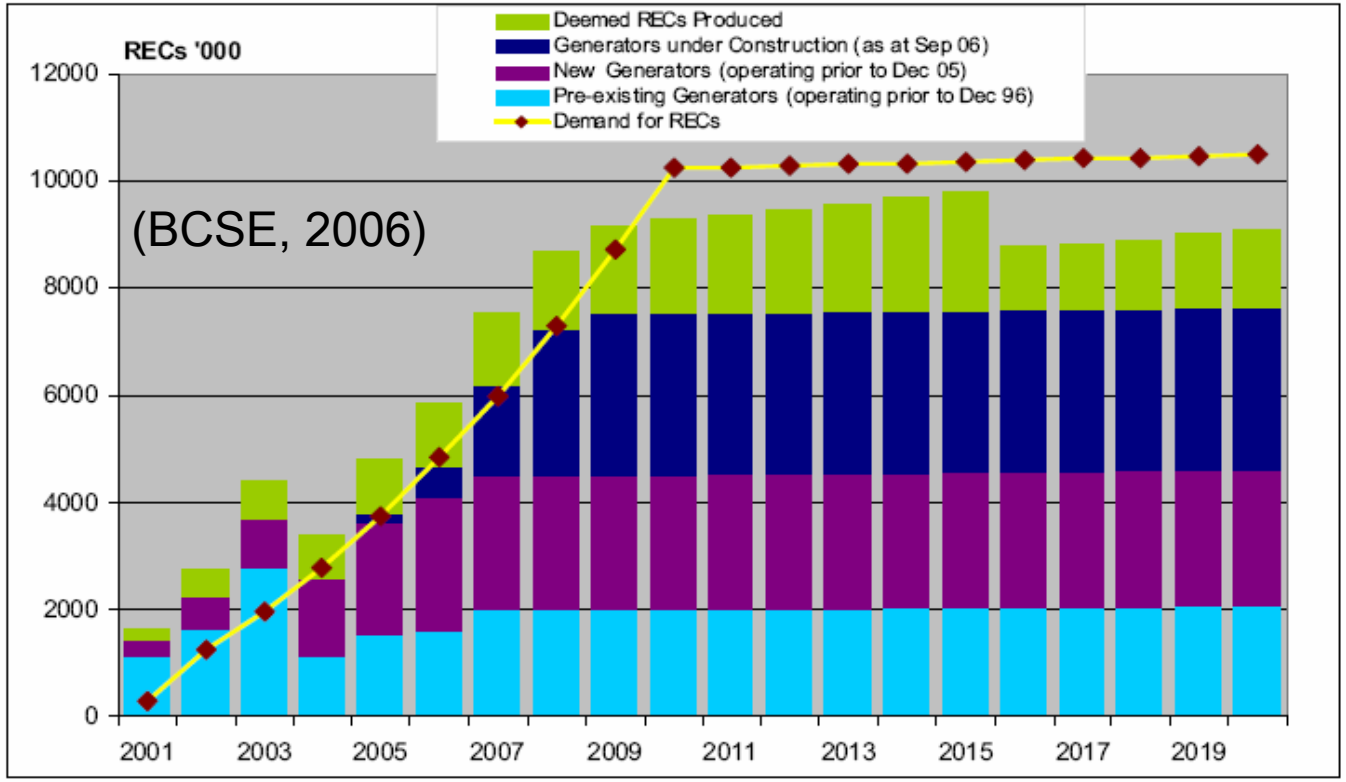
MRET performance – the good

- Ramping target easily met
- Considerable new investment
- Apparent efficiency – highly competitive RECs market with low project costs by international standards
- Technology flexibility has proved valuable
  - eg. biomass an expected winner but slow uptake in practice
    =>wind + others have filled the gap
- Facilitates integration of renewables into NEM
  - Project developers see locational, temporal energy market signals as well as renewable MWh support

But numerous challenges, including

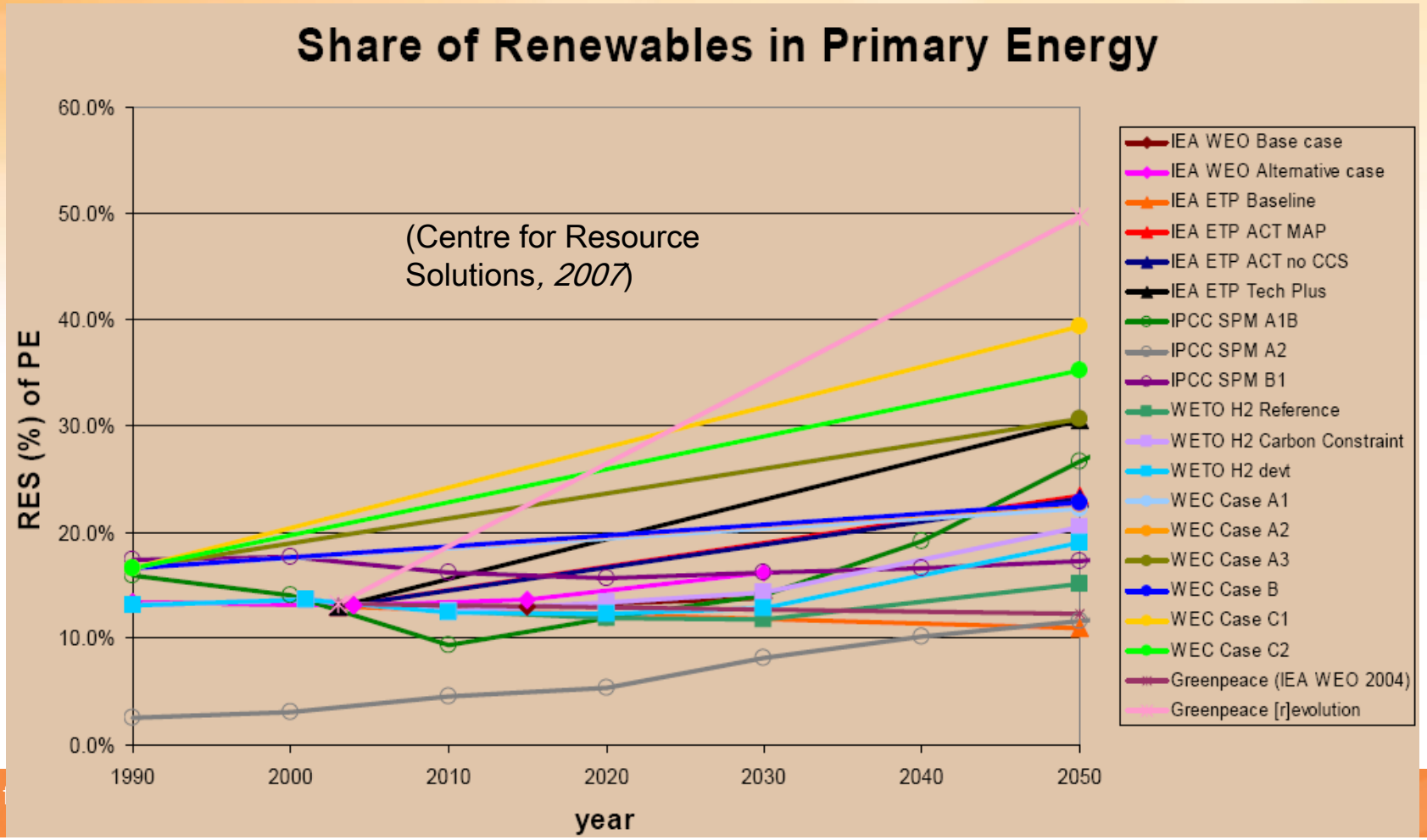
- Windfall profits to some pre-existing renewable generators due to inappropriate baselines
- Target now likely to be far less than 2% new renewables by 2020
- Boom + bust investment cycle from having a modest fixed, longer-term, target
  almost all investment that will be driven by scheme has already been made
- Considerable regulatory uncertainty during formal review processes

Figure 2.6 - RECs available to meet Demand (without new Project Commitments)

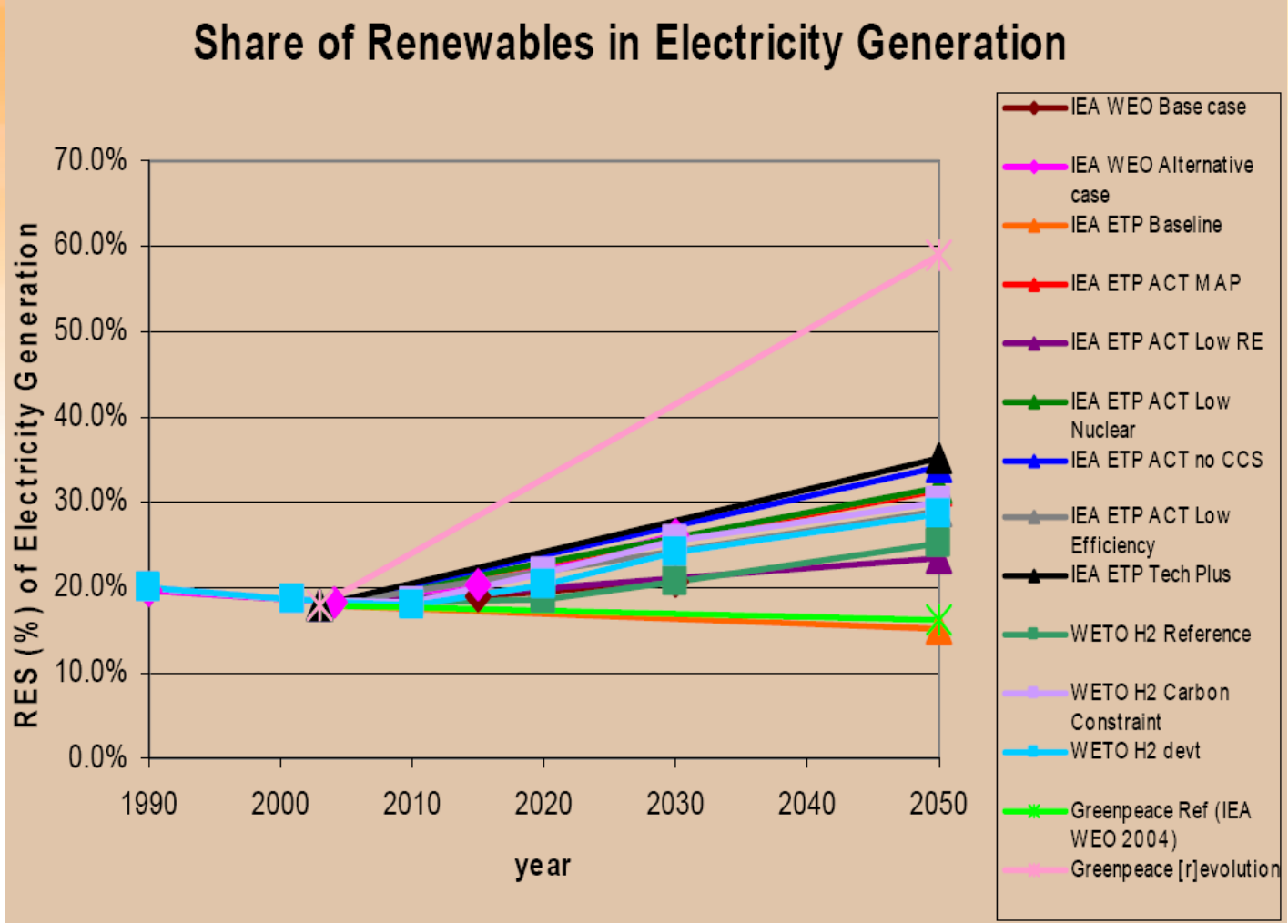


Possible renewable energy futures

- Wide range of scenarios depicting very different possible futures for renewable energy



The key determinant will be policy efforts



The policy challenge for Australia

- Possible sustainable energy futures all need greater renewables *but* not a matter for speculation but action
- Government policy roles in invention, commercialisation and, by far most importantly, **diffusion**
  - Risks in trying to pick winners but need to establish priorities
  - Start now with primary focus on greater diffusion of existing options
- Current Australian policy framework appears unbalanced
  - Major focus on R&D and demonstration of emerging technologies, particularly CCS, but also renewables
  - However, ".. there is no certainty when and to what extent the necessary technologies will be developed." (IEA, 2005)
  - *More support required for existing and possible future options by carbon price, regulation and* ***targeted 'niche' markets for renewables***

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