Technological Development Policy and mitigation

EE 376

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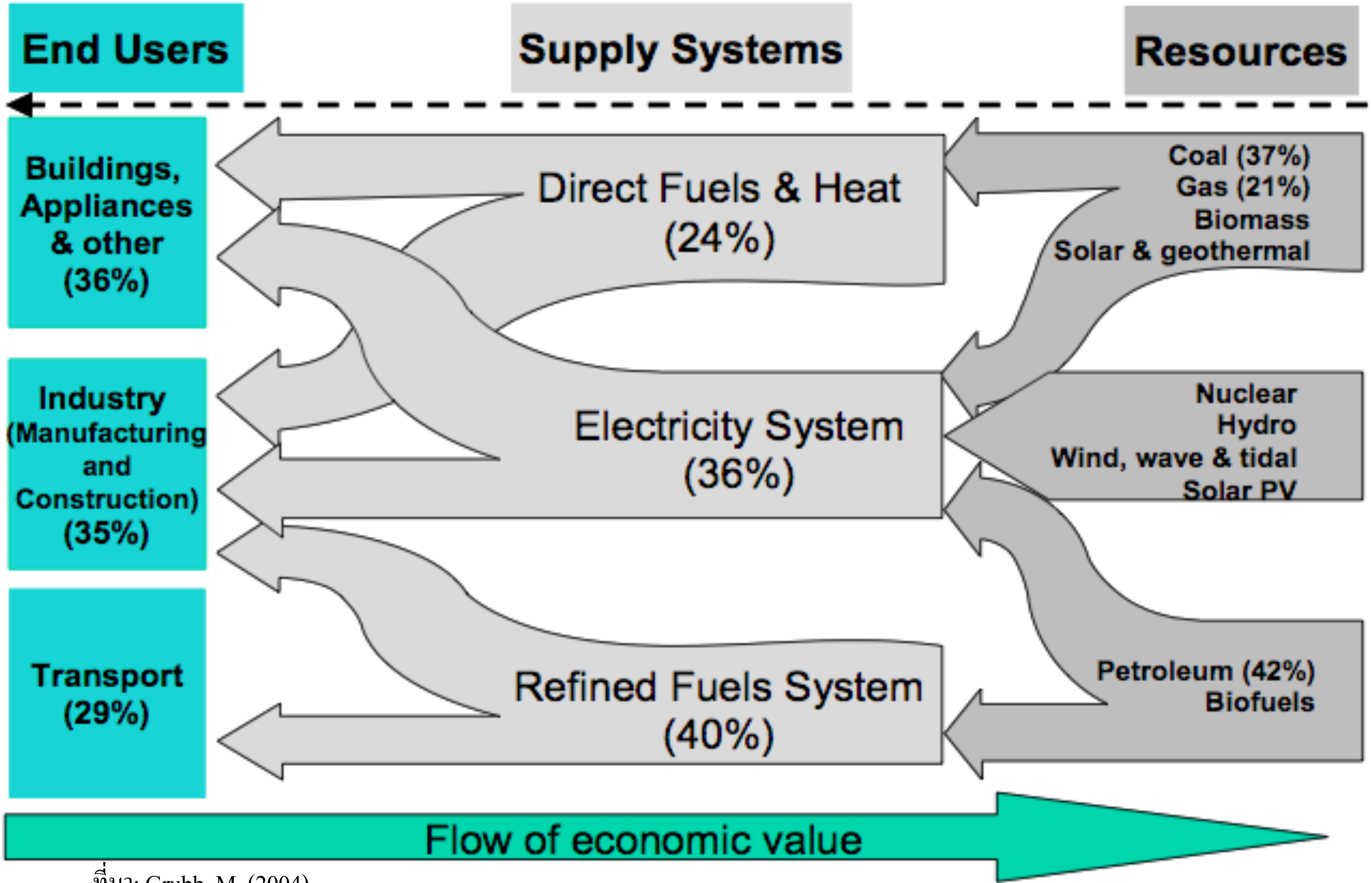
Outline

- The need for GHGs mitigation
- Why do mitigation technology need support?
- The ‘technology-push’ vs ‘demand-pull’ debate
- Steps in the innovation chain
- GHGs mitigation and Induced Technological Change (ITC)
- ITC enhancing policies
- Incremental Abatement Cost of mitigation technologies

The need for GHGs mitigation

- To keep the concentration of GHG below 450 ppm, IPCC IPPC Working Group III report (Box 13.7, p.776) proposes
  - Annex I must decrease GHGs 25 – 40% by 2020 and 85 – 90% by 2050
  - Non-Annex I mus decrease GHGS 15%-30% by 2020 and substantial deviation from baseline in all regions

Sources of GHG



ที่มา: Grubb, M. (2004).

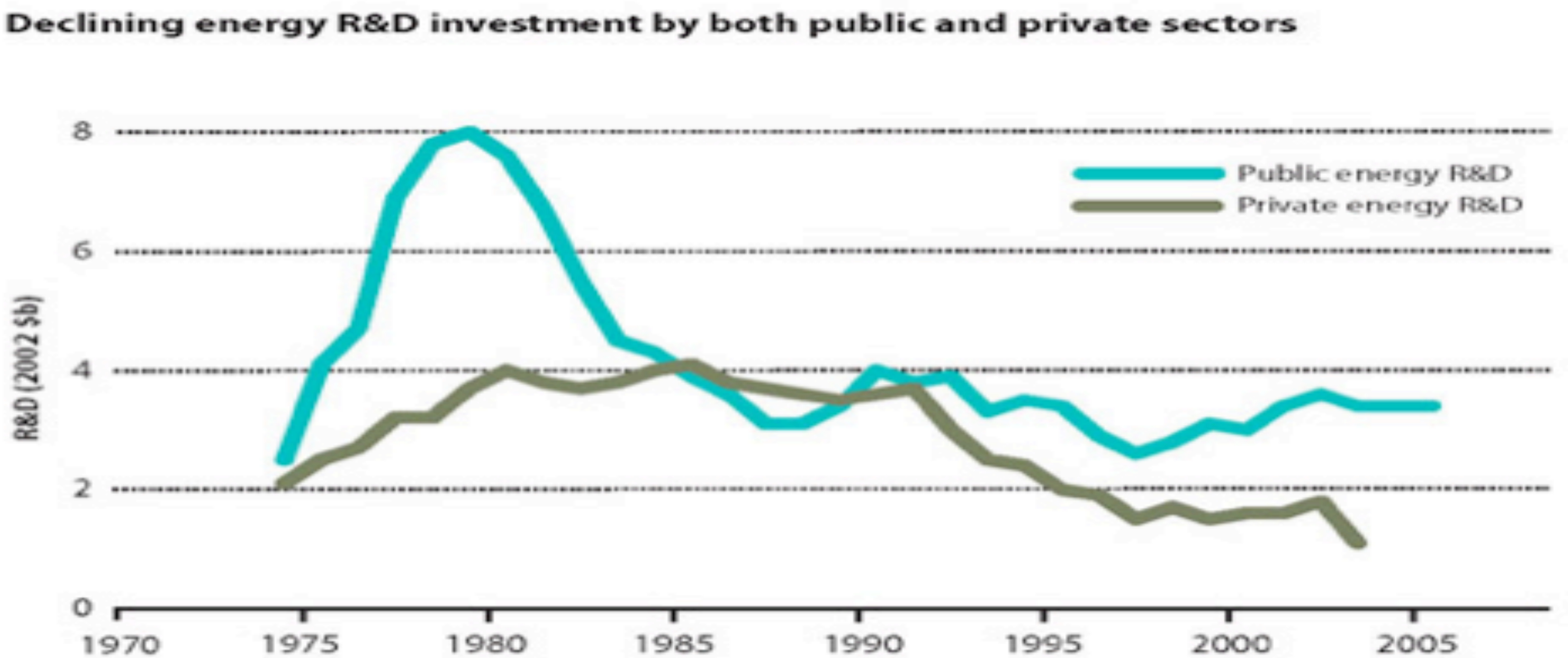
The need for GHGs mitigation

- Technological improvement in production can decrease only one third of GHGs emissions
- It is also necessary to develop mitigation technology for transports and building
- However, historical data has shown that the technology for GHGs mitigation progressed slower than that of other sectors

Why do mitigation technology need support?

- Technology in pharmaceutical and IT sectors progress faster and has higher private share of R&D investment
  - Pharmacy: private R&D intensity was 10 – 20% of the net sales (Neuhoff, 2005)
  - Electricity: Both R&D intensity of the government and private sectors declined rapidly after 1980-1985 and reached only 0.4% of the net sales (Margolis and Kammen, 1999)

Declining energy R&D investment



Sources: R. M. Wolfe, "Research and Development in Industry" (National Science Foundation, Division of Science Resources Statistics, 2004); M. Jefferson, et al., "Energy Technologies for the 21st Century" (World Energy Council, 2001); R. L. Meeks, "Federal R&D Funding by Budget Function: Fiscal Years 2003-05" NSF 05-303 (National Science Foundation, Division of Science Resources Statistics, 20040; R. Margolis, and D. M. Kammen "Underinvestment: The energy technology and R&D policy challenge", Science, 285, 690-692 (1999).

Why do mitigation technology need support? (2)

- R&D requires huge investment and takes time
  - Making it very risky and therefore has less incentive to invest

- The new discovery is a public good which creates spillover effects to other firms and non-exclusive. This leads to free rider problems
  - R&D incentives are too low --> Market failure
  - Government must protect the innovator (e.g., license) or subsidize the innovation

Why do mitigation technology need support? (3)

- Drugs and IT have product differentiation to stimulate demand while energy sector has none
  - Better drugs or smarter and faster phones generates higher profits that compensate the risks for the innovator
  - Electricity has neither variety nor can be faster
- GHGs create externalities which have no market price and no private property --> market failure
- With out product differentiation and externalities, the power sector is difficult to develop and need government assistance

The ‘technology-push’ vs ‘demand-pull’ debate (1)

Technology-Push: R&D-led technical change	Demand Pull: Market-led technical change
Technical change depends mostly on autonomous trends and government R&D	Technical change depends mostly upon corporate investment (R&D, and learning-by-doing) in response to market conditions
Atmospheric stabilization likely to be very costly unless big R&D breakthroughs	Atmospheric stabilization may be quite cheap as incremental innovations accumulate
Efficient instrument is government R&D, Complemented, if necessary, by ‘externality price’ (eg. Pigouvian tax) phased in.	Efficient response may involve stronger initial action, including emission caps /pricing, plus wide mix of instruments, targeted to reoriented industrial R&D and spur market-based innovation in relevant sectors. Potentially with diverse marginal costs

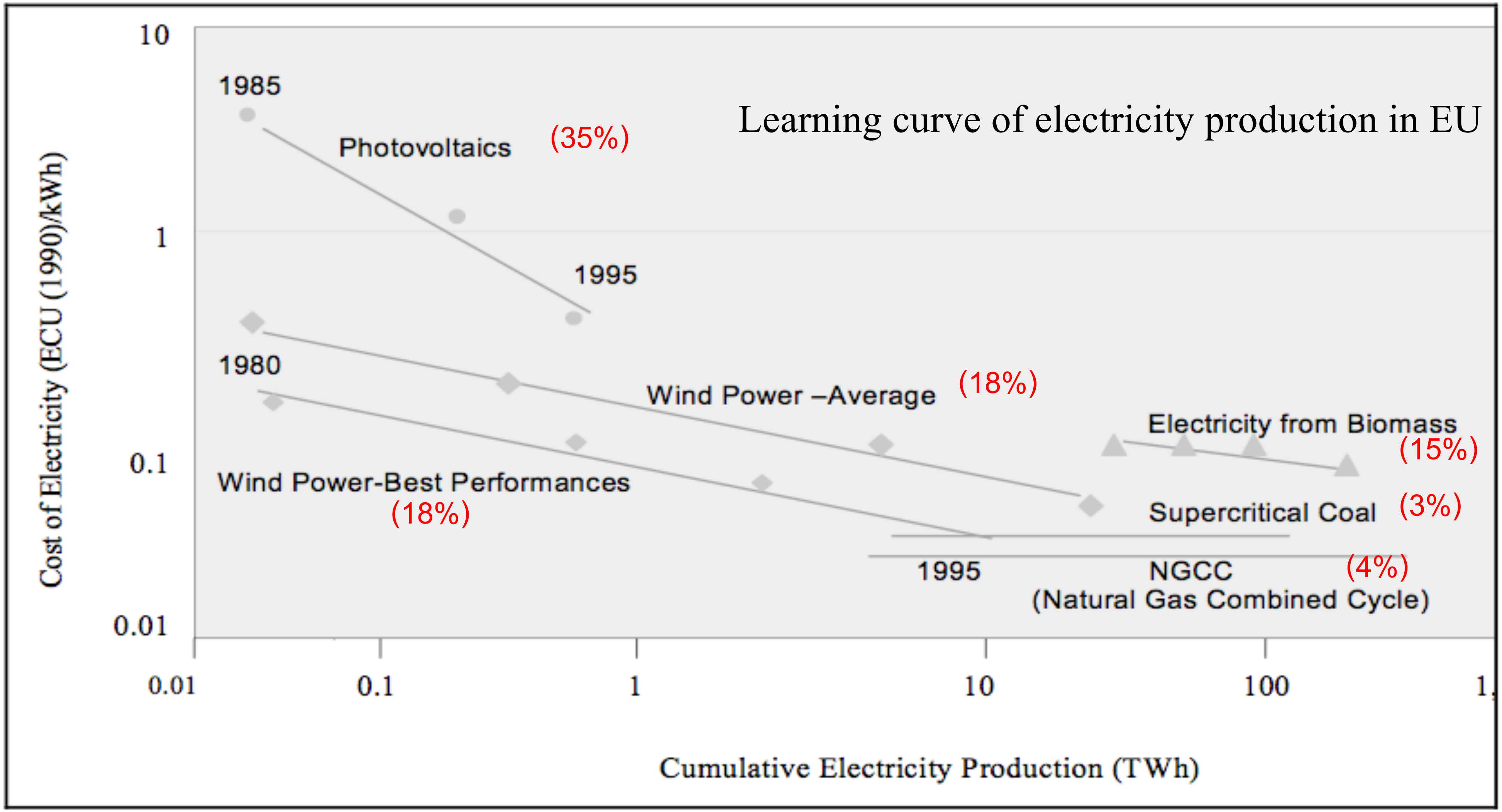
Source: Grubb 2004.

แนวคิดในการพัฒนาเทคโนโลยีเพื่อการจัดการ GHS (2)

Technology-Push: R&D-led technical change	Demand Pull: Market-led technical change
Defer abatement to await technology cost reductions	Accelerate abatement to induce technology cost reductions

Source: Grubb 2004.

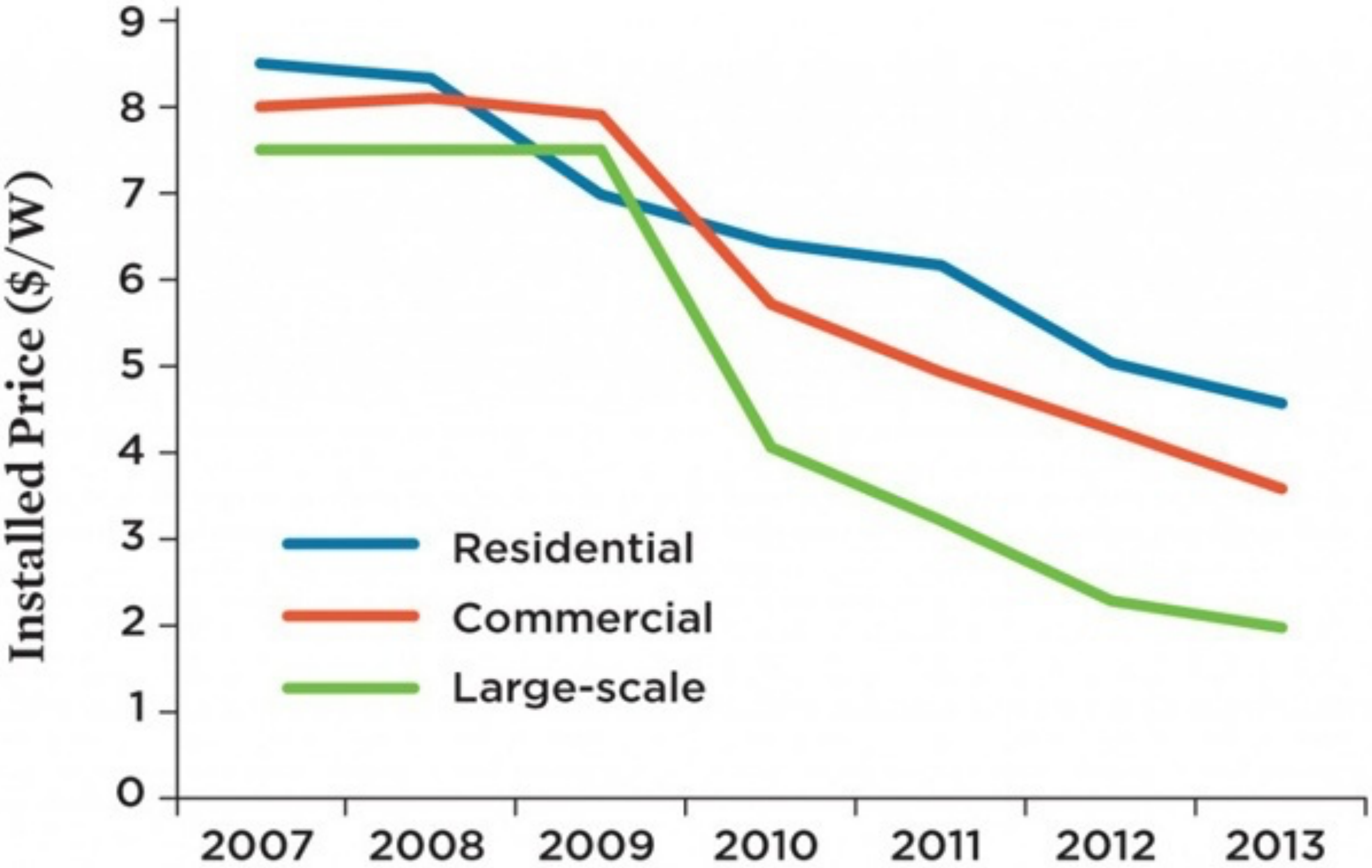
Empirical evidence and learning curves



Source: IEA (2000) Reprint in Alberth (2006).

Note: % in parenthesis represents Learning rate = 1- PR where PR = progress rate ratio which is the percentage of the ratio of the cost in the last year by the cost in the beginning year

FIGURE 3. The Falling Price of Solar PV by U.S. Sector, 2007–2013



Photovoltaic power purchase agreement prices

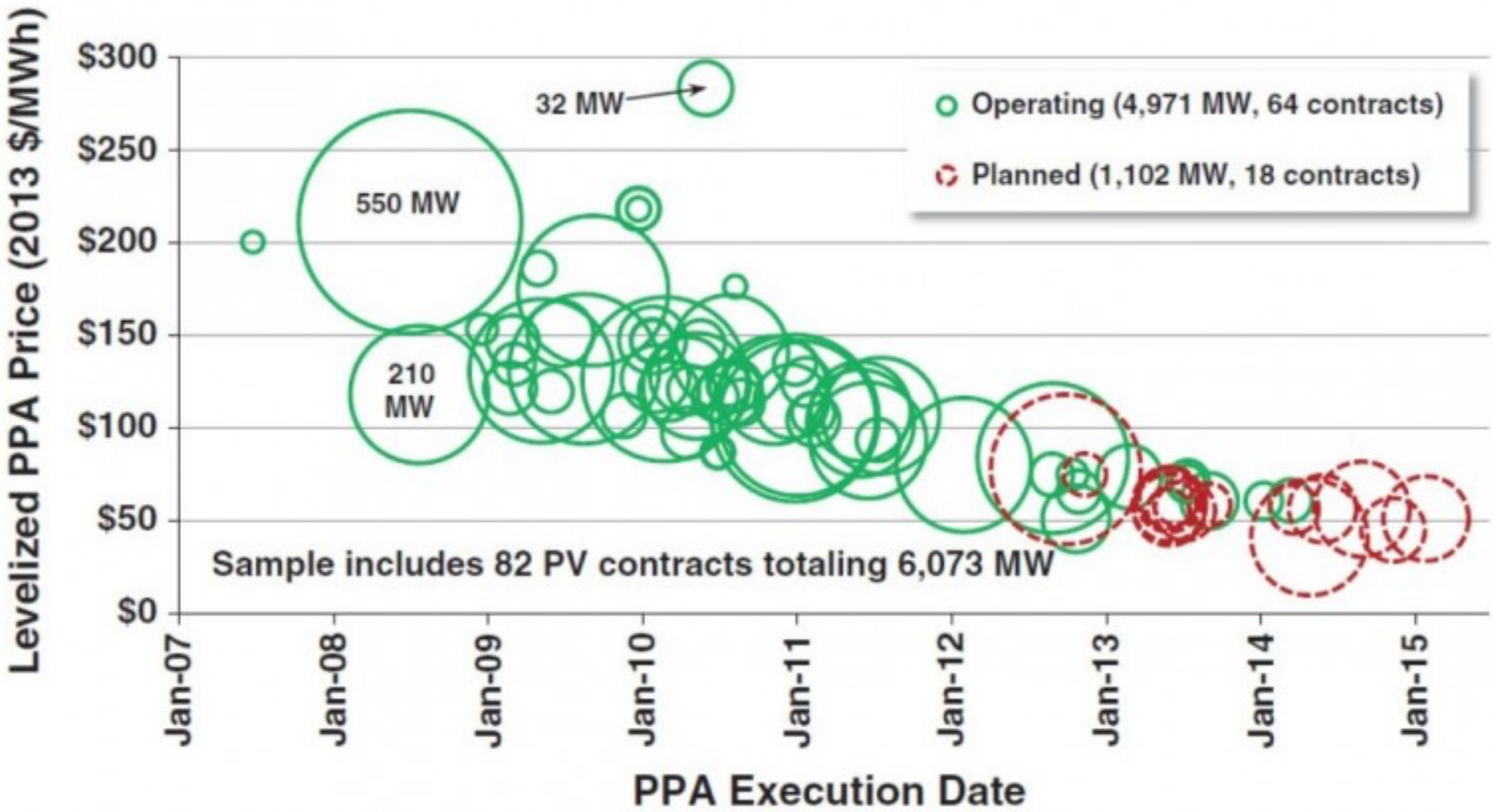
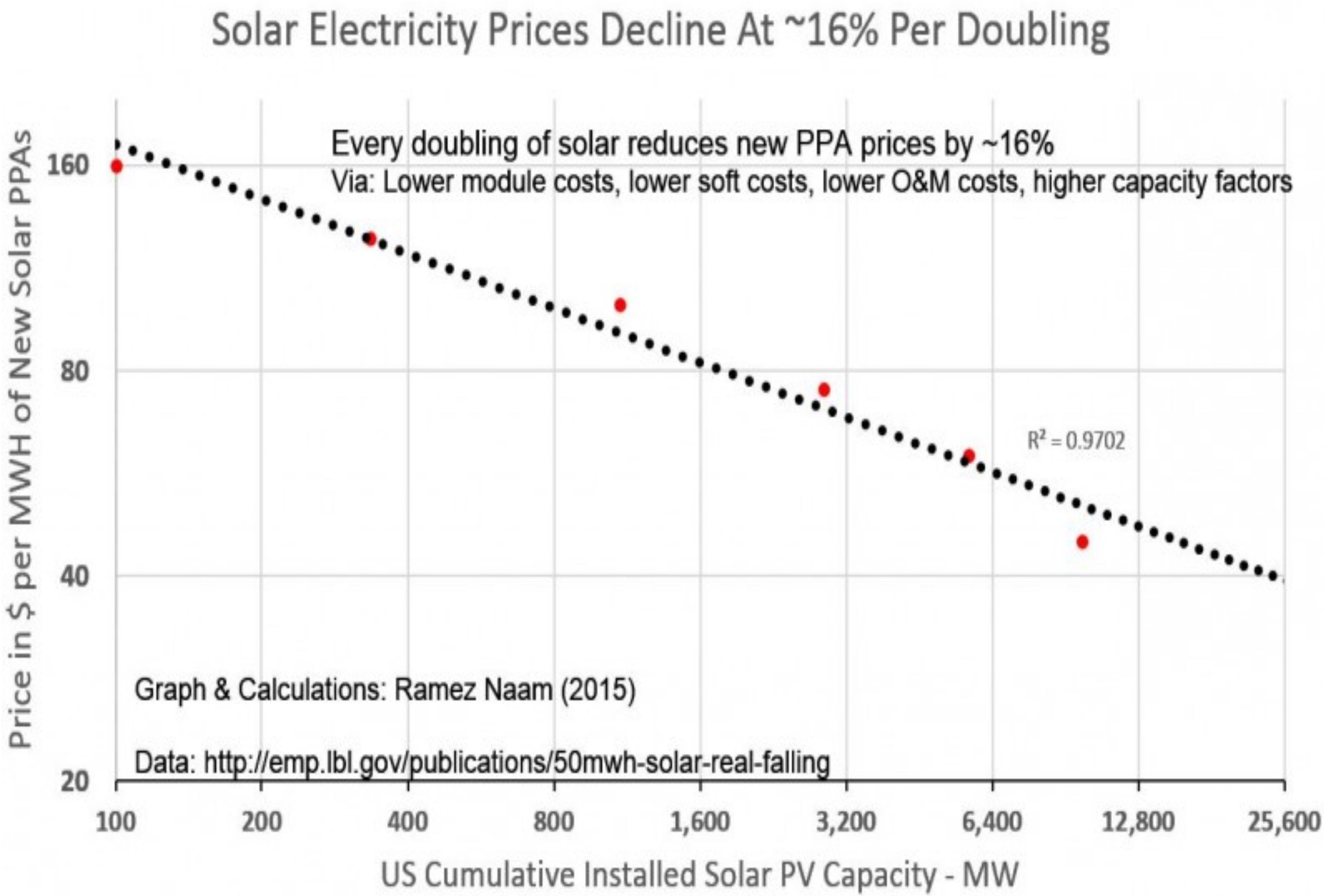


Figure 1. Levelized US utility-scale photovoltaic power purchase agreement (PPA) prices by operational status and PPA execution date.

http://rameznaam.com/2015/08/10/how-cheap-can-solar-get-very-cheap-indeed/

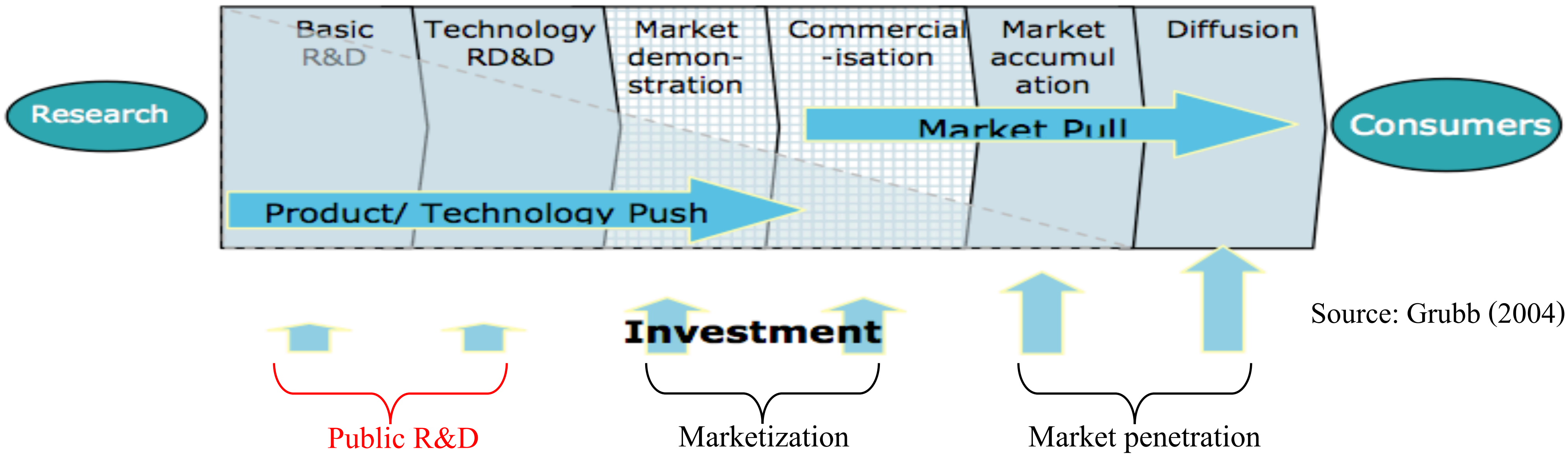


http://rameznaam.com/2015/08/10/how-cheap-can-solar-get-very-cheap-indeed/

Steps in the innovation chain (1)

- Basic research and development
- Technology-specific research, development and demonstration
- Market demonstration of technologies to show to potential purchasers and users that the technology works in real-world applications and test its viability and potential market
- Commercialization – either adoption of the technology by established firms, or the establishment of firms based around the technology
- Market accumulation in which the use of the technology expands in scale, often through accumulation of niche or protected markets
- Diffusion on the large scale

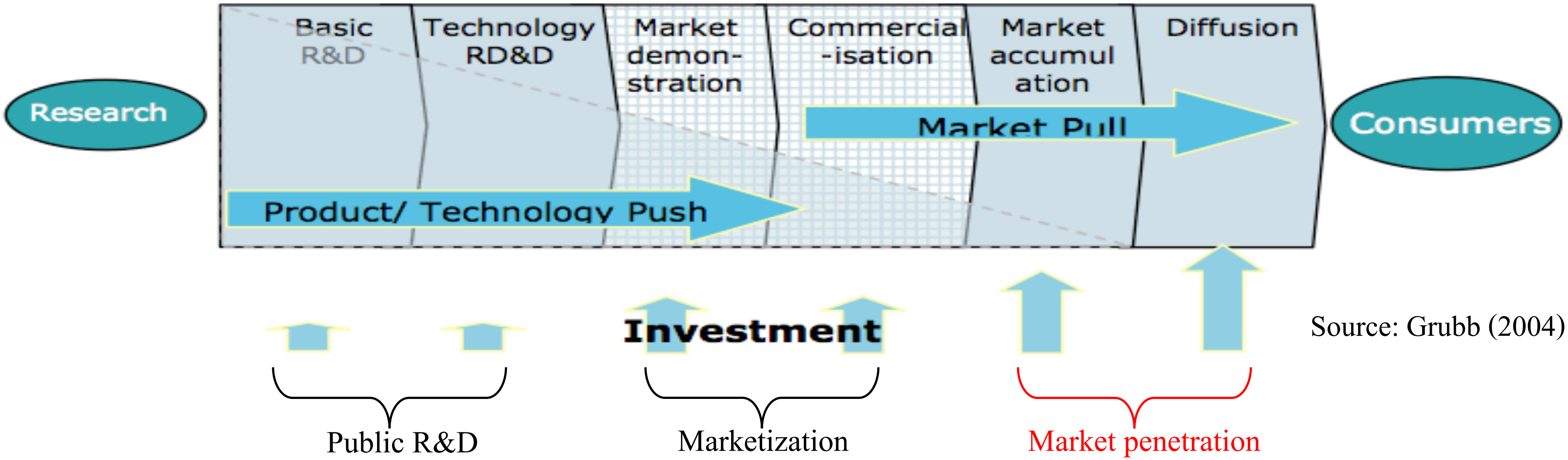
Steps in the innovation chain (2)



Source: Grubb (2004)

- Public R&D: the period of developing new technology, with high technical risks, returns on investment are not yet realized
  - government should be the main budget provider for R&D
  - the Technology push concept is more appropriate

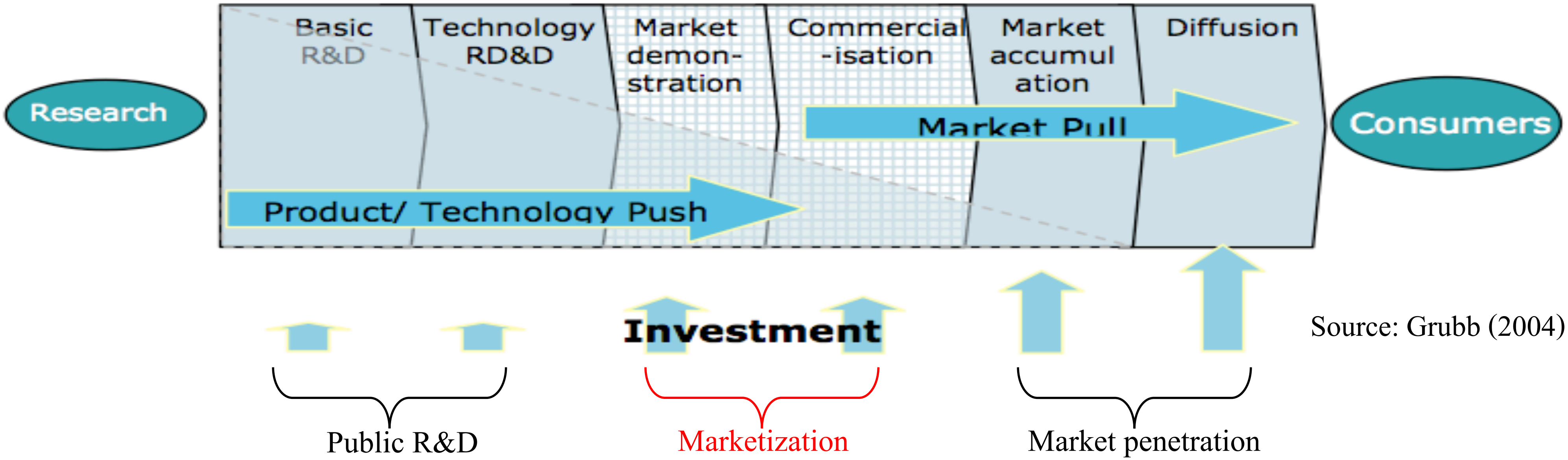
Steps in the innovation chain (3)



Source: Grubb (2004)

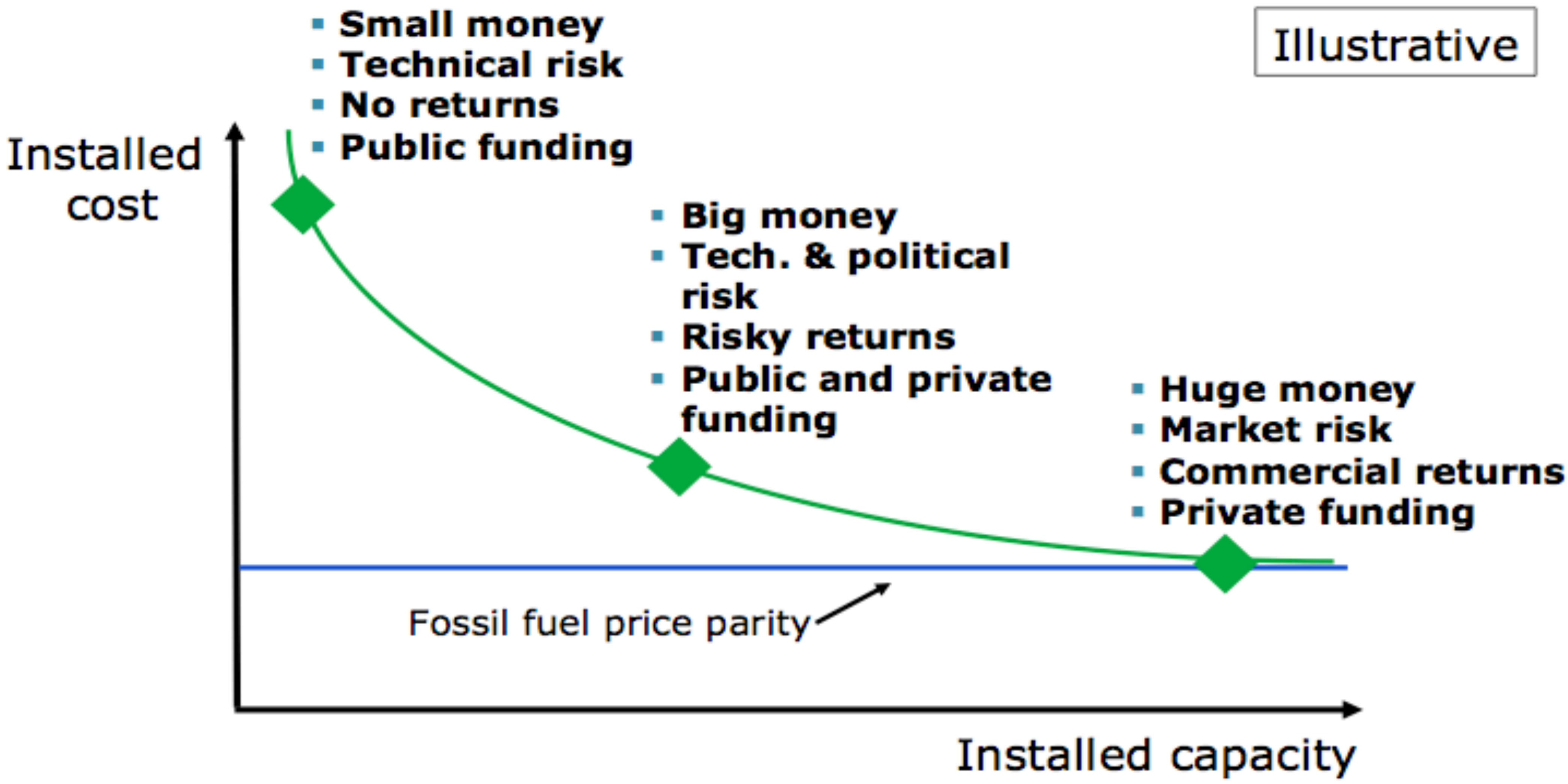
- Market penetration: the market and business risks are high, need large investment to create economies of scale
  - Private firms should be the main source of financial supports more than the government
  - Demand pull concept is more appropriate

Steps in the innovation chain (4)



- Marketization: should combine both concepts with joint supports
- GHGs technology development can combine both concepts
- Apply technology push for developing basic knowledge and prototypes then gradually adjust toward the demand pull

Steps in the innovation chain (5)



Source: Grubb (2004)

GHGs mitigation and Induced Technological Change (1)

- Induced Technological Change (ITC): GHGs mitigation can induce faster technological innovation. Goulder (2004) concludes that
- ITC from climate policies cause the mitigation costs decrease
- Most studies on the impacts of climate policies uses models that do not consider the ITC effects; thus the mitigation costs were over estimated
- The ITC effect implies that it is more reasonable to impose stringent climate policies and the optimal timing should be earlier
  - Although technology can be autonomous, climate policies can speed up the change by inducing more R&D and learning-by-doing

GHGs mitigation and Induced Technological Change (2)

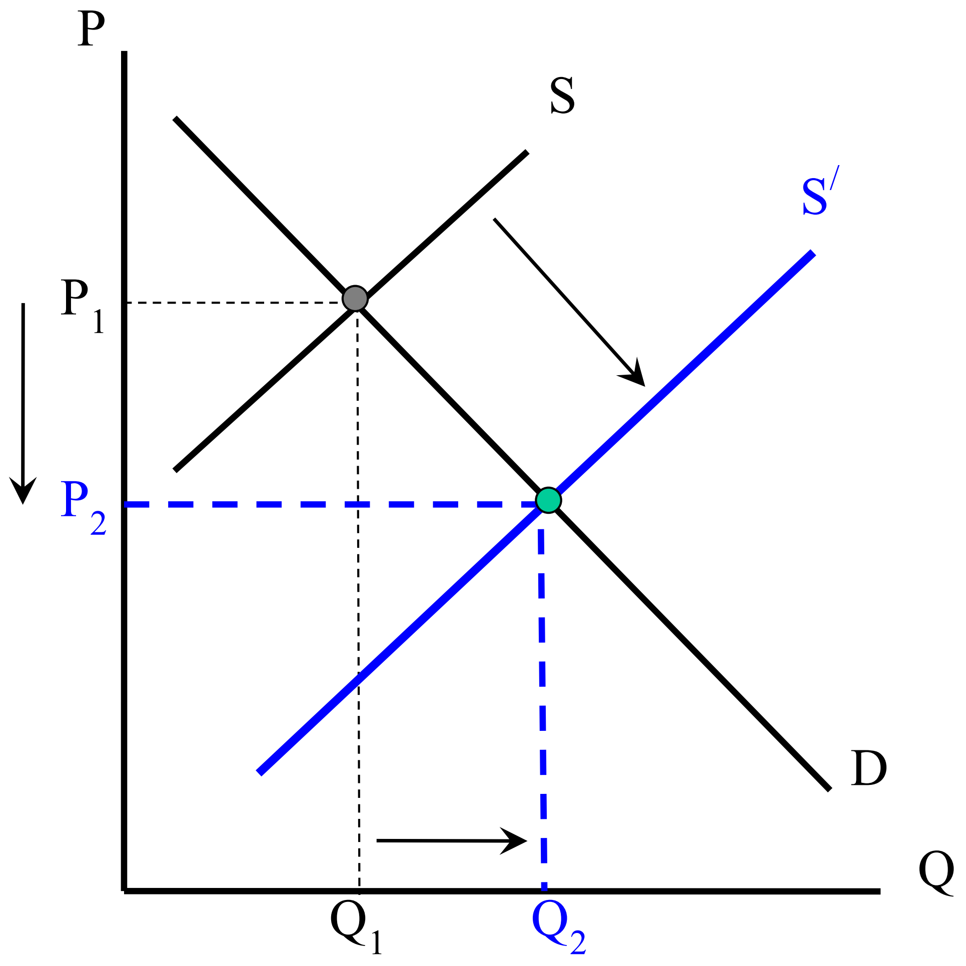
- Announcing the GHGs mitigation policy in advance can help to lower the policy costs
  - Goulder and Schneider (1999) found that a 10-year advanced announcement of $25/ton carbon tax helps lowing 1/3 of the costs compared with no announcement
- The government should use technology-push to solve the market failure resulting from free riding problems and the externalities
  - Subsidizing low carbon technology to solve the free riding problems
  - Carbon pricing policies (e.g., carbon markets or carbon taxes) to solve the externalities

ITC enhancing policies (1)

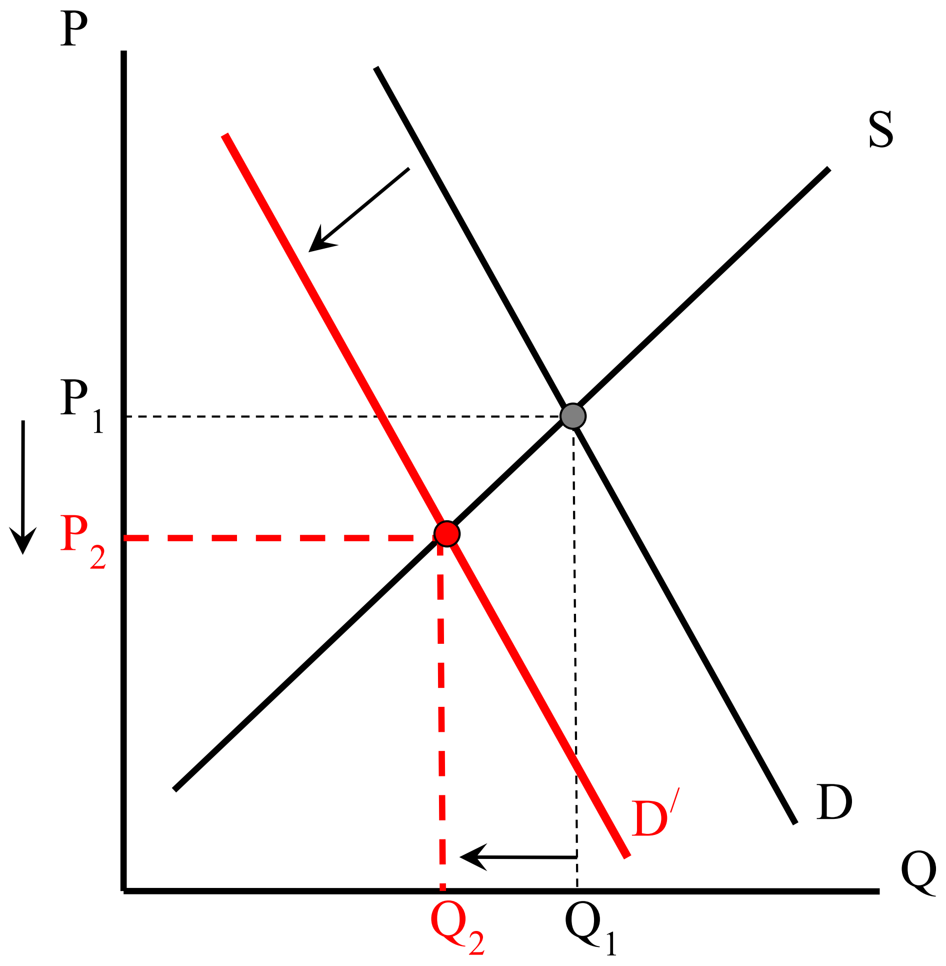
1. Subsidy Policy for Low-carbon Technology

- Support the competitiveness of the low carbon fuels or low carbon technology (e.g., Oil Fund subsidizes E10 and E85, Feed-in Tariff for solar cell http://www.erc.or.th/ERCWeb2/Front/StaticPage/StaticPage.aspx?p=200&Tag=SolarRooftop)
  - Encourage consumers to switch to low carbon products and renewable energy
  - It is an indirect method to reduce externalities of GHGs
- Drawbacks
  - Subsidies may lower energy conservation incentives since energy prices are lower, the "rebound effect"
  - Government may discriminate against some technology (see next slide)

Effects of subsidy



Renewable energy



Fossil energy

US. Hybrid Vehicle Tax Credit Model 2009 Values

Vehicle	MPG	Hybrid Vehicle Tax Credit	Annualized Value of Credit	Annual Gasoline Savings (Gallons)	Tax Credit per Gallon of Gasoline Saved
Chrysler Aspen Hybrid	21	$2,200	$347	30	$11.68
Ford Escape Hybrid (2WD)	32	$3,000	$474	234	$2.02
Mazda Tribute Hybrid (2WD)	32	$3,000	$474	234	$2.02
Nissan Altima Hybrid	34	$2,350	$371	257	$1.44
Toyota Corolla	31	$0	$0	222	$0
Toyota Prius	46	$0	$0	353	$0

Source: Author's calculations of savings relative to a vehicle that gets 20 miles per gallon and is driven 12,485 miles per year. Vehicles are assumed to be driven for ten years and savings are annualized with a ten percent discount rate.

Source: Metcalf (2009)

ITC enhancing policies (2)

- Drawbacks of subsidy policy for low-carbon technology (cont.)
  - Can be wasteful since some technologies may autonomously occur (e.g., tax credit system in USA induce paper mill industry to add diesel to create a mixture to get tax credit)
  - May interact with other regulation in unexpected responses (e.g., Hybrid Vehicle Tax Credit helped increasing the average milage which relaxed the constraint and allowed auto companies to sell more low-milage cars, see Sallee, 2010)

ITC enhancing policies (3)

2. Pushing policies toward Low-carbon Technology (carbon market, carbon taxes

- Aiming at increasing the cost of high-carbon content products or carbon intensive technology to solve the externalities
- Consumers will substitute low-carbon goods for high-carbon goods
- Polluters with low MAC will abate more which will lower the total abatement costs
- Producers will try to develop low-carbon technology to lower the long run costs

ITC enhancing policies (4)

- ITC policies employ price mechanism which have several advantage over the energy standard
  - Standard system has not incentive for further improvement once the standard has been reached while price mechanism continue to induce further improvement
  - Standard system causes polluters that have different abatement costs to abate equally which is inefficient and end up with higher total abatement cost than the price system

Incremental Abatement Cost of mitigation technologies

- Many Engineering studies take the economic concept of MAC and tries to rank mitigation technologies from the lowest cost to the highest cost with the size of the potential GHGs reduction and called them Abatement Cost Curve
- A more appropriate name of this curve should be Incremental Abatement Cost (IAC)
  - Some technologies are easy to implement and can save costs, so they appear to have negative costs, for instance installing LED lights
  - Most mitigation technologies have positive costs
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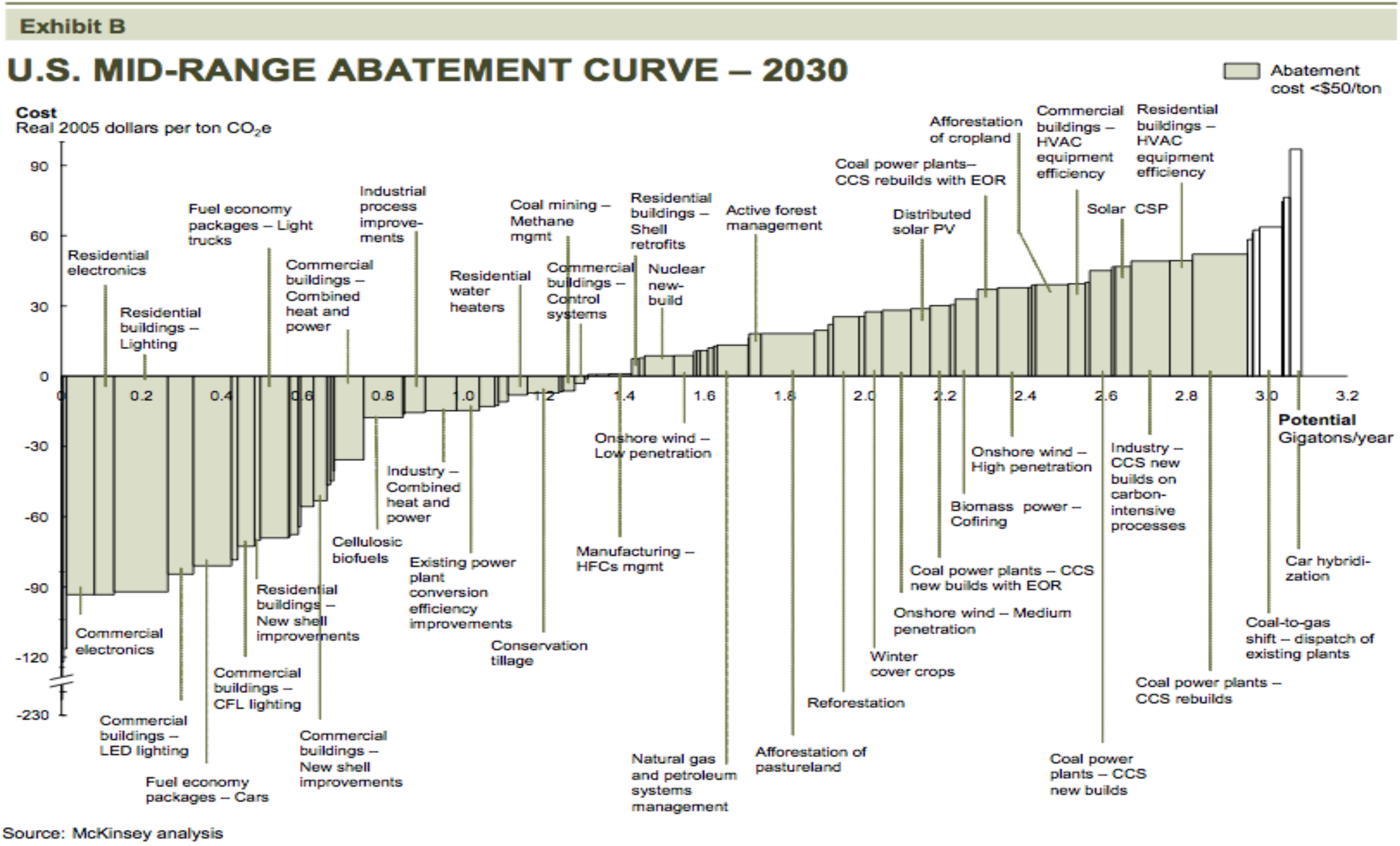
U.S. GHGs Abatement Cost Curve by 2030



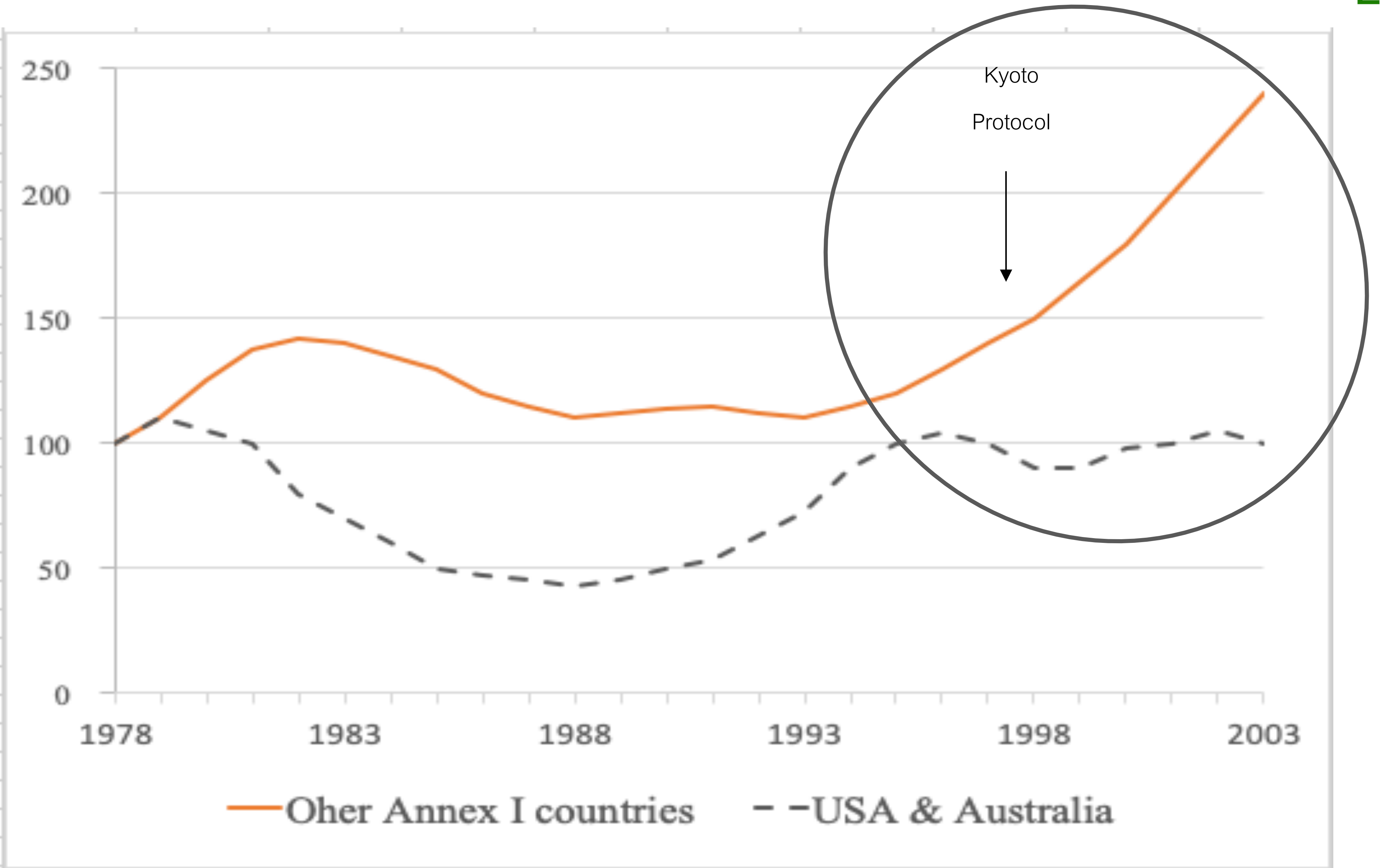
Incremental Abatement Cost (2)

- McKinsey & company (2007) estimates that U.S. must invest up to $50 billion more to mitigate 3.0 Gt of GHGs/year
- However, MacKinsey estimation does not assume any ITC effect
- Thus, we should not conclude that investment in such technologies will be too costly

Incremental Abatement Cost(2)

- Hourcade and Shukla (2001) shows that in order to maintain the CO_2 concentration below 550 ppm. with in 2050 will need investment expense between 0.2% to 1.75% of GDP depending on the different assumptions whether the mitigation policy has ICT effect or not
- The model that assumes ITC effect will have a lot lower cost estimation than the cost from the model that assumes no ITC effect
- Avijit Gautam (2012) shows that the GHG mitigation innovation index of the Annex I group had increased dramatically as compare to those of the U.S. and Australia who did not ratified the Kyoto Protocol

Comparison of GHG mitigation innovation indexes of the Annex I group with the U.S. & Australia



Comparison of Innovation index of Climate change technology with all sectors