



ETP 2008

Technology Learning and Deployment

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INTERNATIONAL ENERGY AGENCY

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Workshop objectives

- **Input on the use of learning curves to estimate deployment costs**
- **Feed back on our initial results**
- **Discuss deployment policies aimed at promoting clean energy technologies**
- **This workshop will feed into our analysis on technology deployment for ETP 2008**

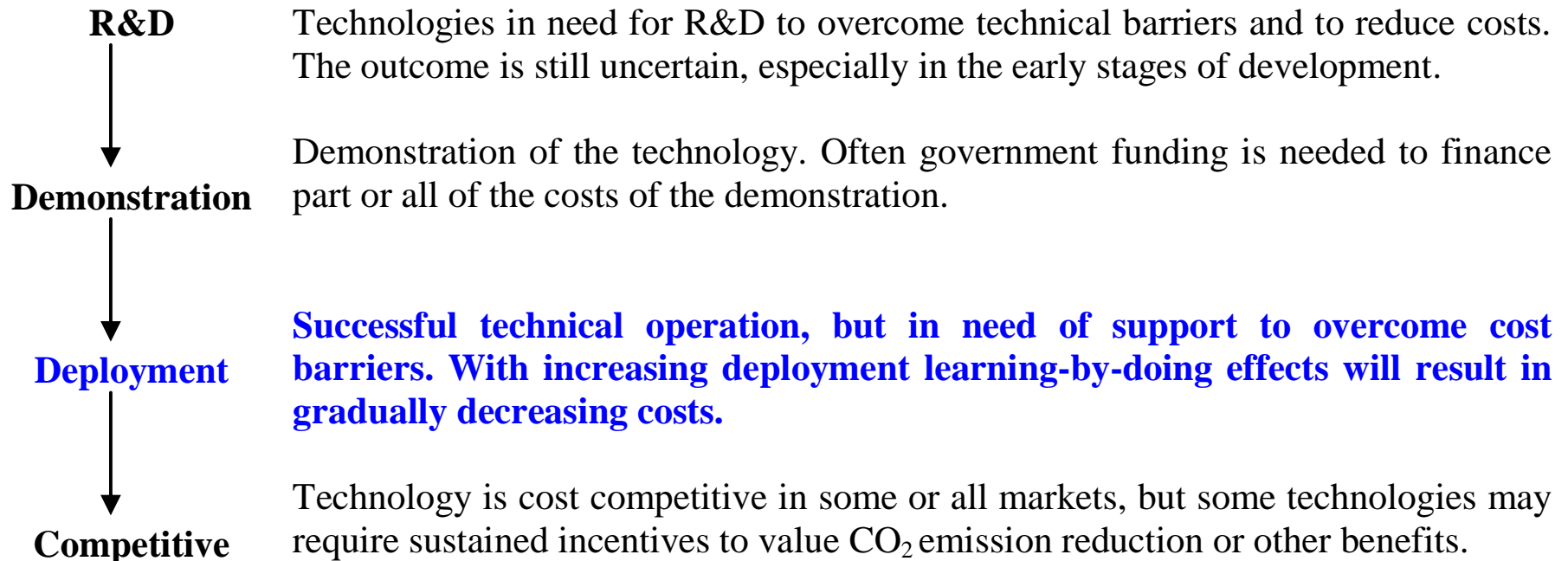


Initial Findings

- Learning curves are uncertain tools used to estimate future deployment needs ...
- ... but they are the best tool we have
- Deployment investments are estimated at \$ 10.5 trillion
- Additional deployment cost over the baseline is estimated at \$ 4.5 trillion
- More analysis is needed

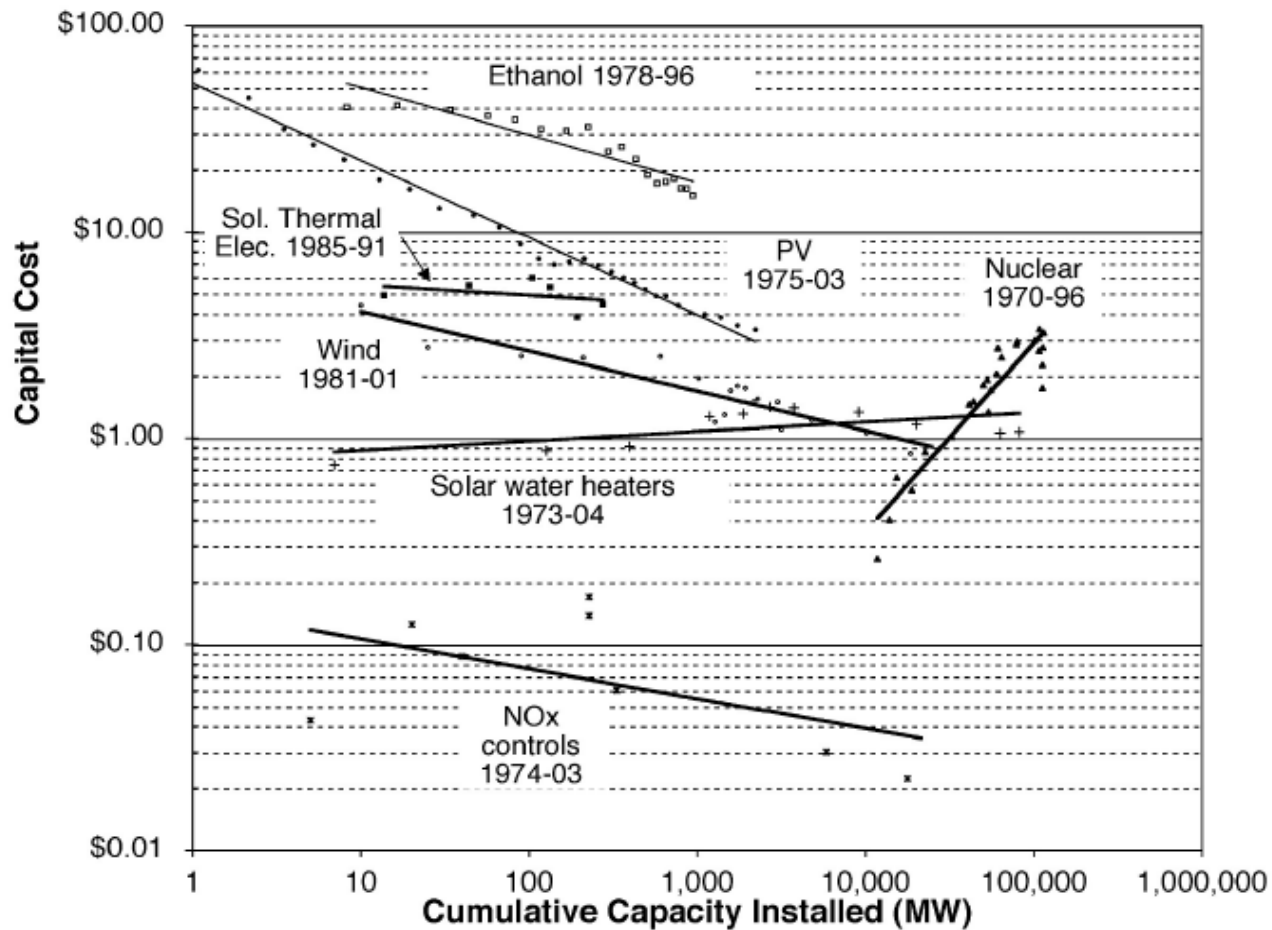


Technology Life Cycle





Learning Curves

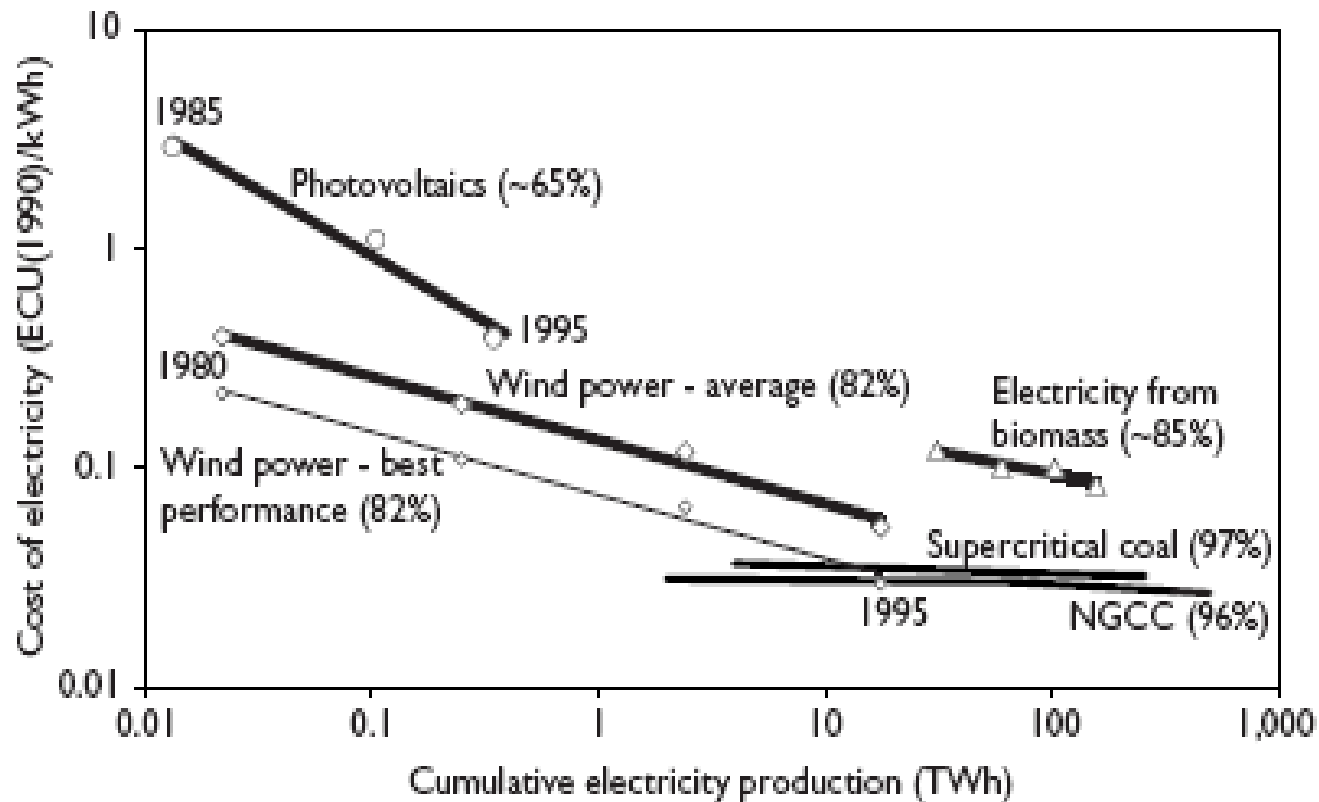


Source: Nemet 2007



Learning Curves

Learning curves for power generation technologies in EU, 1980-1995



Source: IEA (2000)



Choosing the right learning rate

Technology	Source	Country / Region	Period	Learning Rate (%)	Performance measure
Nuclear	Kouvaritakis 2000	OECD	1975-1993	5.8	sp. Prod. Cost (\$/kWh)
Onshore Wind	Neij 1999	Denmark	1982-1997	8	Price of Wind Turbine(\$/kW)
	Durstewitz 1999	Germany	1990-1998	8	Price of Wind Turbine(\$/kW)
	IEA 2000	US	1985-1994	32	Electricity Prod. Cost (\$/kWh)
	IEA 2000	EU	1980-1995	18	Electricity Prod. Cost (\$/kWh)
	Kouvaritakis et al 2000	OECD	1981-1995	17	Price of Wind Turbine(\$/kW)
Offshore Wind	Isles 2006	8 EU countries	1991-2006	3	Installation Cost of Wind Farms (\$/kW)
PV	Harmon 2000	Global	1968-1998	20	Price PV module (\$/Wpeak)
	IEA 2000	EU	1976-1996	21	Price PV module (\$/Wpeak)
	Williams (2002)	Global	1976-2002	20	Price PV module (\$/Wpeak)
	ECN 2004	EU	1976-2001	20-23	Price PV module (\$/Wpeak)
	ECN 2004	Germany	1992-2001	22	Price of balance of system costs
Biomass	IEA 2000	EU	1980-1995	15	Electricity Prod. Cost (\$/kWh)
	Junginger 2006	Sweden	1990-2002	9	Electricity Prod. Cost CHP (\$/kWh)
CCS	Rubin et al 2006	Global	na	3-5	Electricity Prod. Cost (\$/kWh)



Learning Curve - Uncertainty

- **Cost vs price**
 - ◆ Price data leads to distortions, but cost data is not often available
- **Production vs market conditions**
 - ◆ Turbine / Module / Power plant
 - ◆ Balance of system costs
 - ◆ Total system cost
 - ◆ Electricity production cost
- **Global vs national learning curves**



Which system boundaries?

- Global vs. national learning rates
- Which costs / prices to use?
- How to correct for price data distortions?
- Capacity costs/prices versus electricity costs /prices?
- Are learning rates constant or decreasing?



Deployment Costs

- Estimates calculated through the use of learning curves
- Deployment costs are very sensitive to both learning rate and market growth rate (time needed for each doubling)
- Global learning rates used
- Learning rates based on investment cost



Key Technologies

- **Power generation**
 - ◆ Onshore and Offshore Wind
 - ◆ Solar PV and Solar Thermal
 - ◆ BIG / CC
 - ◆ Nuclear generation III and IV
 - ◆ Tidal
 - ◆ IGCC
 - ◆ CCS
- **Industry**
 - ◆ CCS
- **Transport**
 - ◆ H2-FCVs
 - ◆ Grain ethanol
 - ◆ 2nd generation biofuels (lignocellulosic ethanol, new biodiesel)



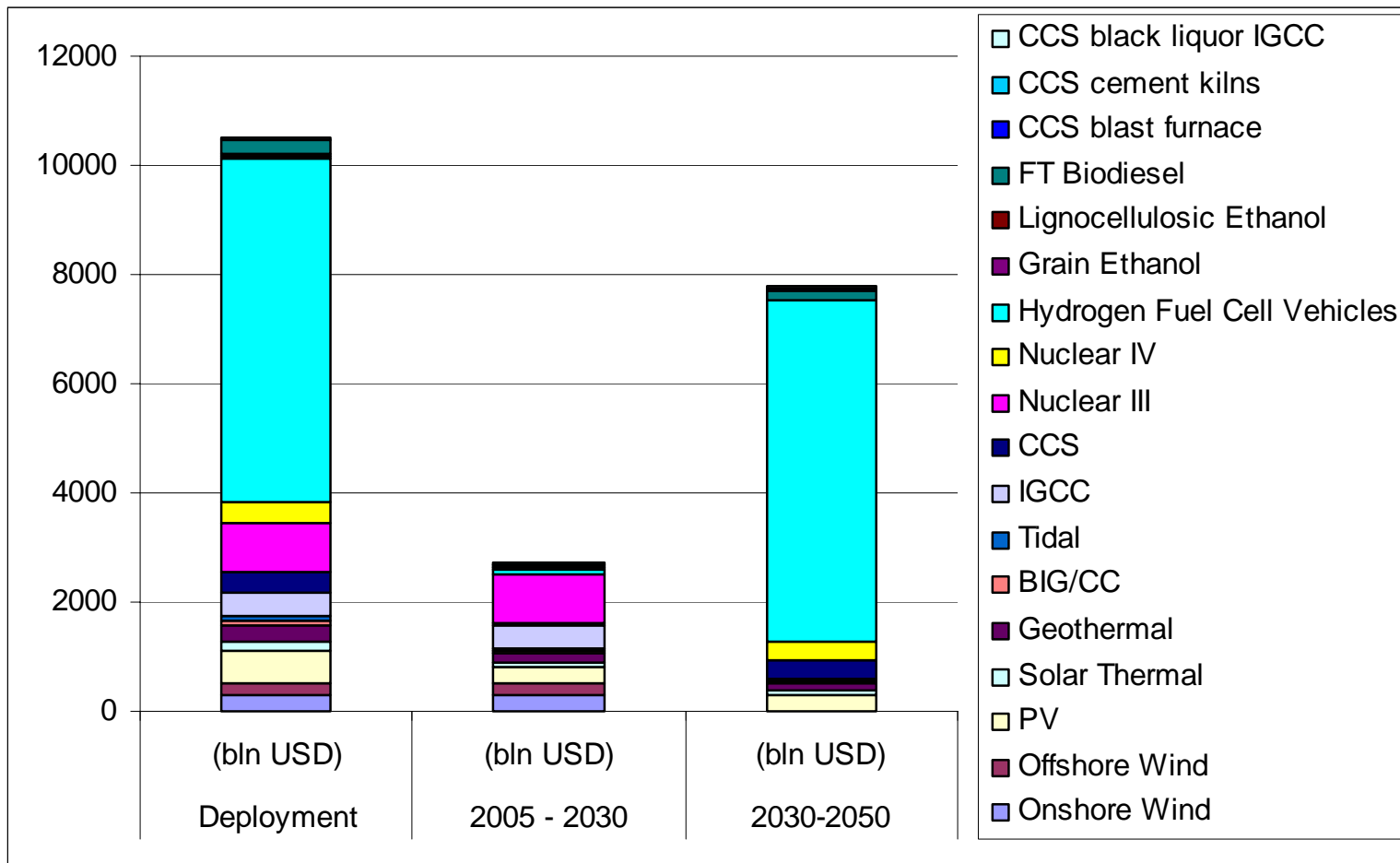
Assumed Learning and Growth Rates

	Current Cumulative Capacity GW	Current investment Cost \$/kW	Learning Rate	Growth rate 2005- 2030	Estimated Technology Breakeven
Onshore Wind	44.06	935-1102	7%	10%	2025-2030
Offshore Wind	3.05	1545-2523	9%*	16%	2030-2035
PV	5.41	3778-3850	18%	19%	2040-2045
Nuclear III	0.50	3000	4%	29%	2025-2030
IGCC	1.00	1800	3%	25%	2025-2035

* Only for incremental offshore costs

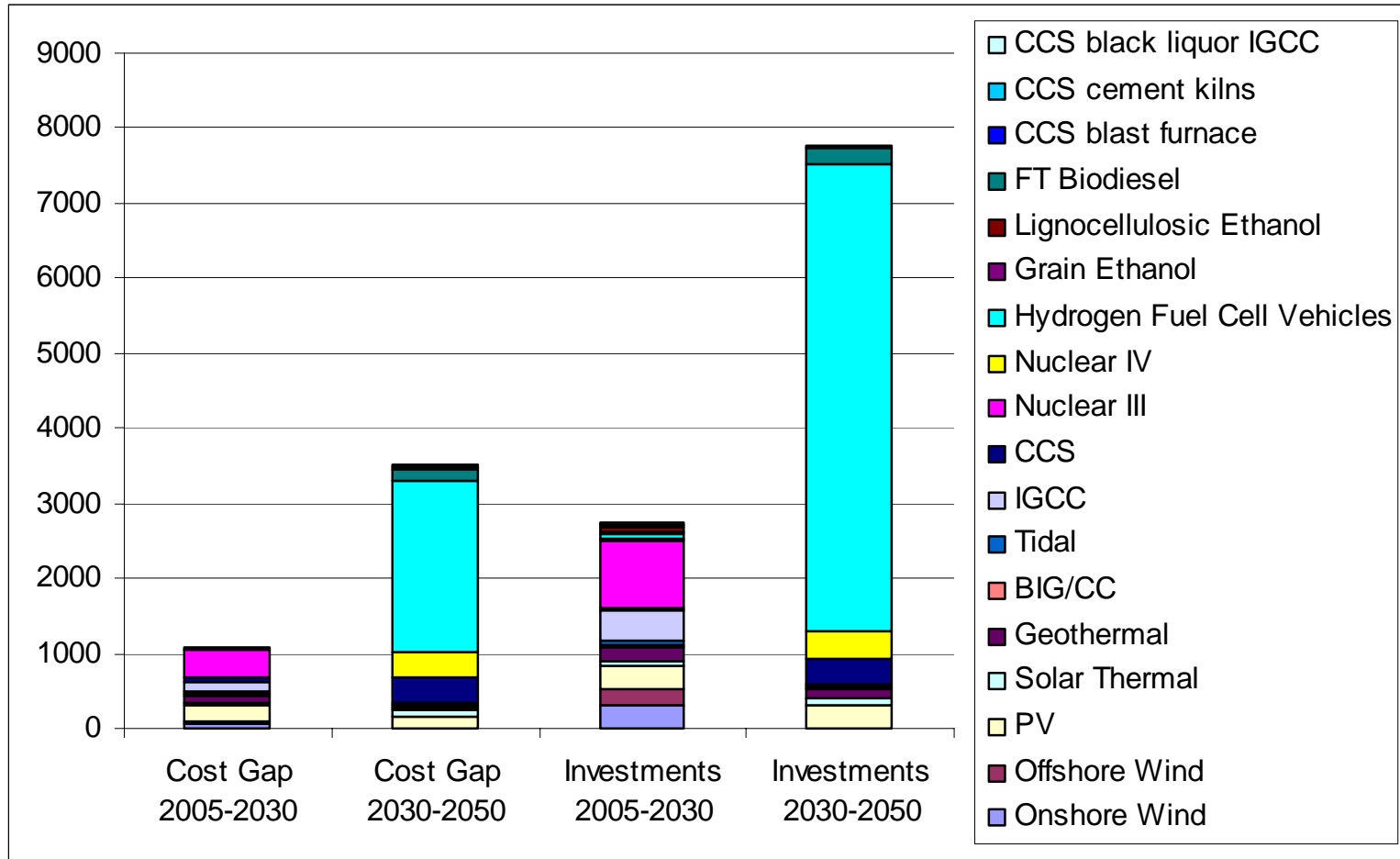


Estimated Deployment needs





Additional Investments





Thank You

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