Introduction to AMPERE Technology Workshop

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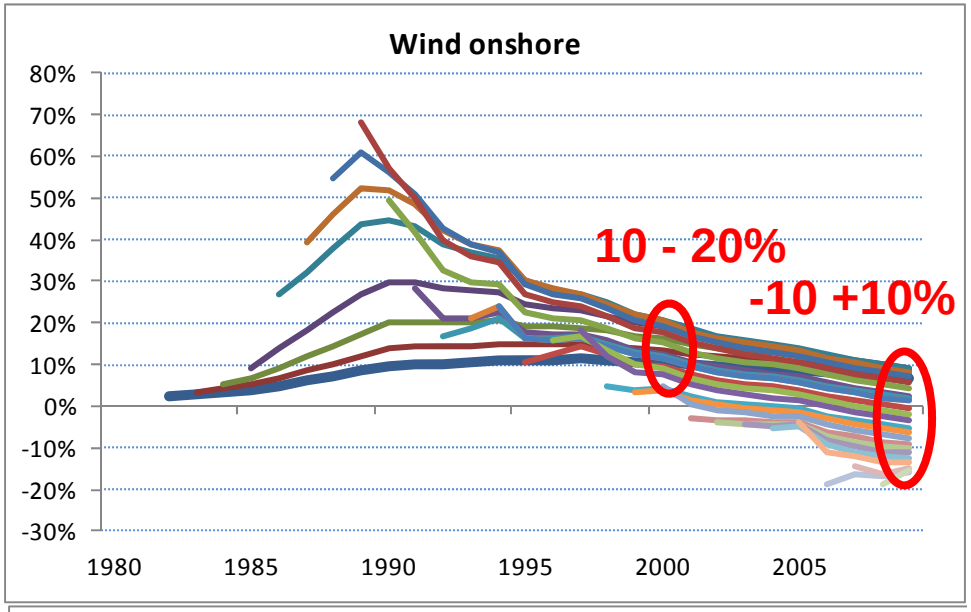
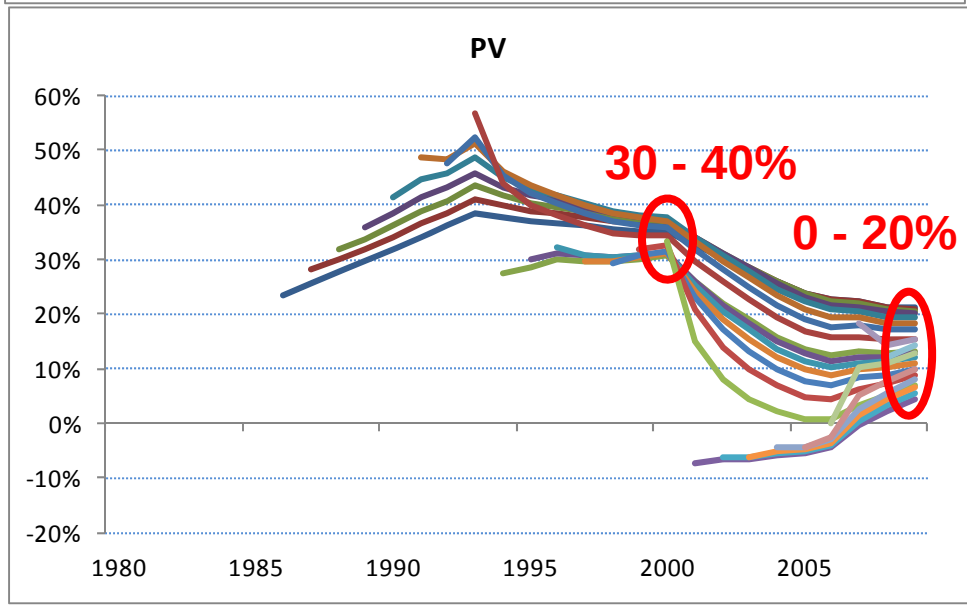
The learning curve and beyond

- The endogenization of technical change in applied IAM models is structured by the learning curve / learning factor concept
- An abundant literature exists both on the LC itself and on the factors that are not explicitly dealt with in the LC
- Today, the question of using synthetic or detailed approaches for technical change remains open

CK-1(common-knowledge): variability of LRs

- The variabilityof the learning factor has been recognized by McDonald and Schrattenholzer in 2001
- Applying the same methodology the instability is confirmed in the 2001+10 analyses...
- That even provide a lot of negative learning rates in the last decade





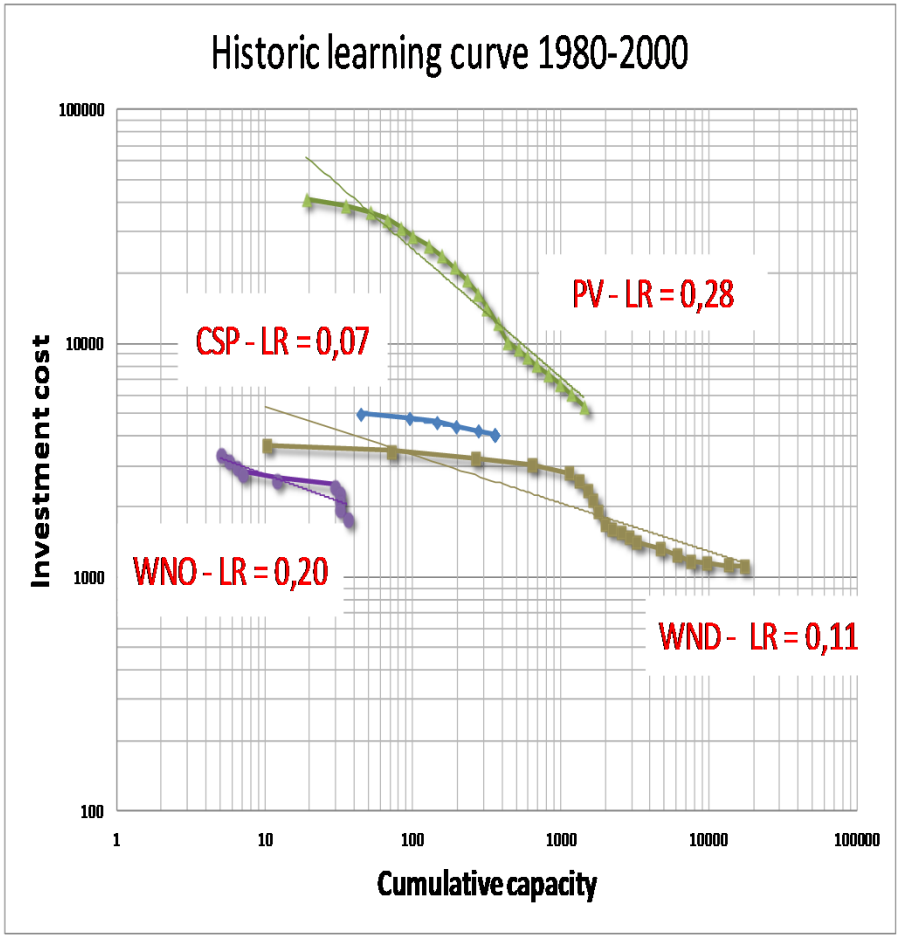
What happened in the last decade ?

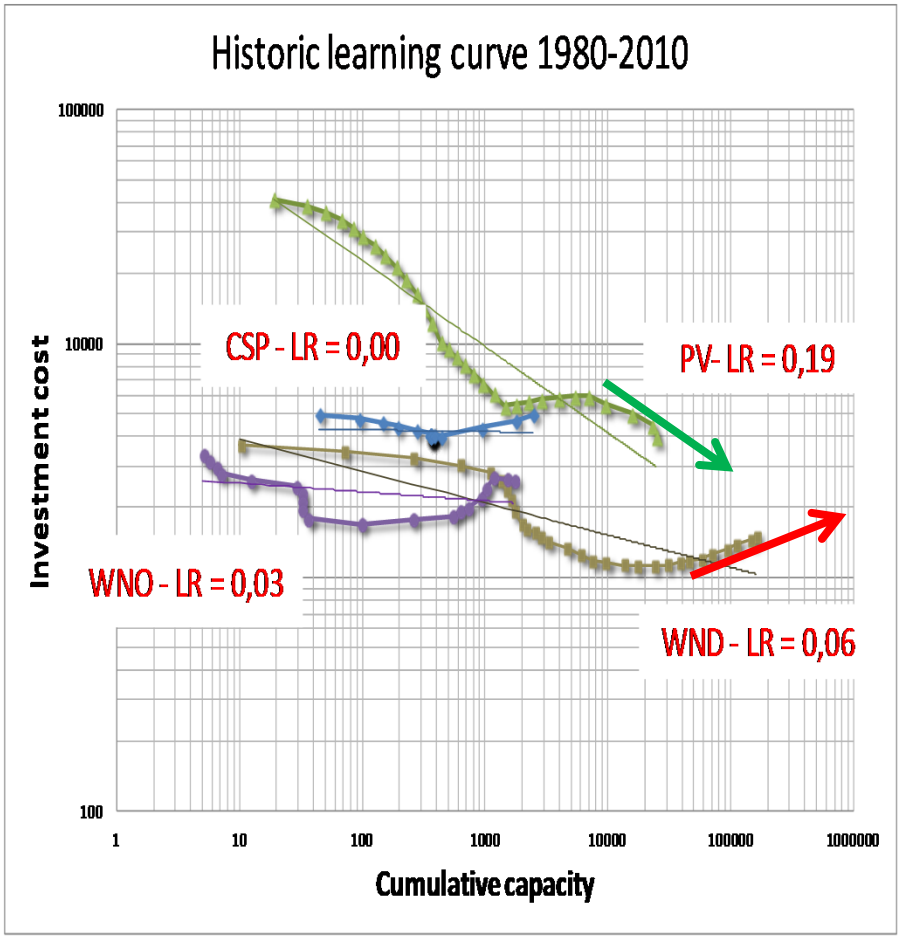
- Studies have identified the impacts of industry/market structure (price/cost margins, industry cycles)
- Other concentrated on the inflation in commodities' prices during the « Great Convergence » period (1998-2008)

Description: Commodity Industrial Inputs Price Index, 2005 = 100, includes Agricultural Raw Materials and Metals Price Indices

Source: Index Mundi

CK-2: Industry dynamics also matter





Learning rates (observed and simulated) – Scenario AM2R2

Learning rates	Historic		Simulated
	1980-2000	1980-2010	2010-2100
Wind on shore	11%	6%	13%
Wind off shore	20%	3%	7%
Photovoltaics	28%	19%	15%
Nuclear (3rd gen)	-16%	-24%	13%
Pulverised coal	18%	16%	6%
Concentrated solar power	7%	0%	10%
Gas turbine*	16%	10%	6%
PC + CCS			nd
GT + CCS			nd

Notes :
- LR for pulverised coal refers to the average cost and cumulated installed capacity of coal power plants including conventional and supercritical plants. LR is high because costs of SC plants decrease while the respective increase of cumulative capacity is rather limited
- For gas turbines, the initial year is 1990.
- For CSP plants, initial year is 1985

Behind the learning curve

Factors impacting	Cost components
Experience effects (cumulative capacity)	Learning by doing
	Learning by using

=> Total Investment Cost

Behind the learning curve

Factors impacting	Cost components	Manufacturing costs		Installation costs / Civil engineering	=> Total Investment Cost	Variable costs		=> LCOE	System costs	
									Renewable	Nuclear
		Shared Components (clusters)	Dedicated Components			Efficicency / Load Factor / FOR	Fuel Cost		Balancing Adequacy Grid reinforc.	Safety Fuel cycle Dismantling
Experience effects (cumulative capacity)	Learning by doing									
	Learning by using									
Kowledge stock effects	LbS Government R&D									
	LbS Industry R&D									
Spillover effects	International									
	Interindustry									
	Intraindustry									
Input effects	Land									
	Manpower									
	Energy									
	Raw material									
Industry size and competition effects	Maturity									
	Scale of production									
	Ind. concentration									
	Market conditions									

Behind the learning curve

Factors impacting	Cost components	Manufacturing costs: Shared Components	Manufacturing costs: Dedicated Components	Installation costs / Civil engineering	=> Total Investment Cost	Variable costs: Efficicency / Load Factor / FOR	Variable costs: Fuel Cost	=> LCOE	System costs Renewable: Balancing Adequacy Grid reinforc.	System costs Nuclear: Safety Fuel cycle Dismantling
Experience effects (cumulative capacity)	Learning by doing									
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Industry size and competition effects	Maturity									
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Disagregated Learning Curve

Learning Curve

Two Factor Learning Curve

GERD budget

BERD budget

Patent analysis

Technology cluster matrix

Floor cost ?

Incremental vs radical innovation ?

Econometric studies

S curves / Ind. cycles

Industrial economics Price/cost ratio

Closing the blackbox again ?

Cost components	
Factors impacting	
Experience effects (cumulative capacity)	Learning by doing
	Learning by using

=> Total Investment Cost

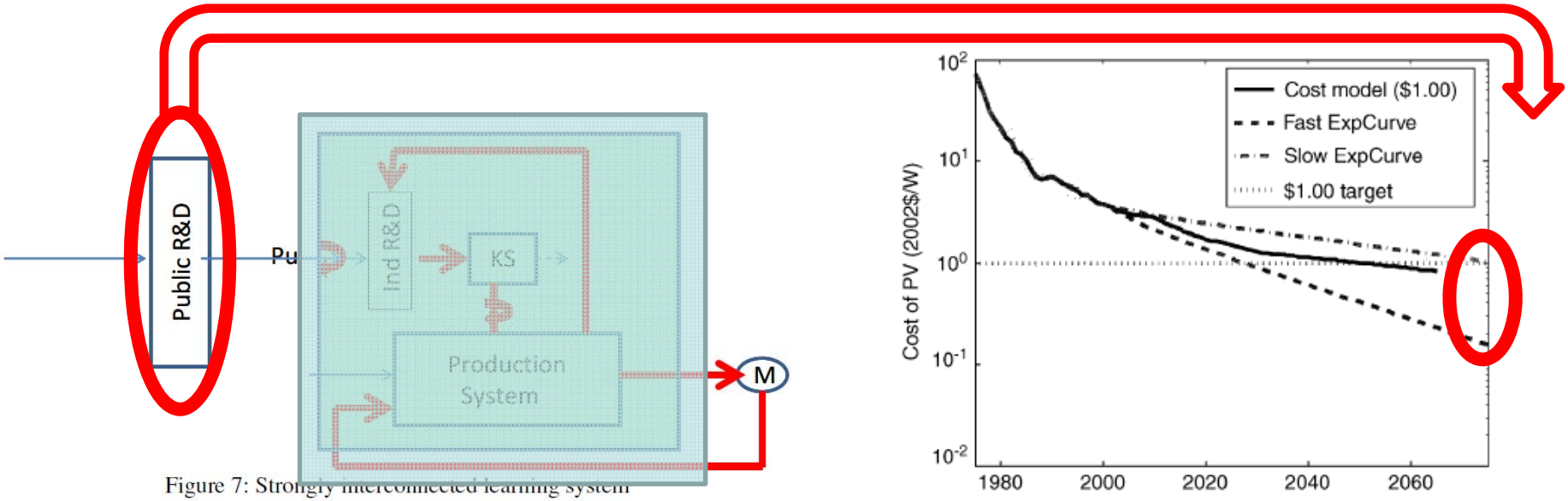


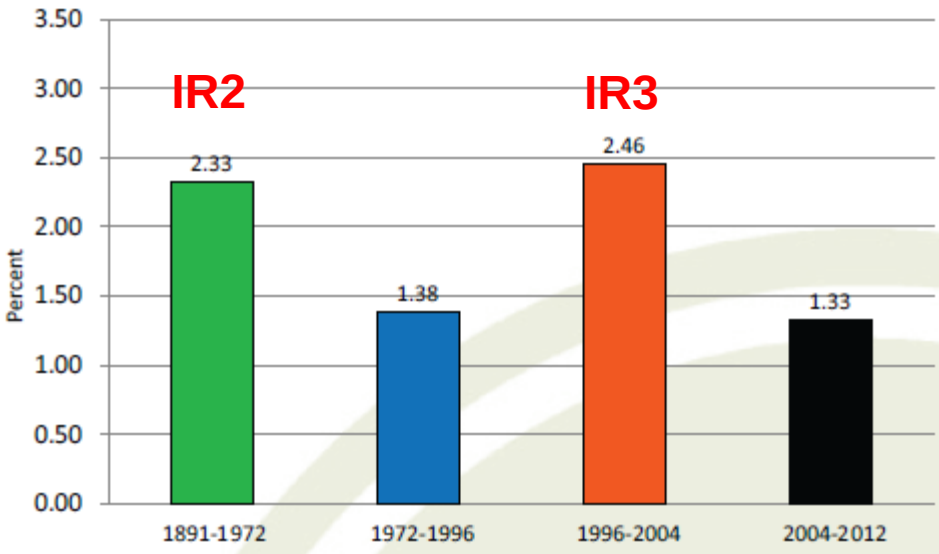
Figure 7: Strongly interconnected learning system
Source: Presentation Clas-Otto Wene

Fig. 7. Scenarios comparing cost model, experience curves, and $1.00/W target price. ***Source: Nemet 2006***

A wider perpsective: is US economic growth over ? (Robert Gordon) vs 12 disruptive technologies (McKinsey)

Is US eco. growth over ? Robert Gordon

Figure 4 Average growth rates of US labour productivity over selected intervals, 1891-2012



1. Mobile internet
2. Automation of knowledge work
3. Internet of things
4. Cloud technology
5. Advanced robotics
6. Autonomous vehicle
7. Next generation genomics
8. **Energy storage**
9. 3D printing
10. Advanced materials
11. **Advanced O&G recovery**
12. **Renewable energy**