The
Cambridge-MIT
Institute

Deployment of Renewables

Optimal subsidy levels

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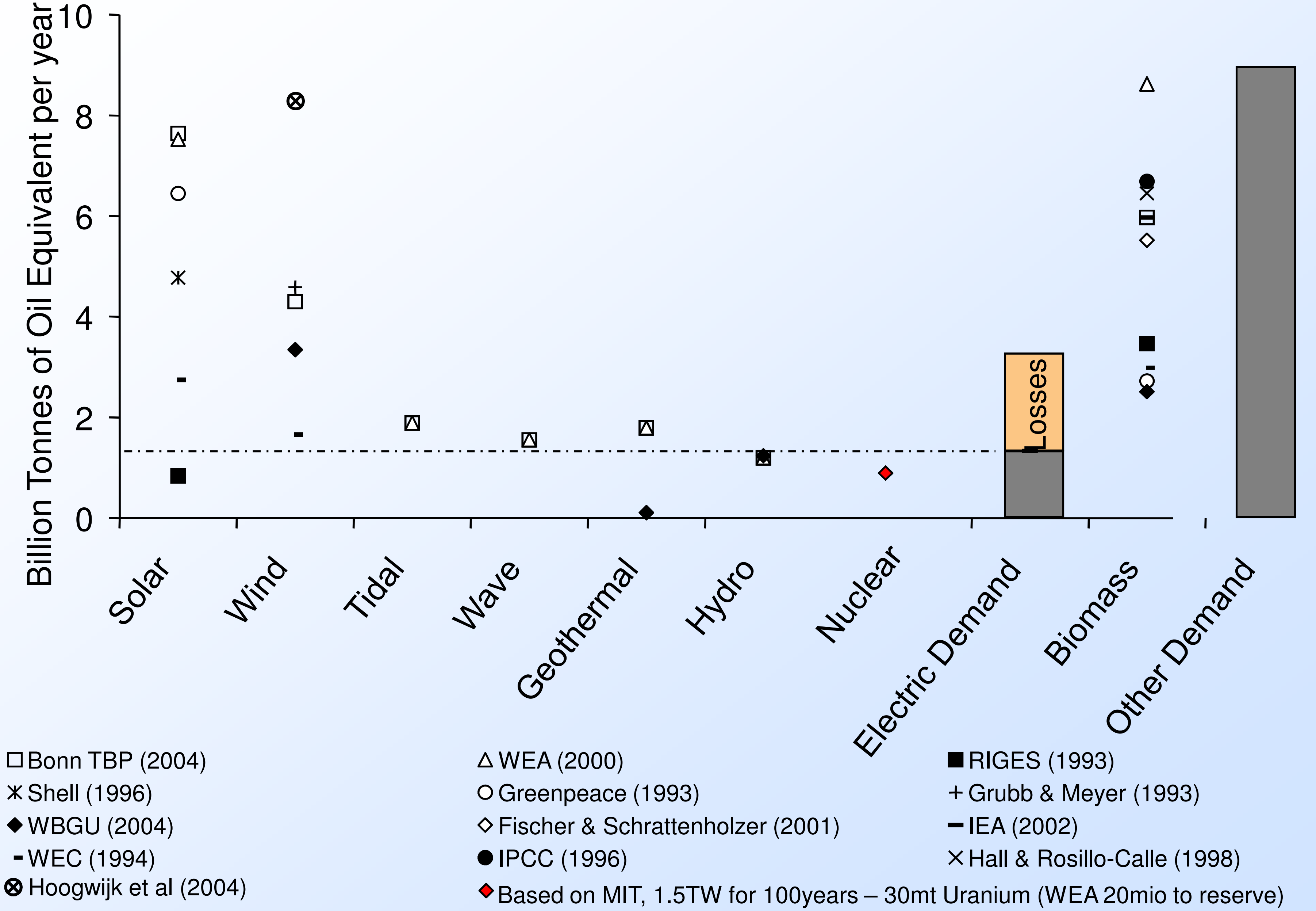
For references, sources etc. see CMI EP 59.

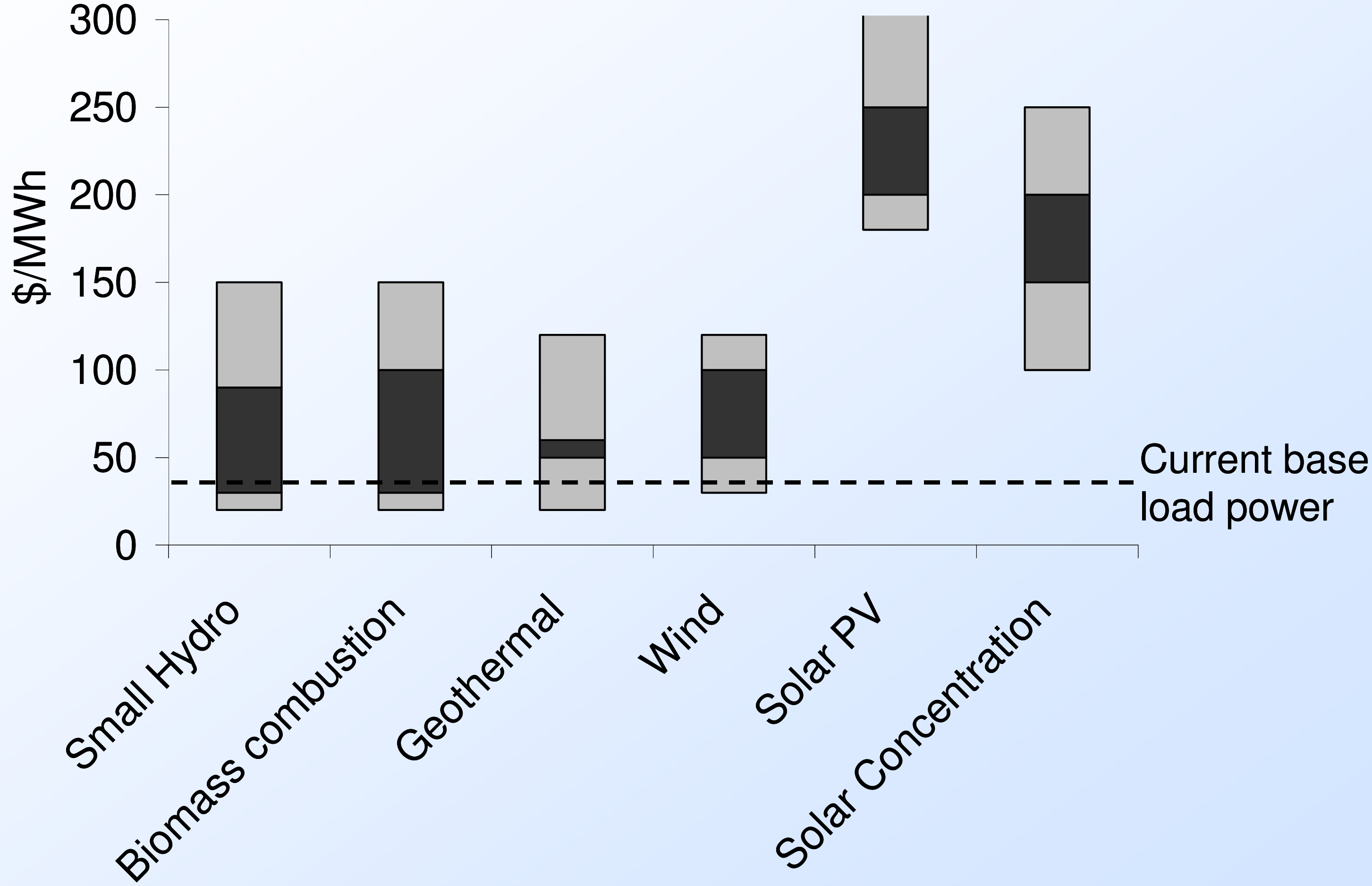
Outline

- Potential of Renewables
- Learning externalities
- Market place barriers
- Non market place barriers

Resource base is available

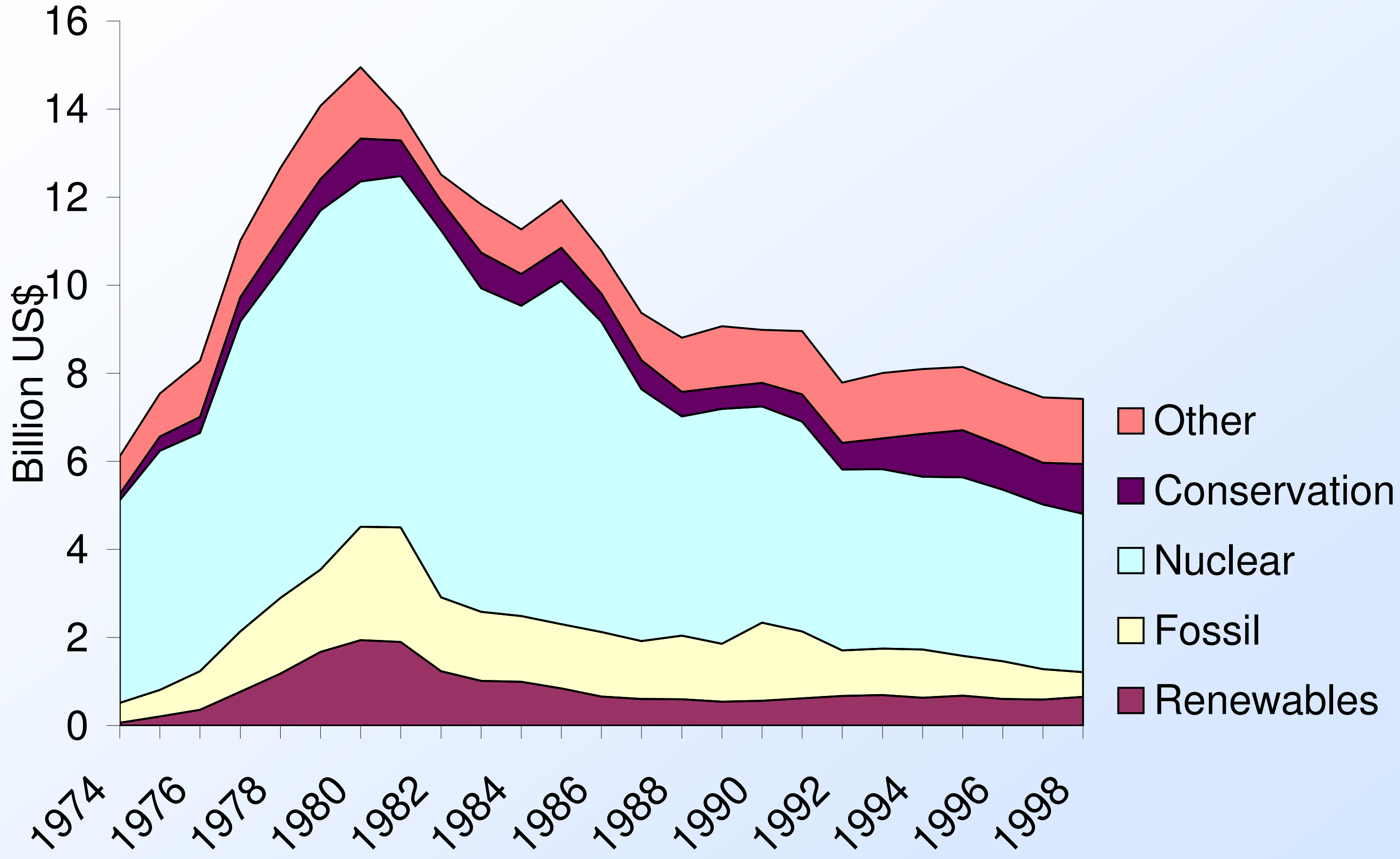


But costs for most technologies still higher



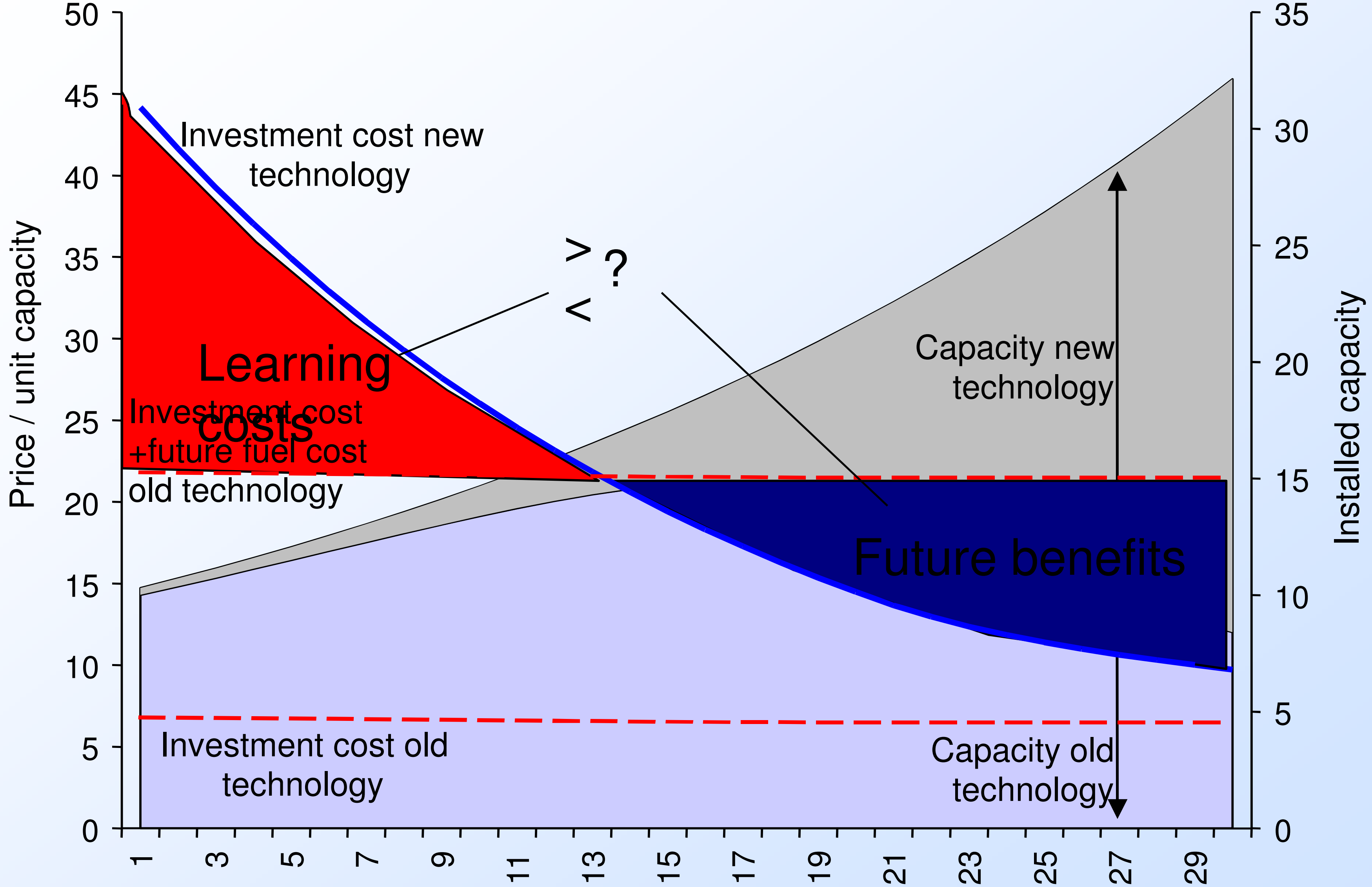
Source: International Energy Agency 2003.

Public R&D differs between technologies (OECD)



Source IEA

Expectation – learning will reduce costs



Use global welfare function to calculate marginal benefits

$U(X,L)$	utility with consumption X, labour L
$P(K,L)$	production with capital K, labour L
$C(E)$	Cost of new capacity with experience E
β	discount factor

Global welfare function:

$$W = \sum_{t\geq 1} \beta^t U(P(K_t, L_t) - C(E_t)I_t, L_t)$$

Constraints on capacity and experience

$$K_t = (1-\delta)^t K_0 + \sum_{l=1..t-1} (1-\delta)^{t-l} I_l \quad \forall t$$

$$E_t = E_0 + \sum_{l=1..t-1} I_l \quad \forall t.$$

Marginal impact of changing investment at *l*

$$\frac{dW}{dI_l} = -\beta^l \frac{\partial U_l}{\partial X} C(E_l)$$
$$+ \sum_{t>l} \beta^t \left(\frac{\partial U_t}{\partial X} \frac{\partial P_t}{\partial K} (1-\delta)^{t-l} - \frac{\partial U_t}{\partial X} \frac{\partial C_t}{\partial E_t} I_t \right).$$
$$+ \sum_{t>l} \frac{\partial W}{\partial I_t} \frac{\partial I_t}{\partial I_l}$$

Marginal impact of changing investment at *l*

Lost utility if consumption changes to investment

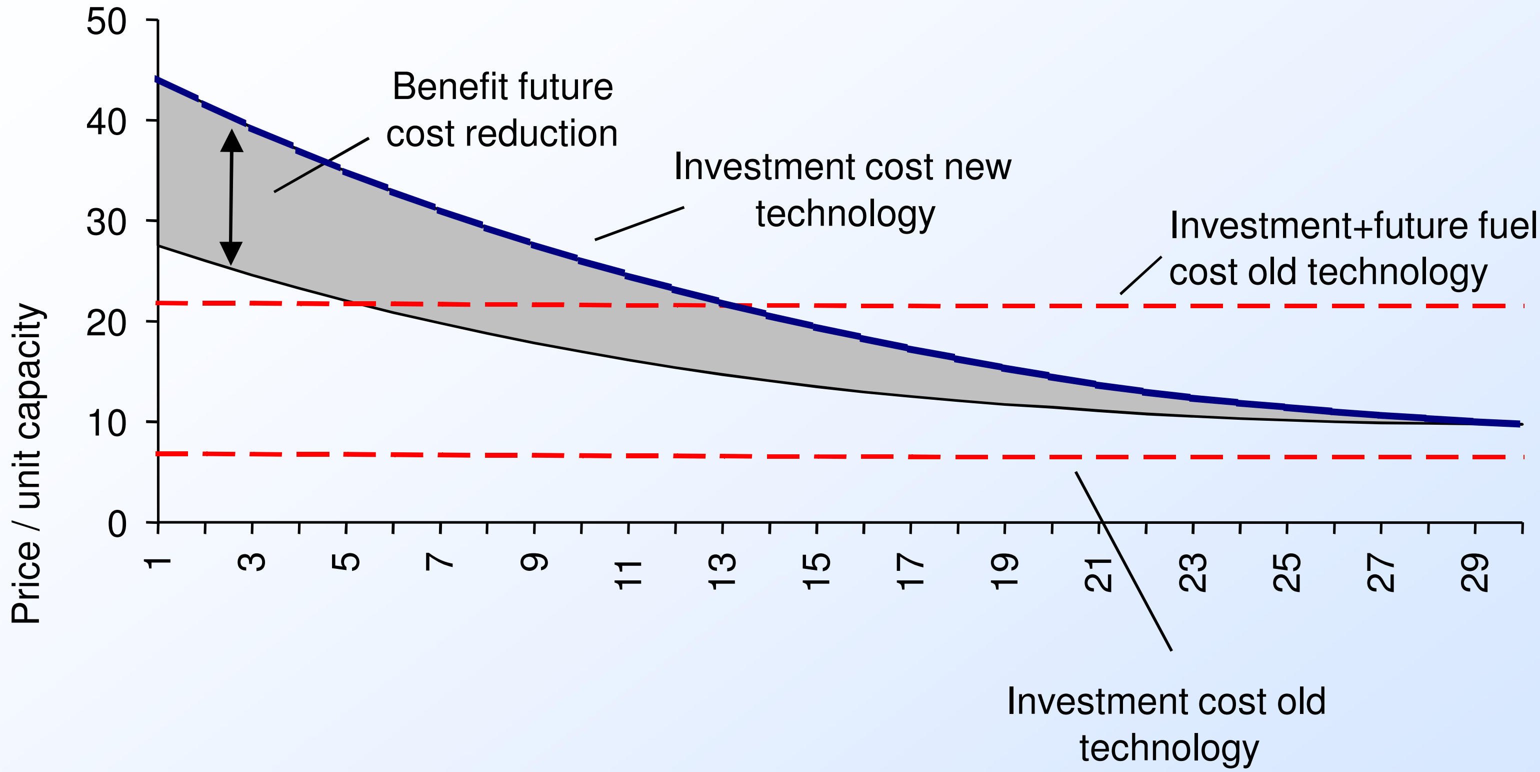
$$\frac{dW}{dI_l} = -\beta^l \frac{\partial U_l}{\partial X} C(E_l) + \sum_{t>l} \beta^t \left(\frac{\partial U_t}{\partial X} \frac{\partial P_t}{\partial K} (1-\delta)^{t-l} - \frac{\partial U_t}{\partial X} \frac{\partial C_t}{\partial E_t} I_t \right). + \sum_{t>l} \frac{\partial W}{\partial I_t} \frac{\partial I_t}{\partial I_l}$$

Benefit from Extra future production

Cost saving from future cost reductions

Future output should be optimal – 0?

Marginal Learning Externalities



Additional investment brings additional experience
-> this reduces future investment costs
-> but not sufficient to justify technology in early years

did we consider all the aspects?

$$
\begin{aligned}
\frac{dW}{dI_l} &= -\beta^l \frac{\partial U_l}{\partial X} C(E_l) \\
&+ \sum_{t>l} \beta^t \left(\frac{\partial U_t}{\partial X} \frac{\partial P_t}{\partial K} (1-\delta)^{t-l} - \frac{\partial U_t}{\partial X} \frac{\partial C_t}{\partial E_t} I_t \right). \\
&+ \sum_{t>l} \frac{\partial W}{\partial I_t} \frac{\partial I_t}{\partial I_l}
\end{aligned}
$$

did we consider all the aspects?

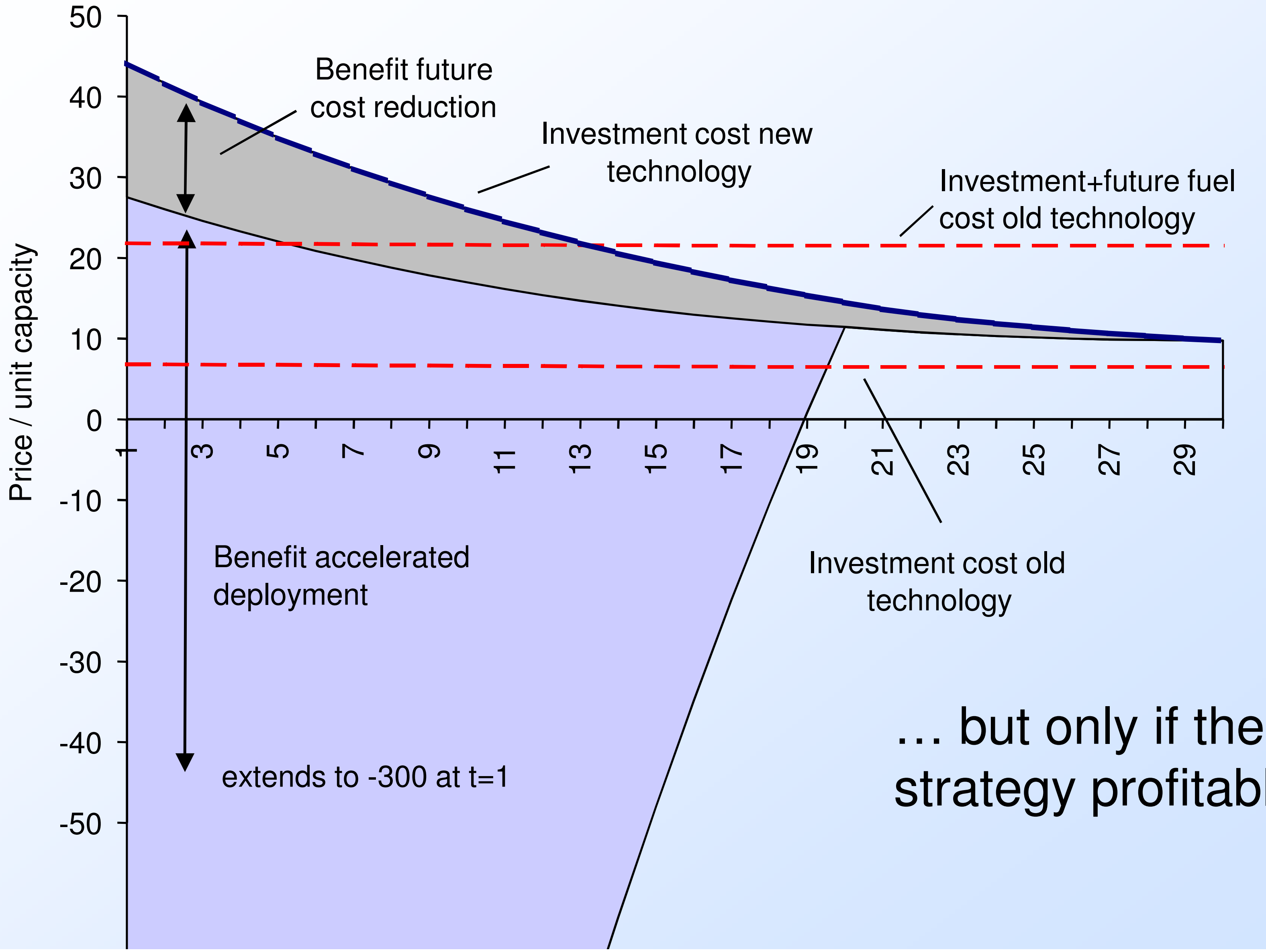
$$\frac{dW}{dI_l} = -\beta^l \frac{\partial U_l}{\partial X} C(E_l) + \sum_{t>l} \beta^t \left(\frac{\partial U_t}{\partial X} \frac{\partial P_t}{\partial K} (1-\delta)^{t-l} - \frac{\partial U_t}{\partial X} \frac{\partial C_t}{\partial E_t} I_t \right). + \sum_{t>l} \frac{\partial W}{\partial I_t} \frac{\partial I_t}{\partial I_l}$$

Not necessarily zero

Assume growth constraints: $I_{t+1} \le (1+g) I_t$

$$\frac{dW}{dI_l} = \frac{\partial W}{\partial I_l} + \sum_{t>l} (1+g)^{t-l} \frac{\partial W}{\partial I_t}$$

… adding the benefit from accelerated future deployment adds value to early deployment



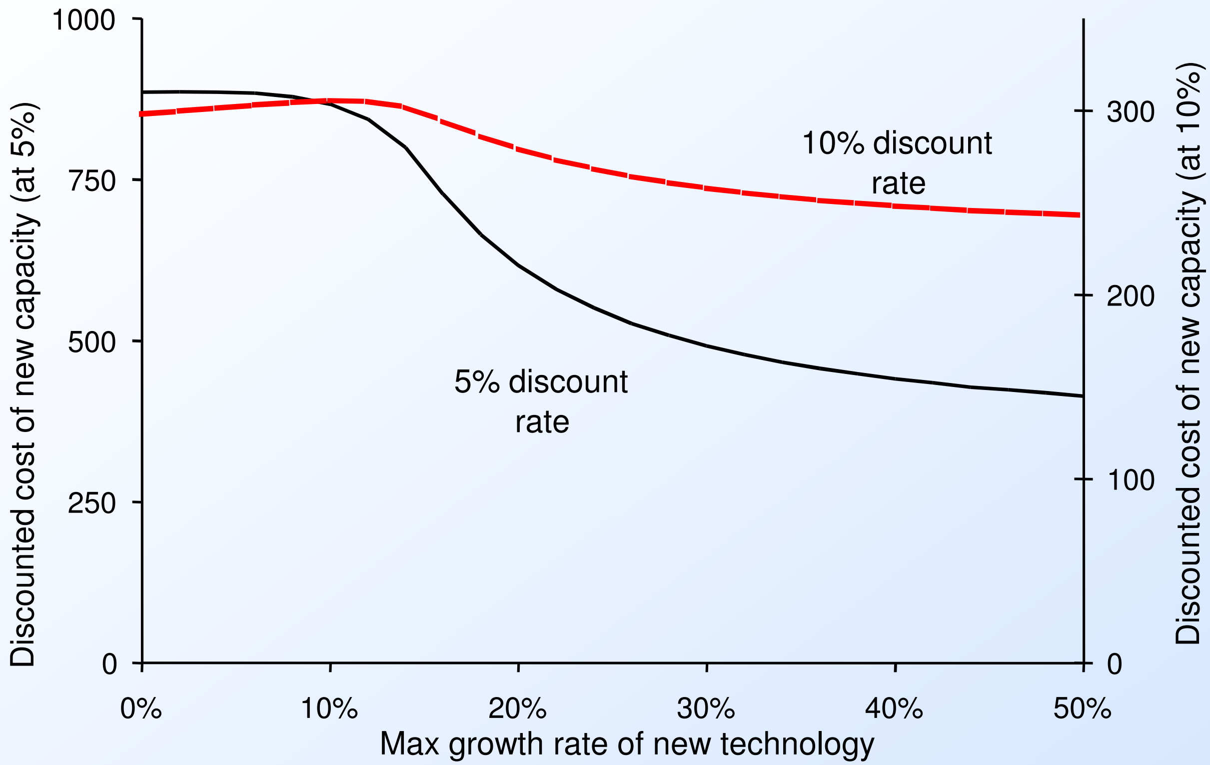
… but only if the total strategy profitable.

Why does market not invest?

- Non homogeneous product -> IT has diff. pricing
- Learning spill over -> can’t appropriate benefit
  - Patenting works ‘only’ in Pharmaceuticals
  - Long timeframes -> large spill-over, high risk

- Example Oil: Government offered tax rebates to incentivise deep water drilling

What drives deployment benefit?



- Higher g, lower r -> more weight on future benefit.
- Multiple local equilibria possible.

Strategic deployment of Photo Voltaics

Learning investment required (5% discount, 2005-2040)

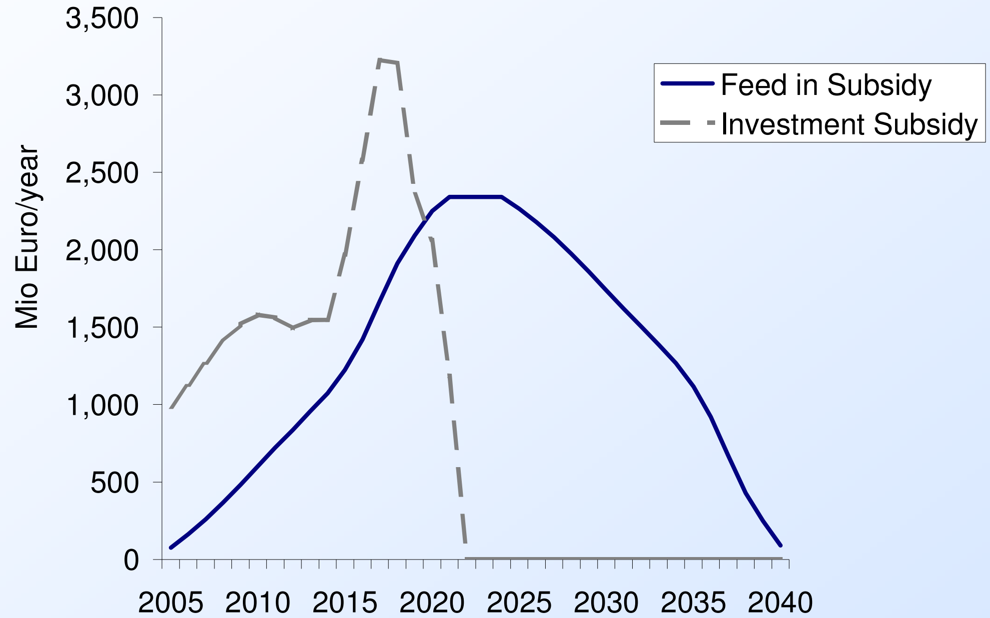
Billion Euro	€40/MWh	€50/MWh	€60/MWh
17%	110	55	29
20%	38	**20**	12
23%	17	10	6

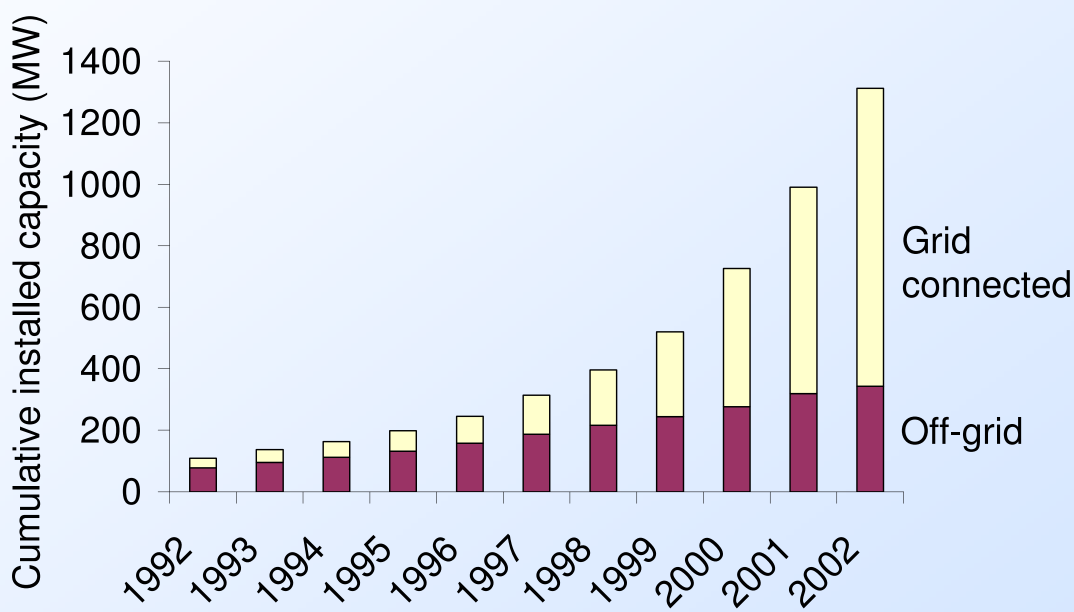
Benefit cost ratio (5% discount, 2005-2040)

NPV /Learning	€40/MWh	€50/MWh	€60/MWh
17%	0	2	9
20%	4	**15**	38
23%	17	44	92

Support profile:

- Increases with market size
- Decreases with tech costs
- Funding mechanism shifts costs





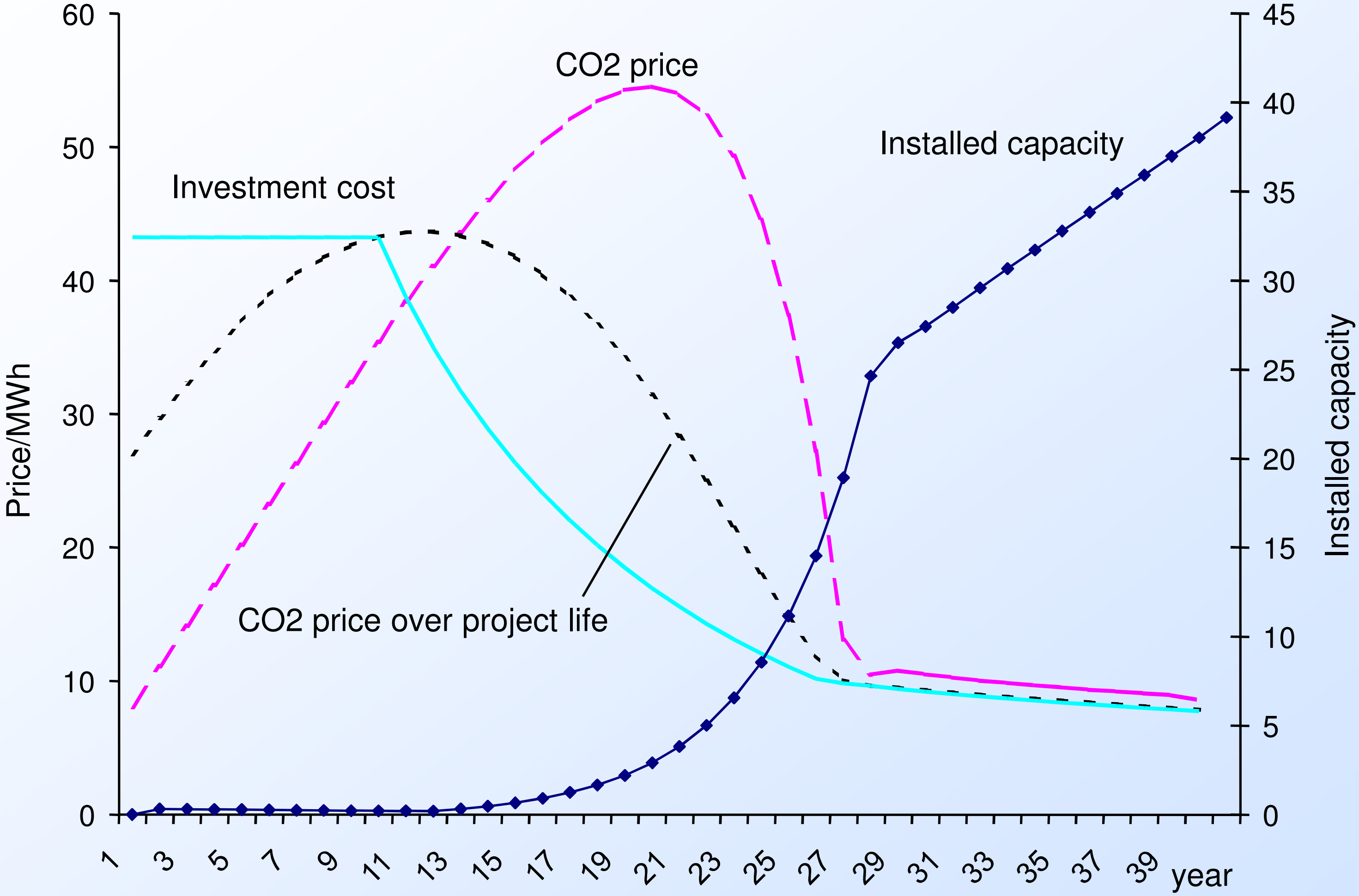
Off grid niche markets:

- contribute but don't suffice

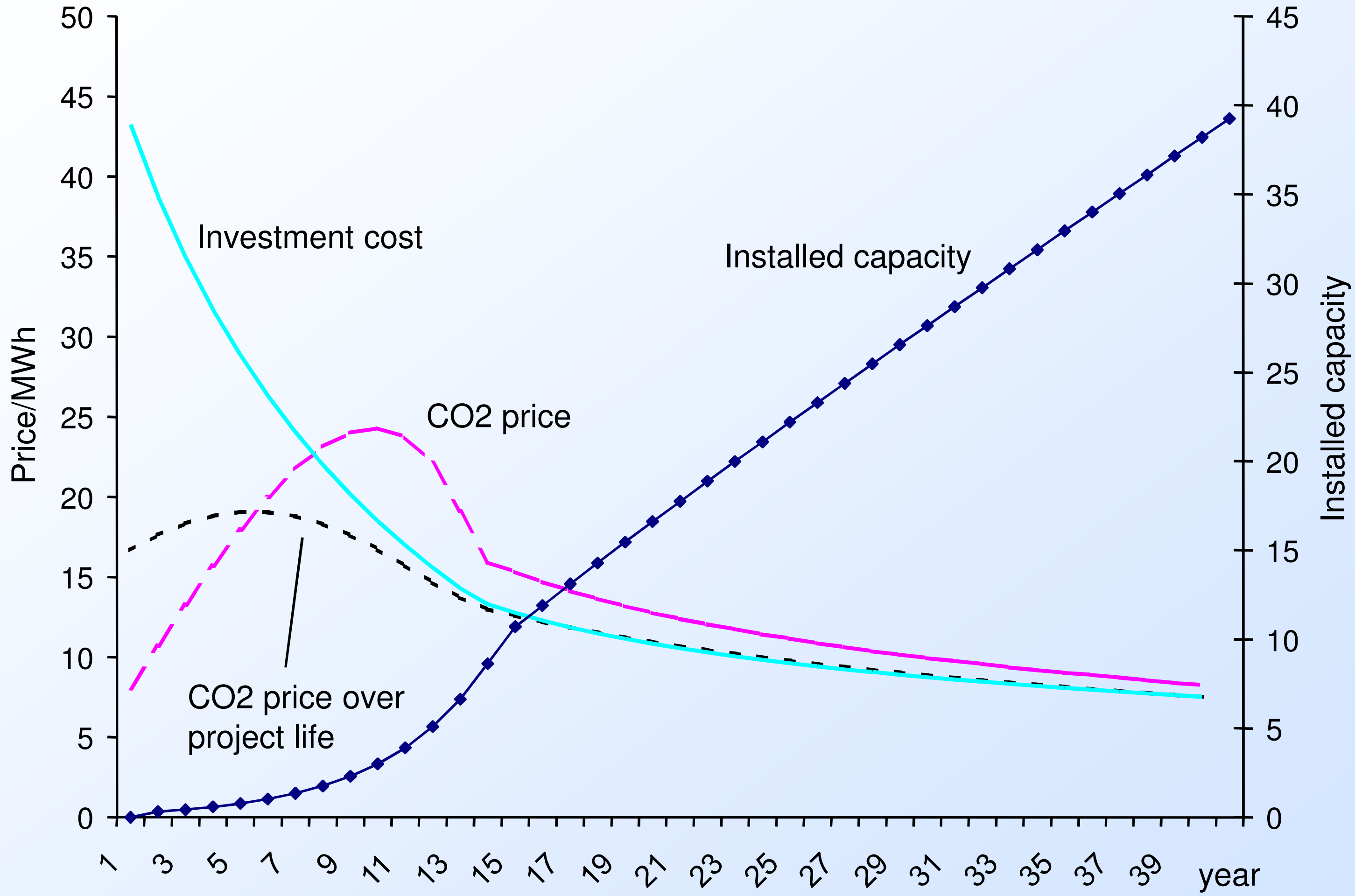
Distributed high value

- crucial

What happens if we only use CO2 policy?



Strategic deployment cuts discounted cost by factor three



Uneven playing field

- OECD direct subsidies US$20-30 billion in 2002
- 0.8 of $17 billion export credit guarantees for renewables
- Government carries main risk for nuclear & CCS
- Environment Externality of coal €8.7 to €25/MWh
- Additional €10-€23/MWh for estimated CO_2 damage
- Regulation or free allocation does allocate damage costs
- Security of supply risk, geo-political costs

Market place barriers

- Network tariffs do not reward distributed generation if e.g. peak correlated
- Trade, dispatch, T-allocation historically day ahead, but wind needs hours to have accurate prediction
- With large intermittent generation – large spot market volume – large market power - discriminates against renewable generation
- Vertically integrated firms benefit from balancing costs which they can pass on to consumers
- Without LT contracting high investment/regulatory risk -> especially strong for 0 MC technology

Non market place barriers

- Administrative frameworks tailored for existing tech
- Administrative frameworks for large projects -> small projects face relative higher transaction costs
- Public acceptance requires time & commitment

Conclusion

- Potential of Renewables is sufficient
- Strategic deployment to address learning and growth externalities
- Market place barriers … surprisingly many
- Non market place barriers … administrative frameworks and public acceptance crucial