Efficiency matters.

Expert Workshop on Technological Learning in the Energy Sector

Learning curves for selected demand side technologies

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Presentation overview

- Short introduction and overview of project
- Methodology for data collection
- Results
- Conclusions and model implications

Short introduction and overview of project

- REFLEX is investigating flexibility options and technological progress to comply with higher shares of fluctuating electricity generation
- On the demand side various technologies are implemented in bottom-up simulation model to calculate future demand
  - What is the impact of cost assumptions on demand development -> learning curves shall help to improve understanding

Experience curves: $C = f(Q) = aQ^{-b}$

methodological progress needed

More explanatory power of innovation process and drivers of costs and deployment needed

Estimation Method

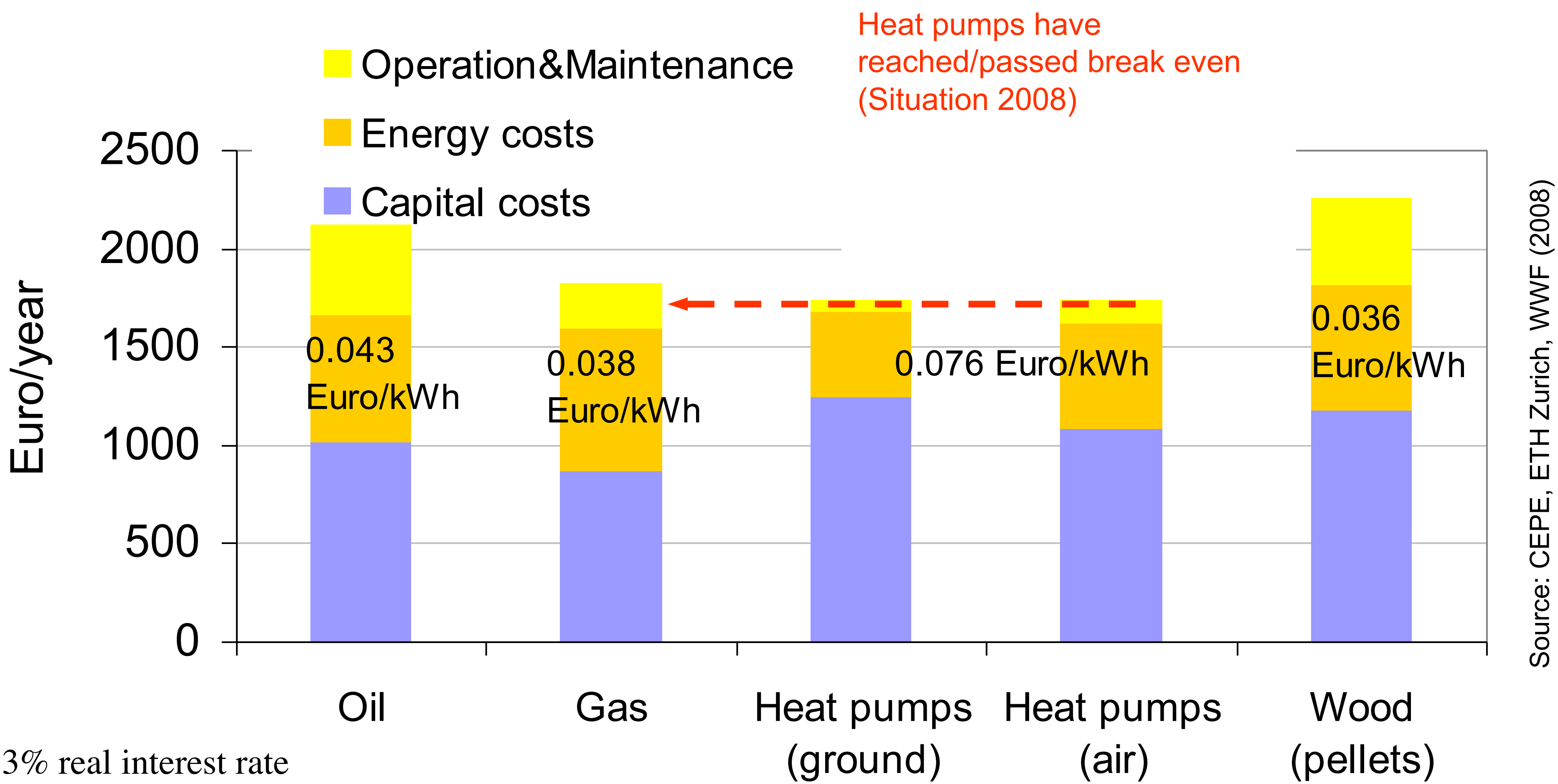
$$C \text{ (or Price)} = f\left(Q(d_1, d_2, d_3 \ldots .), M, P, L, B, E \ldots . \right)$$

d1, d2, d3…	drivers of deployment, e.g. M, P, Price (Cost)
M	market structures and situation [prices of input factors]
P	Policy action
L	Quality of product, new standards
B	Business cycle
E	External conditions (weather, climate)

=> Understanding techno-economic progress, diffusion process, barriers and successful policy measures as important as knowing the exact progress ratio

CASE 1

Economics of renewables
(new single-family houses)



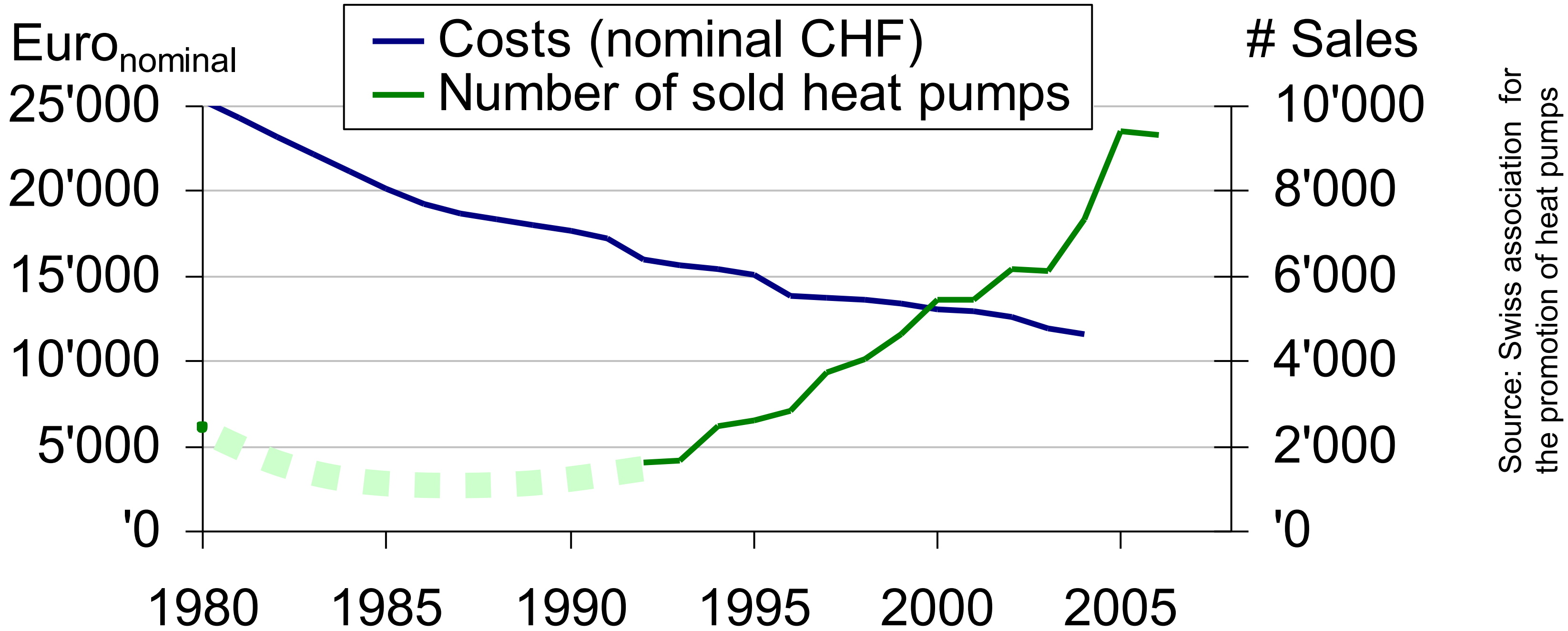
3% real interest rate

How did we come here:
Heat pumps success factors

- Research and development of motivated actors from the 1970s
- Association for the promotion of heat pumps (1993) manufacturers, installers, electricity industry, authorities
- Quality assurance (education, COP, noise reduction) test-center (since 1993) and field tests (since 1994)
- Strong and coherent advertising
- Economic incentives from electricity sector (special tariffs)
- Incentives from building codes in some cantons ("20%-rule")
- Incentives also through Minergie-label (weighting of energy)
- D-A-CH quality seal (Germany, Austria, Switzerland): 2001
- Good word-of-mouth propaganda of home owners

Heat pumps: success indicators

- Increasing number of sales and market share (mainly new SFH, since 2004 also existing ones)
- Strongly decreasing investments costs, increasing COP
- => Significant techno-economic progress



Heat pump: next steps

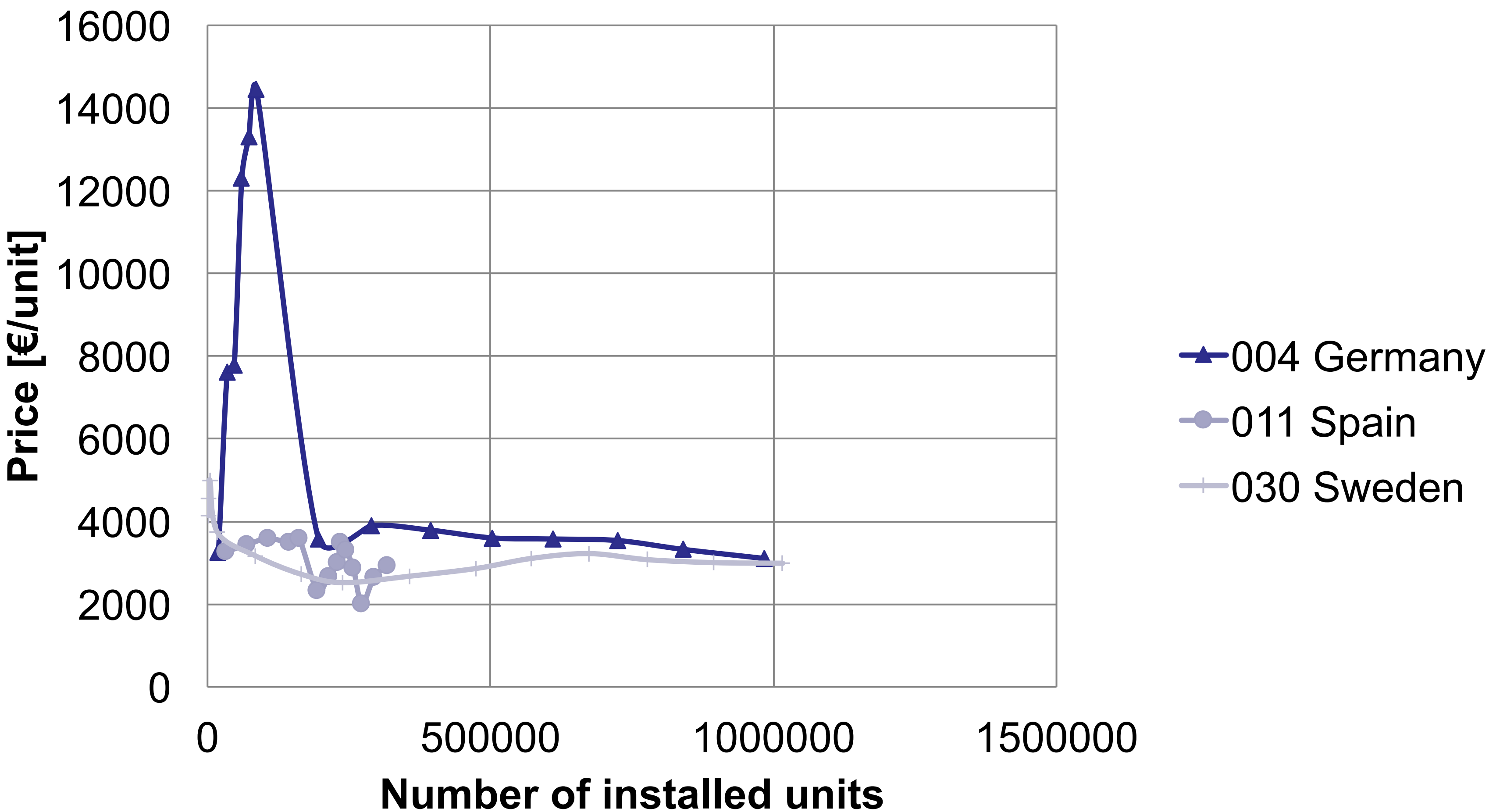
Heat pumps

- Two approaches to update data series
  - Microeconomic analysis considering project specific data (country specific)
  - Including local learning
  - To be conducted
- Publicly available data
  - Unit unspecific (COP/size)
  - LR approx. 14% for Germany only
  - Productivity thresholds for 10’000 units and 100’000 units sold per company. No company in Europe producing more than 100’000 units per year

Heat pumps:
Gather original data from Swiss planners

- Break-down on cost categories: borehole heat exchanger, HP machine, installation, planning, geological expertise
- Context variables:
  - Base year (year of planning or of construction)
  - Cost typ: final cost / quote
  - Building typ (SFH, MFH, other)
  - RFA (m2)
  - Installed power
  - Case: New built / existing building (Outlet-Temperature)
  - HP-Typ (accoriding HP test centre)
  - Length and number of borehole heat exchangers
  - Geological conditions
  - System attributes: bivalent/ monovalent; Hot water yes / no ; Solar yes / no
  - Type of installer
  - Location
  - Type of owner, investor or builder (private, public, general builder etc.)

Eurostat production units



Long-term technical progress of envelope insulation in Switzerland

Drivers of past cycle:

- Energy crises and price increases/high levels (or expectations) 1973, 1979-1986, 2004 - and concern on energy / environment
- Standards set by professional association SIA
  building elements: 70ies; whole building 1988 / 2001 / 2007
- Codes by cantonal authorities: mainly 1980ies, harmonization 1990ies, reinforcements 2001, 2008 and planned for 2018/2020
- (Autonomous) technical progress (competition)
- Voluntary Standards and Labels (MINERGIE as from 1997)

Long-term technical progress of envelope insulation in Switzerland

- Continuous increase of insulation thickness (cf. table)
- Easier to install (e.g. due to glues)
- Development of insulated elements (window sill / breast / reveal)
- Reduction of thermal bridges (e.g. fixings)
- More recently: lower λ (thermal conductibility): compound materials: ≤ 0.03 W/mK, vacuum insulation: < 0.01 W/mK

Example: Rock wool insulation in Switzerland

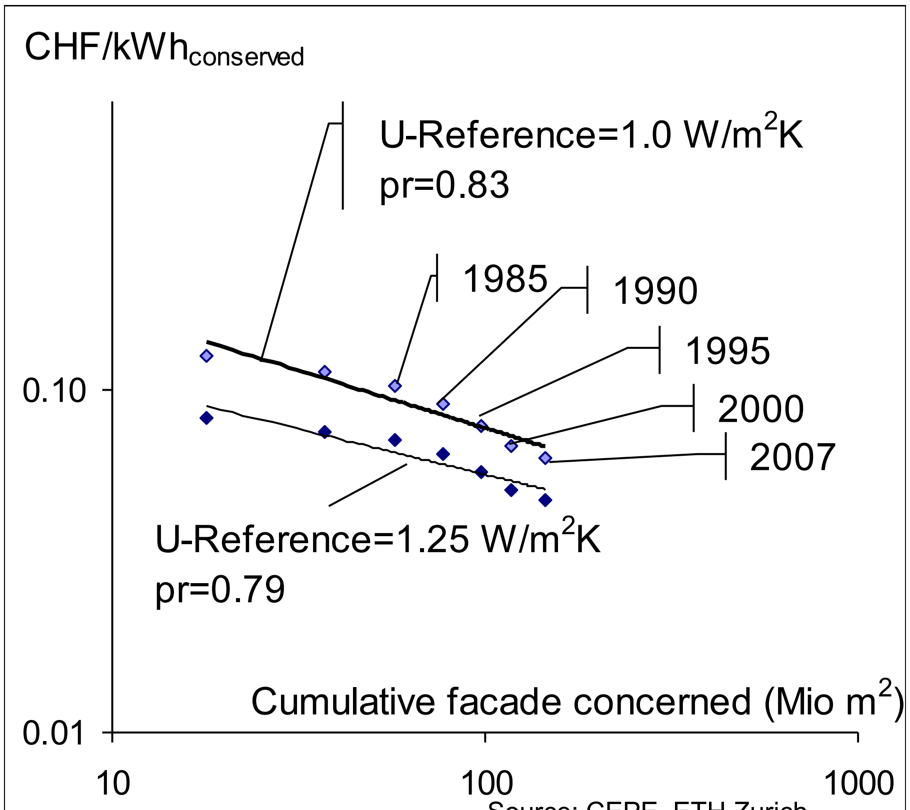
	< 1960	1961-1965	1966-1970	1971-1975	1980	1985	1990	1993	1995	1997	2000	2003	2007	*2012*
Incl. roof			50	75	90	100	105	117	129	129	135		160	*180*
Façade					60-80	75	84		91	96	108	120	140	*200*
Flat roof	30	40	50	60-80	80-100		110		120		140			
Bas. ceiling				20	30		40							

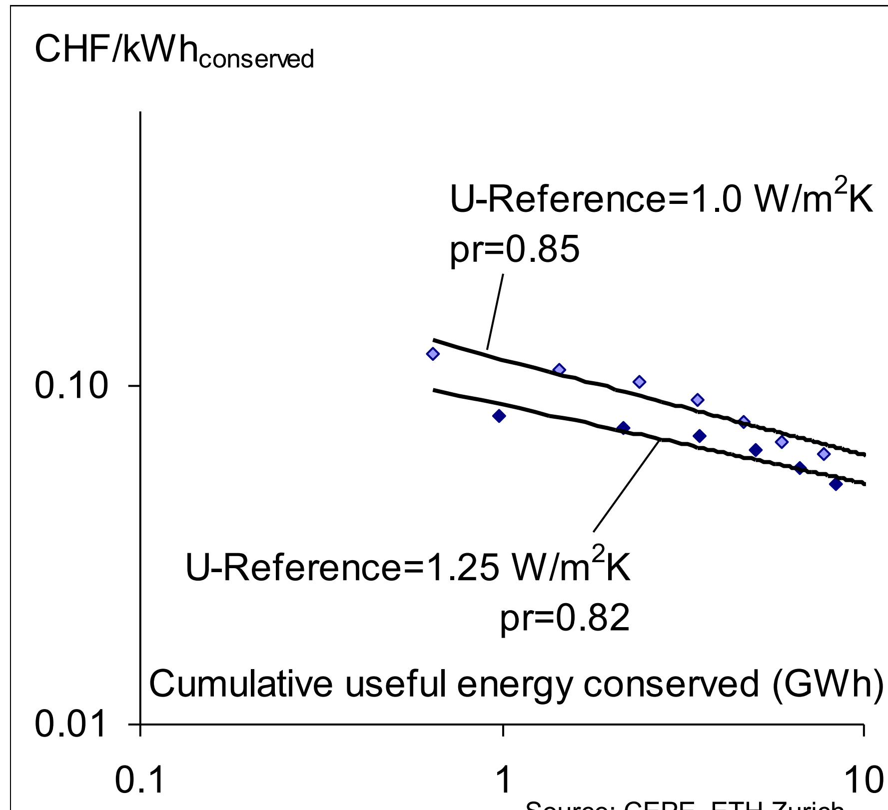
Source: Flumroc/CEPE ETH Zurich, *TEP Energy*

Progress ratio of <u>standard</u>
compound façade insulation (PS)

Development since 2001:

- Updates (2008) confirm results of Jakob and Madlener (2004)





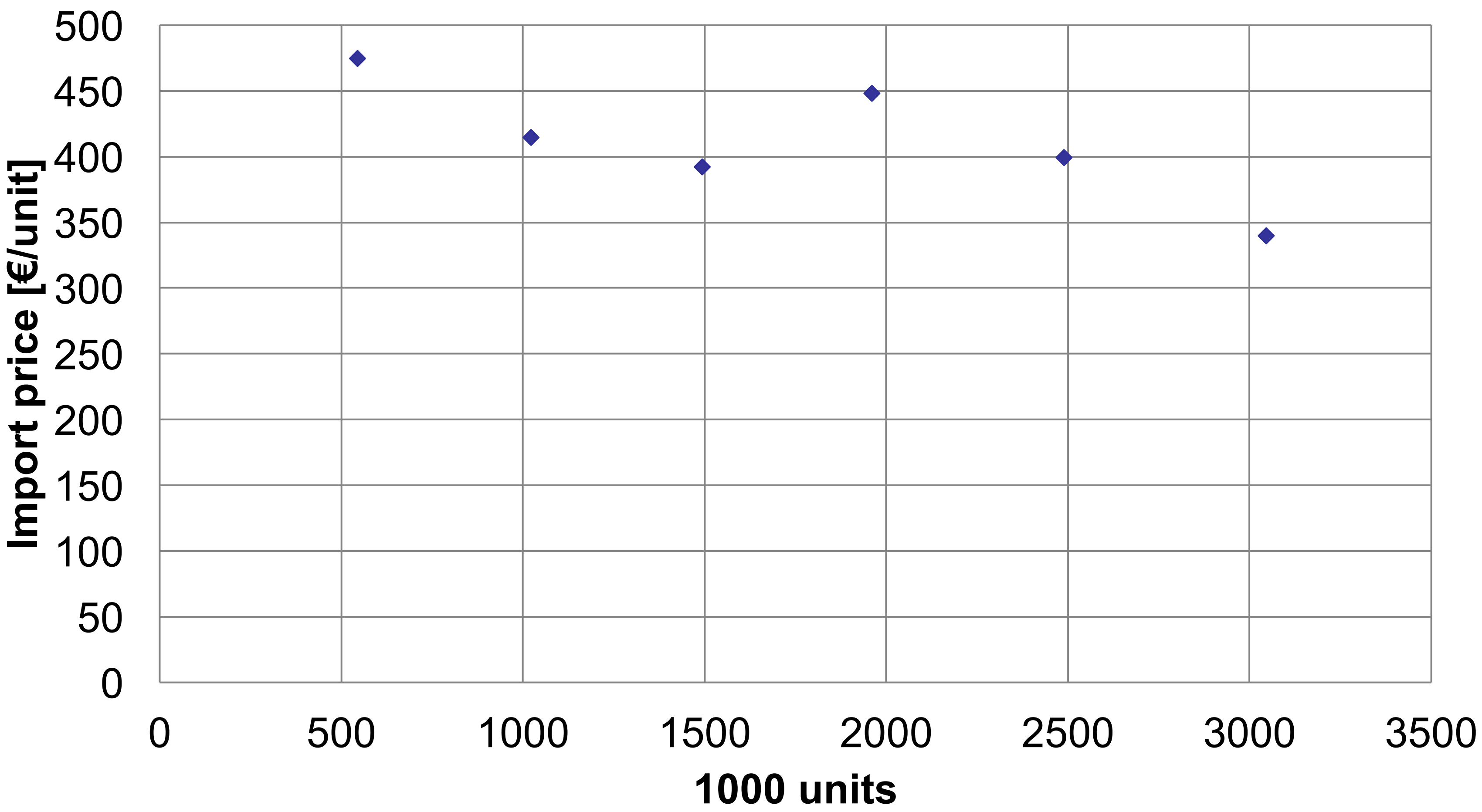
Further Cases

Technology addressed

Air conditioning

- Data based on European customs statistics and global air conditioning association data
- 2014 new CEN standards
- Sales influenced by annual heat conditions
- Units not specified
- Short timeline

Air conditioning

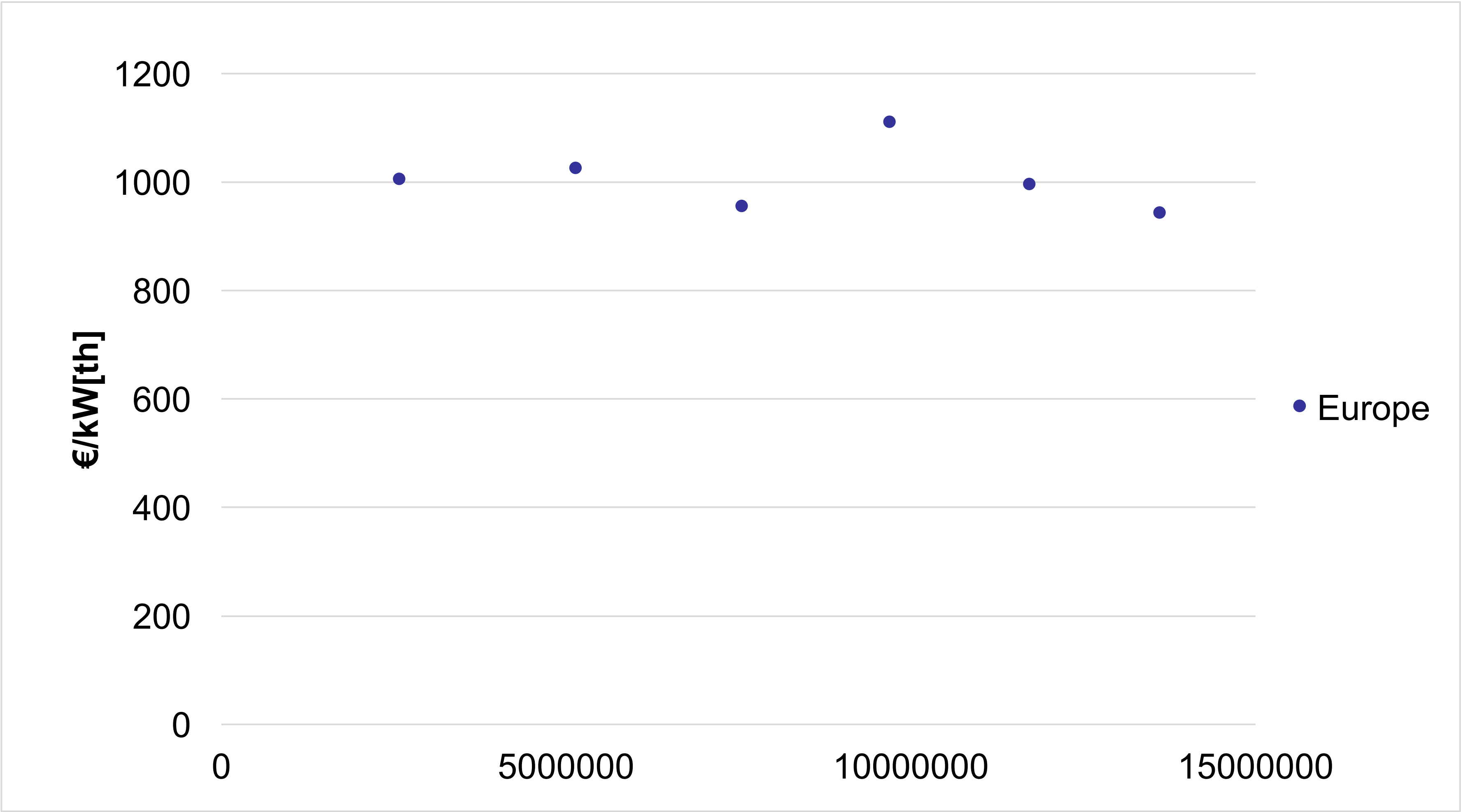


Technology addressed

Solar thermal

- Data based on European solar association
- Inflation corrected (base 2010)
- 2013 new CEN standards
- (no) learning in terms of cost reduction

Solar thermal results

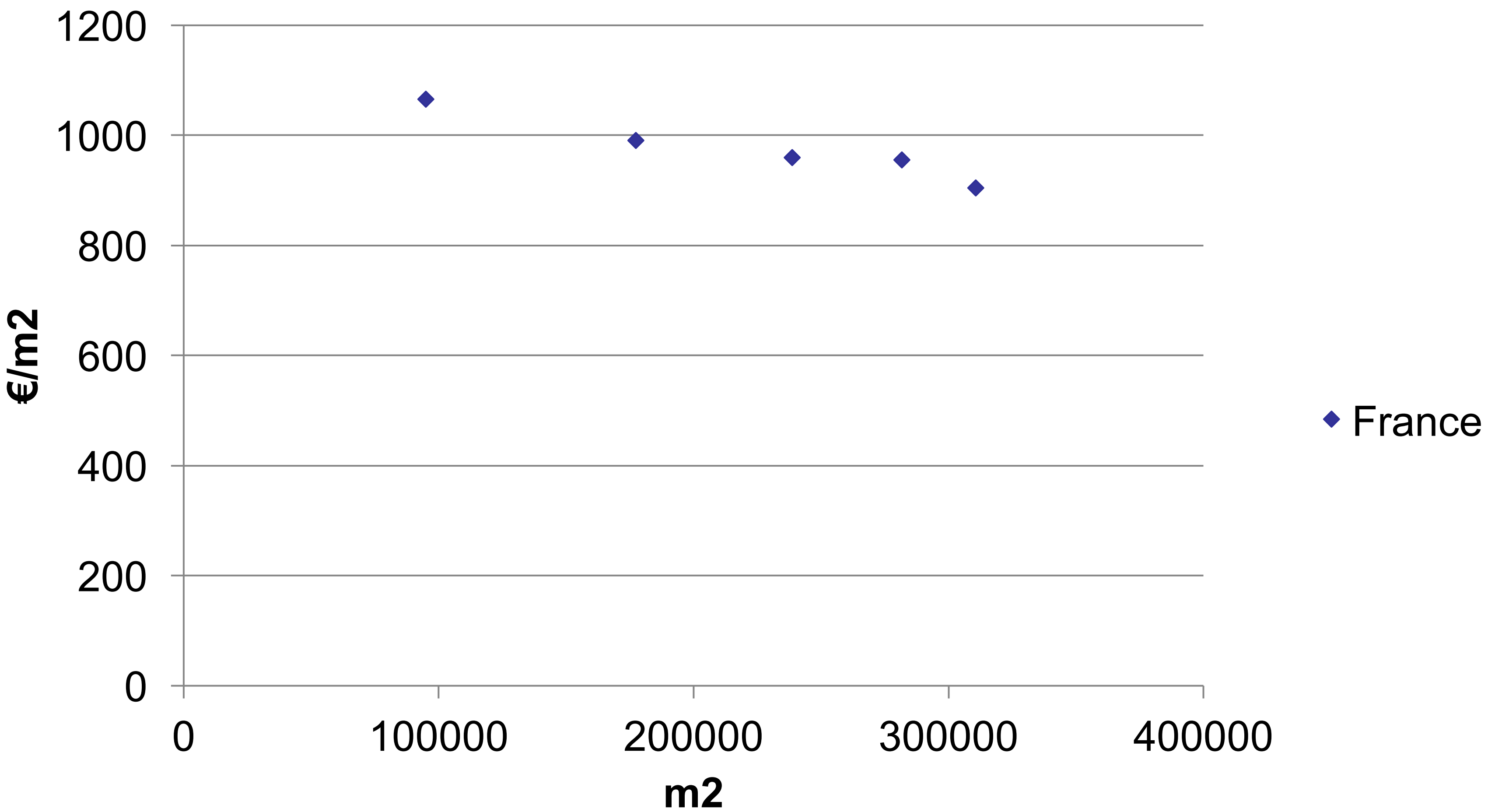


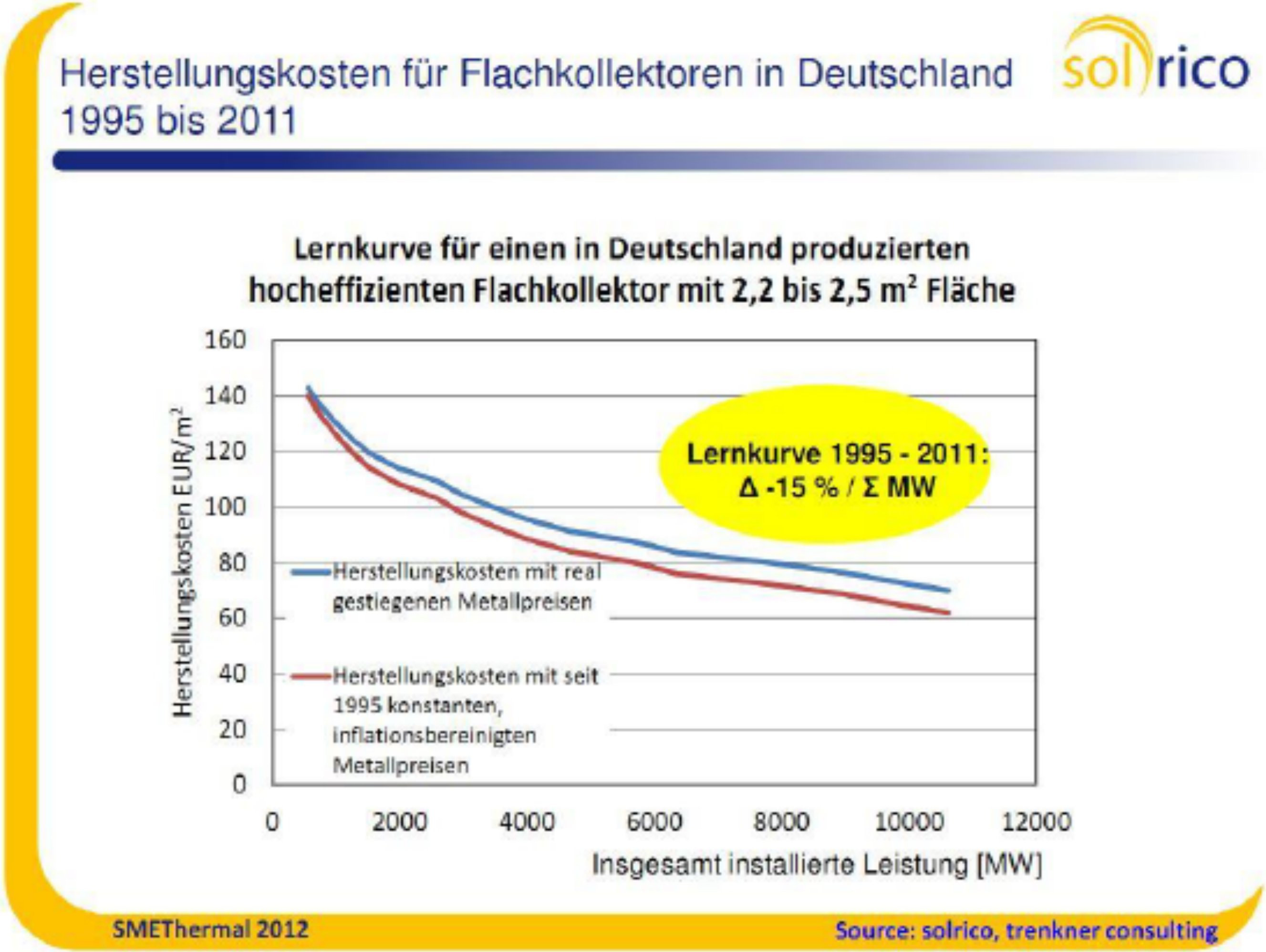
Solar thermal

Data for France

- Based on Observ’ER data
- Small market volumes (40% of German market)
- Qualification activities for installers by associations
- Declining market from 2012 onwards
- Differences in units of costs to be investigated
- Learning rate estimate at approx. 6%

Solar thermal France




Herstellungskosten für Flachkollektoren in Deutschland
1995 bis 2011
solrico
Lernkurve für einen in Deutschland produzierten
hocheffizienten Flachkollektor mit 2,2 bis 2,5 m² Fläche
Herstellungskosten EUR/m²
160
140
120
100
80
60
40
20
0
Lernkurve 1995 - 2011:
Δ -15 % / Σ MW
Herstellungskosten mit real gestiegenen Metallpreisen
Herstellungskosten mit seit 1995 konstanten, inflationsbereinigten Metallpreisen
0
2000
4000
6000
8000
10000
12000
Insgesamt installierte Leistung [MW]
SMEThermal 2012
Source: solrico, trenkner consulting

Conclusions and model implications

- Demand technologies seem to be strongly influenced by:
  - Price effects from market conditions (buyers or sellers' market)
  - Influence from changing standards
  - Local learning of relevance (installation costs, local manufacturing)
  - Construction cost indices only partially applicable
- More explanatory power of innovation process and drivers of costs and deployment needed
  - Only for demand technologies???

Thank you for your attention

Questions?

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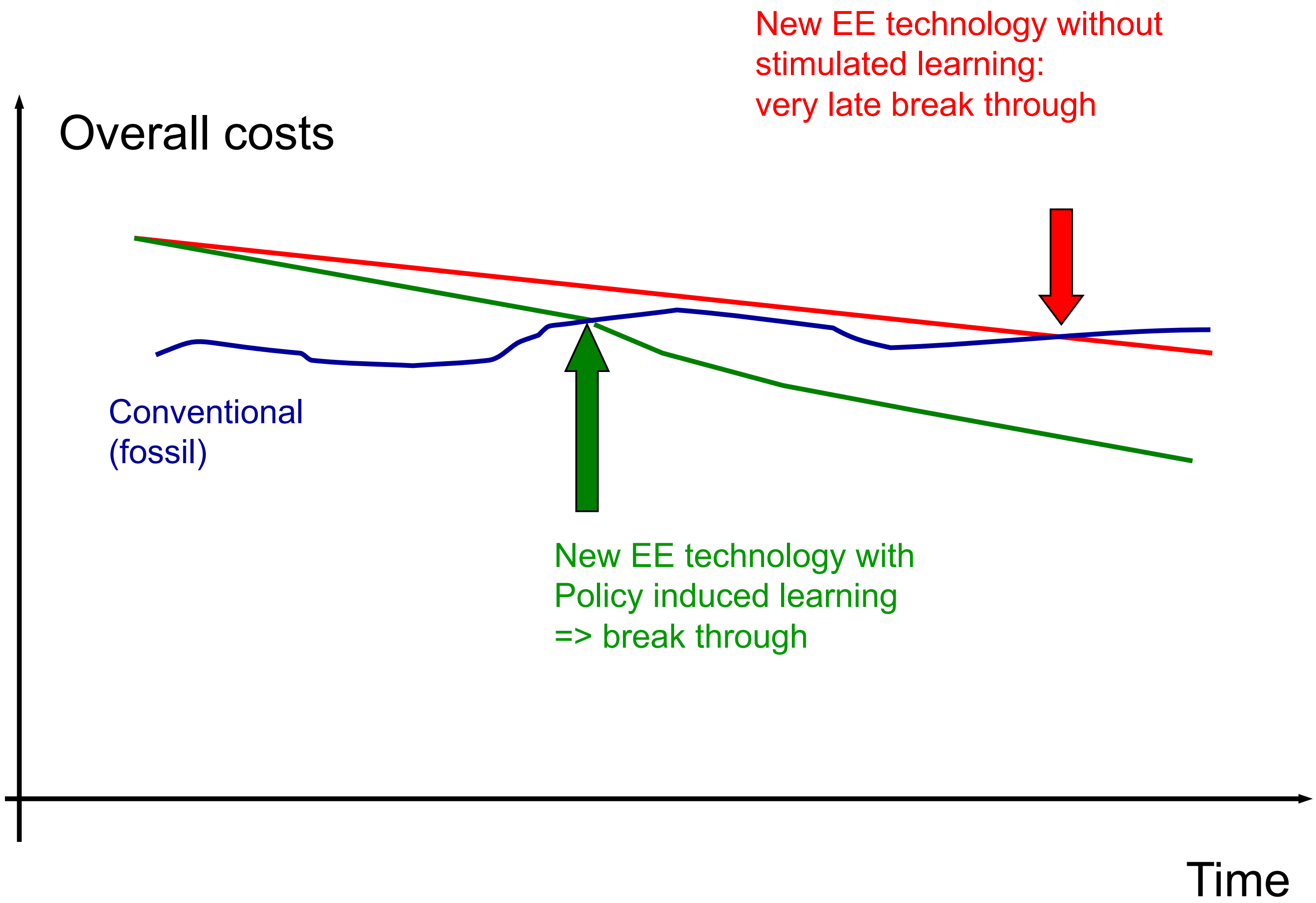
Dead lock vs. break through



Case 1

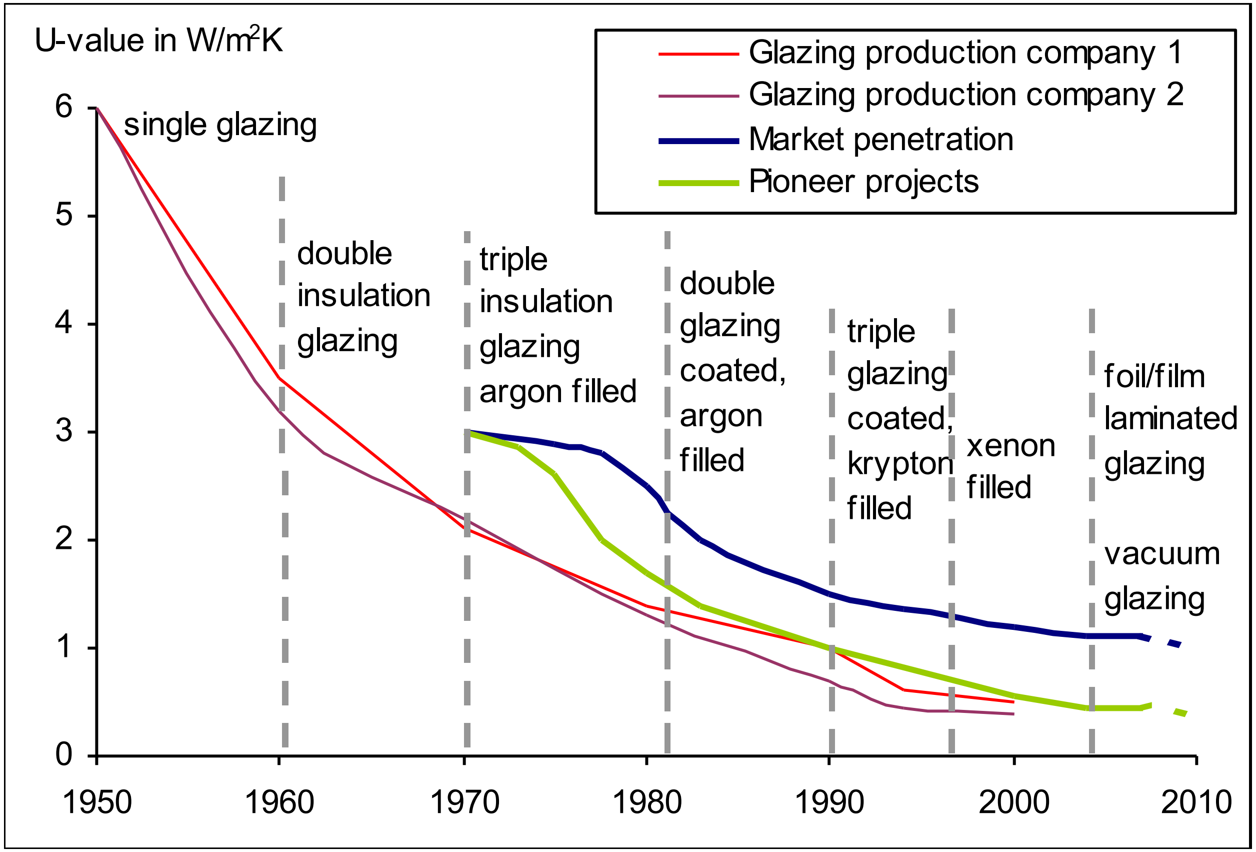
Heat pumps in (new) single-family houses

Case 2

Window glazing

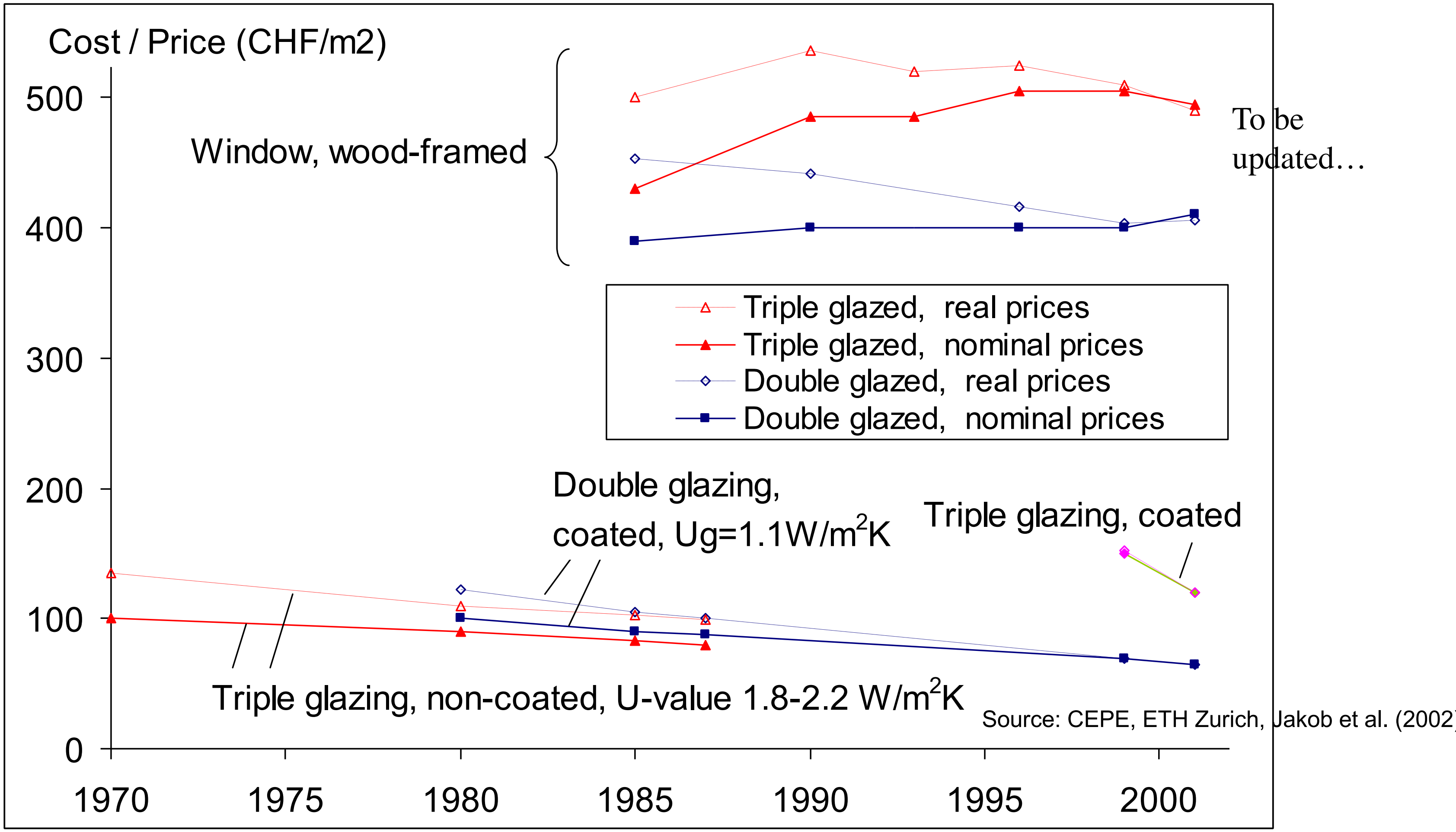
Techno-economic progress of window glazing
(Switzerland)

- Significant decrease of thermal transmittance (U-Value) since 1950s
- Price decrease of low-e double glazing from 110 to <70 Euro/m^2: -35% between 1984 and 1997

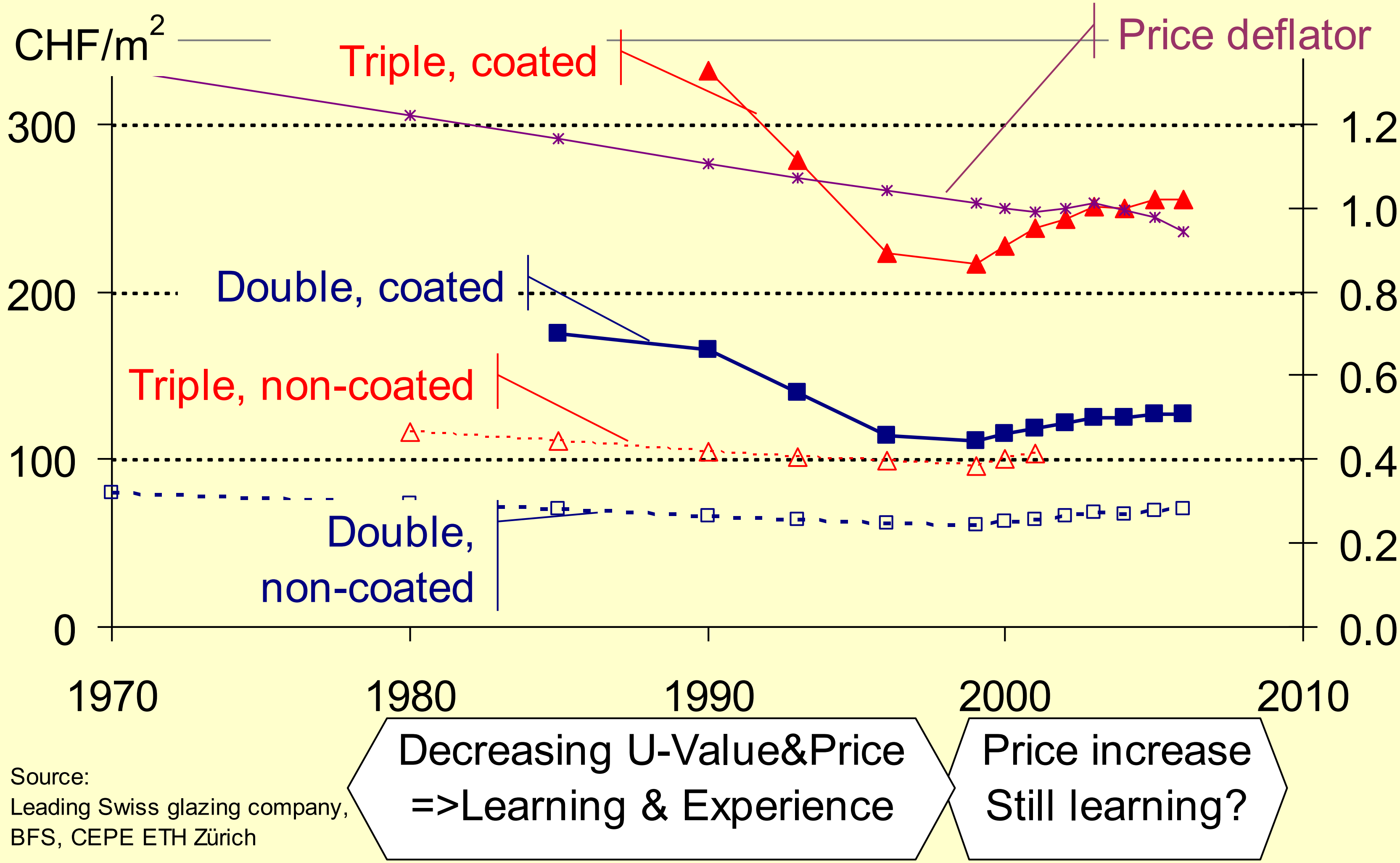


Source: CEPE, ETH Zurich, Jakob and Madlener (2004)

Cost/price development of
glazing and windows



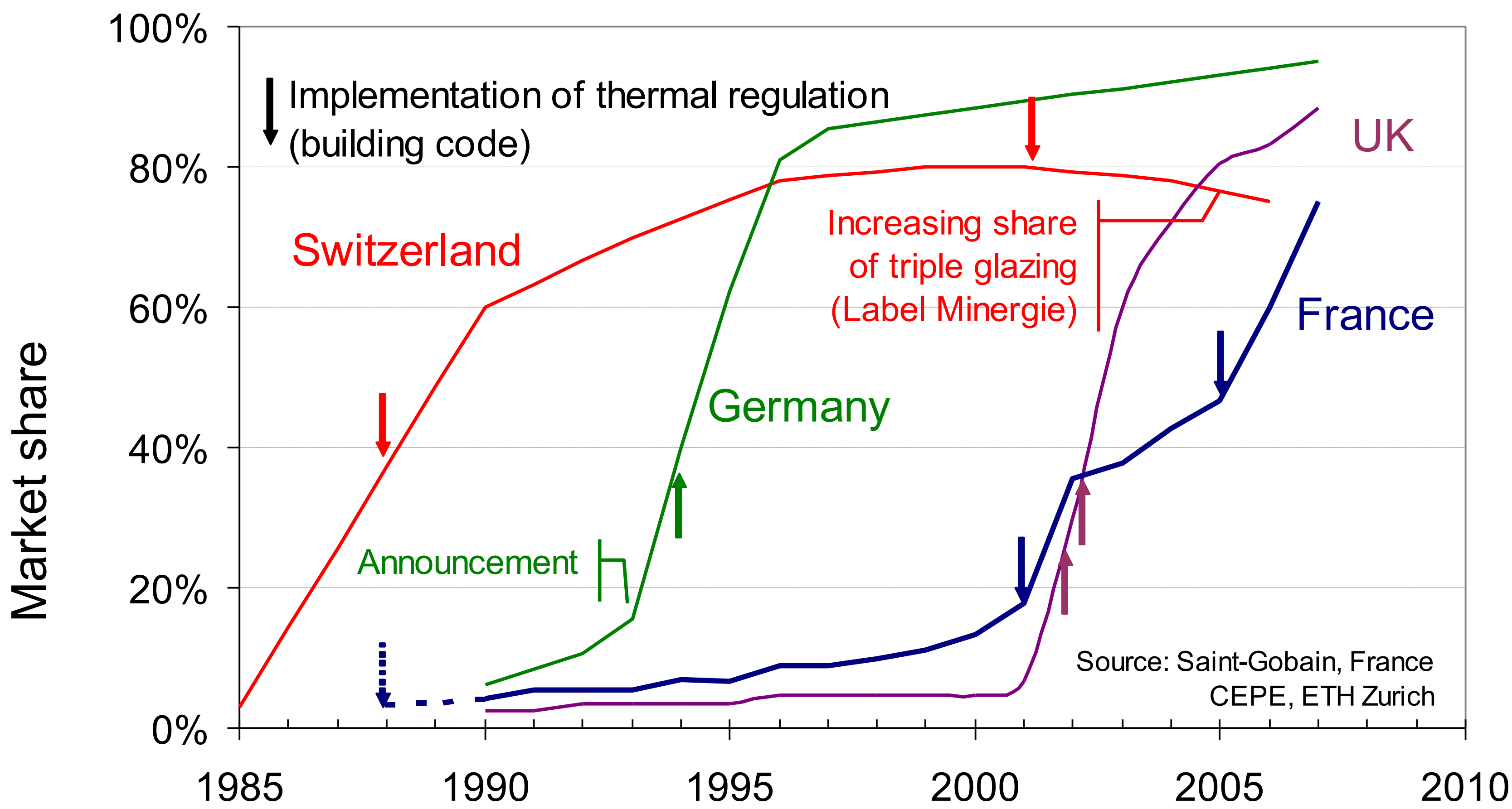
Cost/price development of
glazing and windows



Source:
Leading Swiss glazing company,
BFS, CEPE ETH Zürich

Diffusion of coated double glazing

Ambitious codes => rapid diffusion and market transformation



Diffusion of coated double glazing

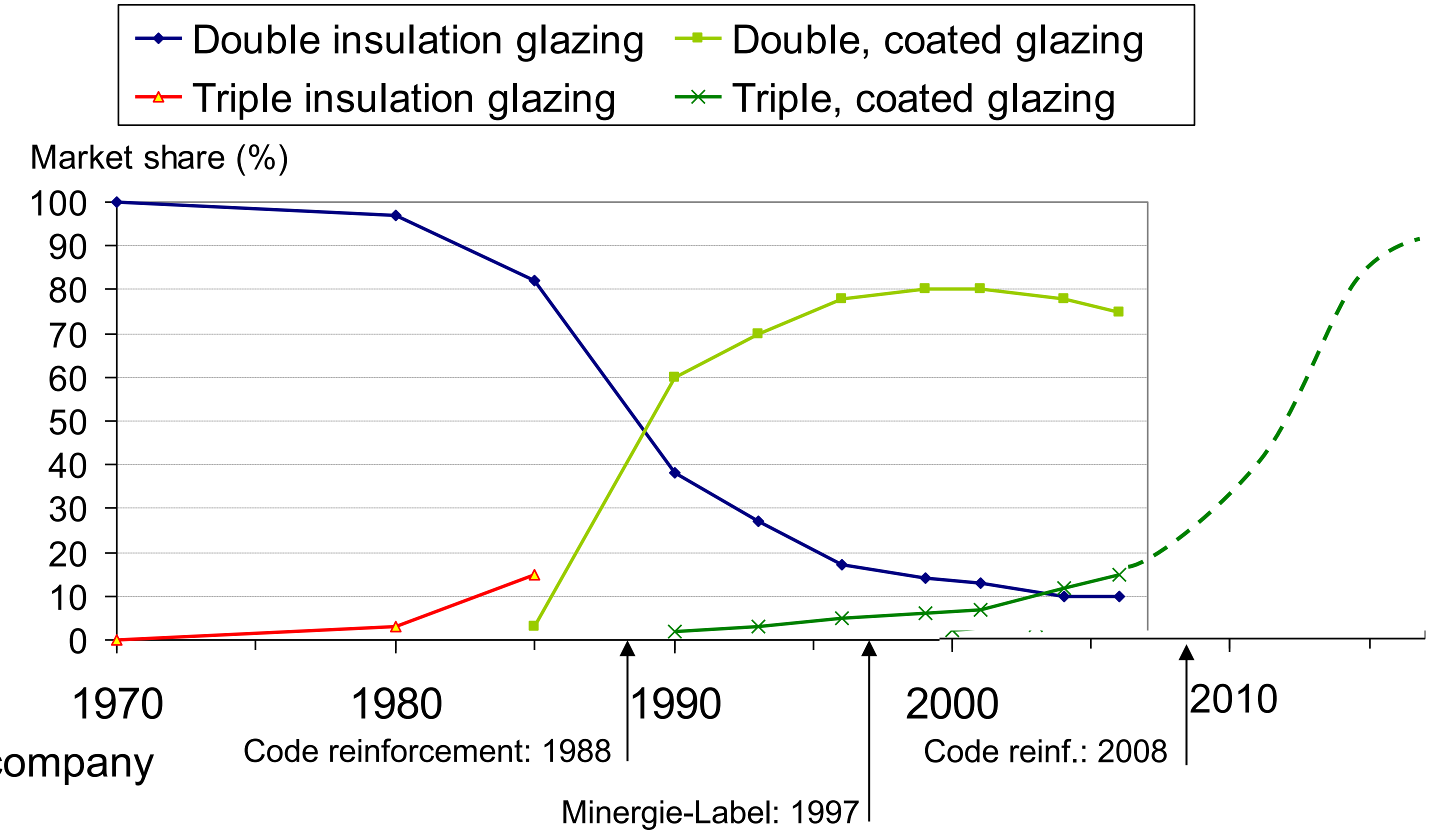
Ambitious codes => rapid diffusion and market transformation

Development 2001-2007:

- Non-coated glazing fading out
- Diffusion of triple glazing increasing steadily (despite price increase), but only slowly

Development >2007:

- Diffusion of triple glazing more rapid



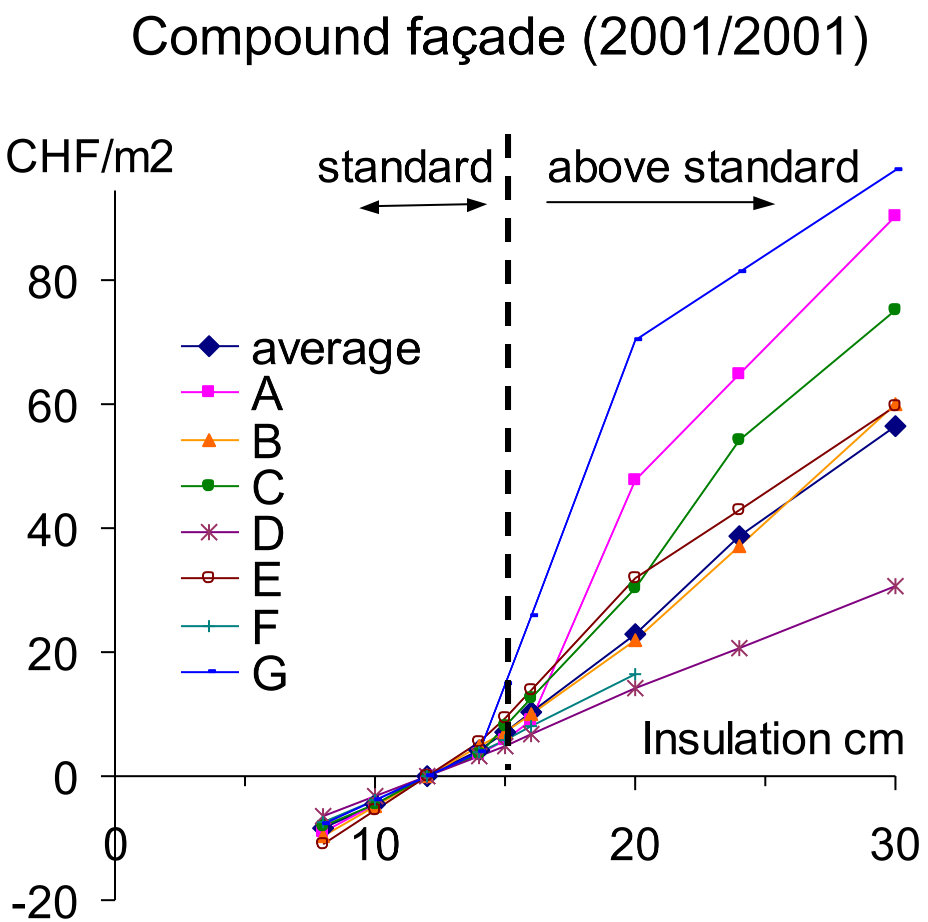
Source:
Leading Swiss glazing company
CEPE, ETH Zurich

Case 3

Building envelope insulation

Add-on Prices of Facade Insulation

as compared to reference 12 cm (CHF/m²)



New market

- Pioneer market pricing
- Pricing learning costs
- Security surcharge
- Benchmark?

Source: Jakob and Madlener 2004

Conclusion of cases
Window glazing and building envelope

- Codes and standards enable market transformation
- Diffusion from new buildings to existing ones
- EE ok, low retrofit rates still a problem

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- Sorrell, O'Malley, Schleich, Scott (2004): The economics of Energy Efficiency – Barriers to Cost-Effective Investment. Edward Elgar Publishing

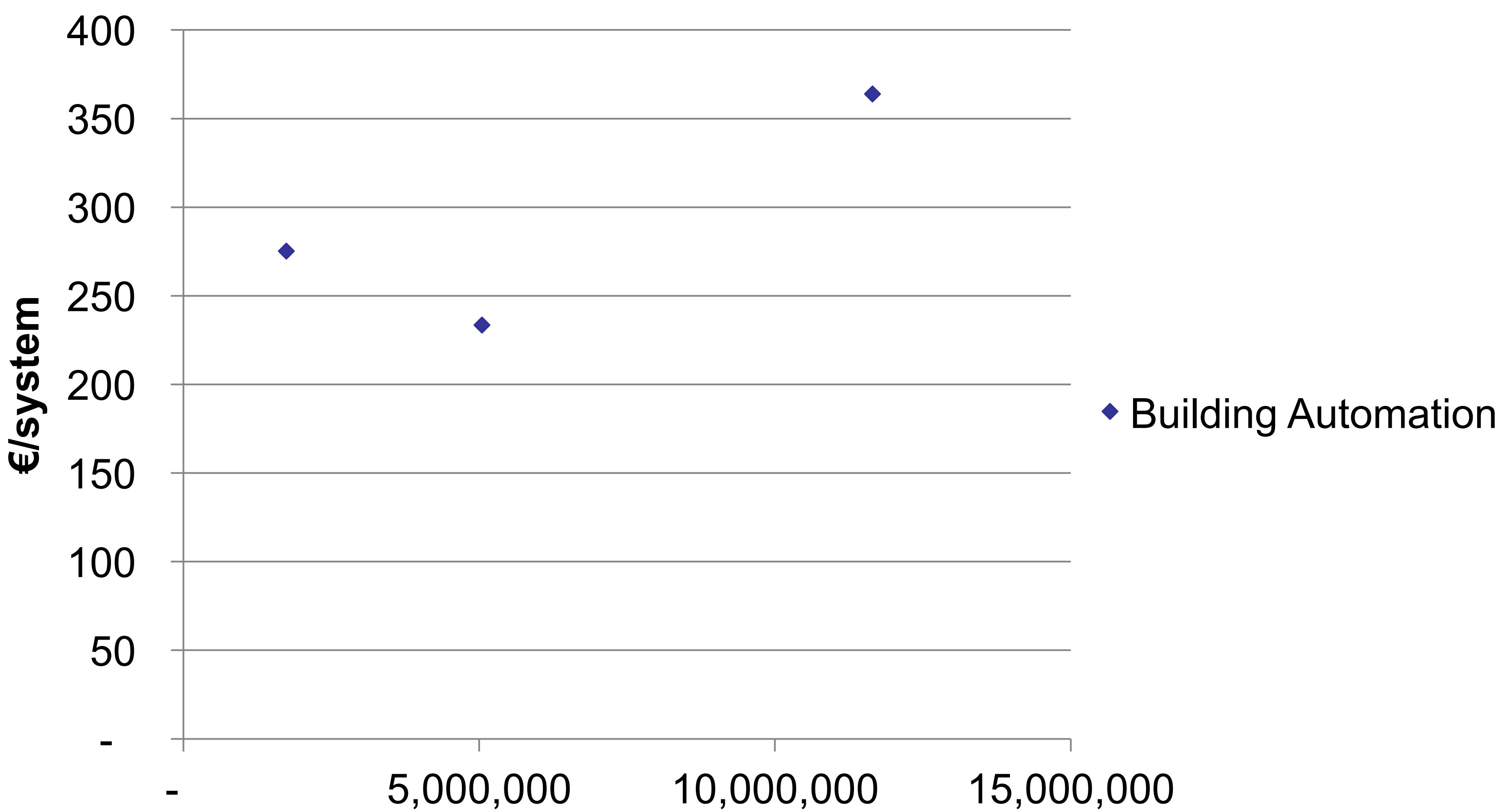
Technology addressed

Building automation

- Data based on European and US data from “Berg insights”

Data issues

- Very short timeline
- Mix of point solutions and multi-functions included


400
350
300
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Building Automation

Thank you for your attention!

Questions?

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