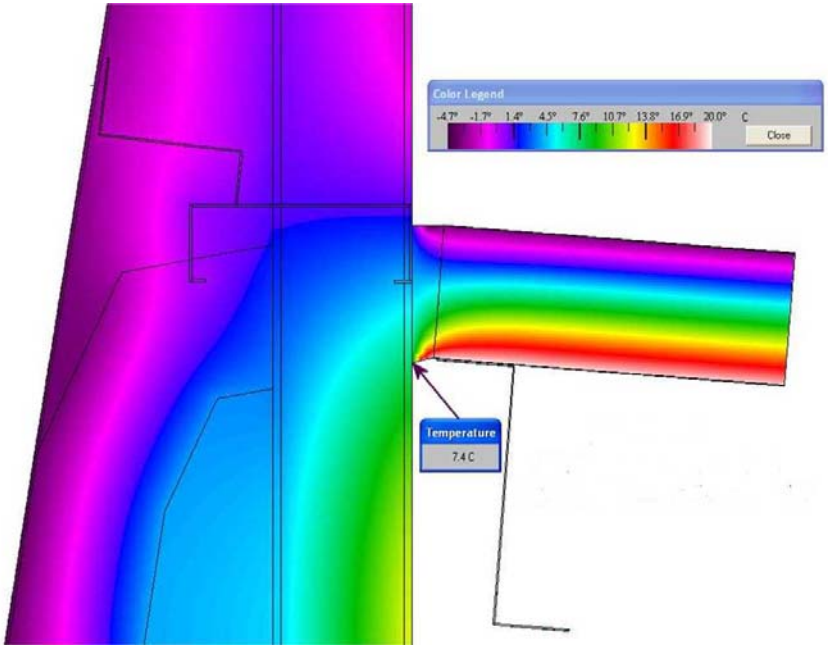
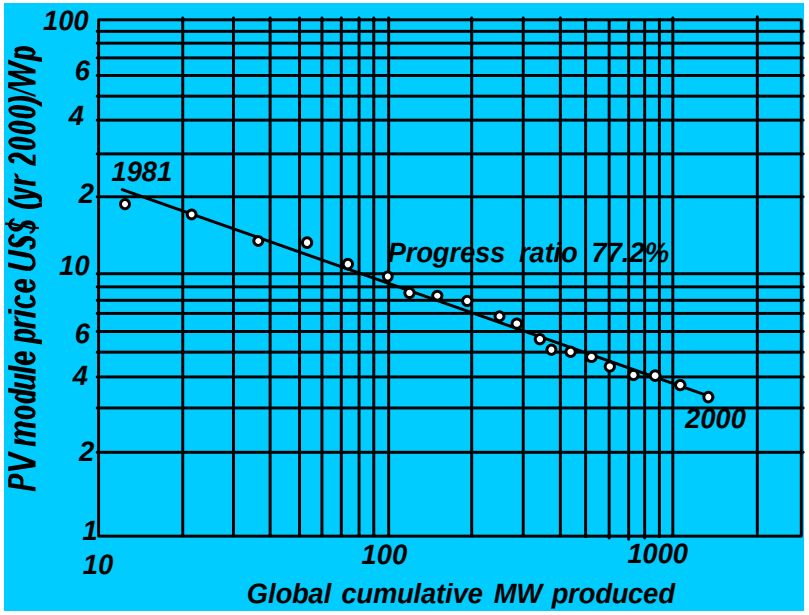
Innovation and the Learning Curve: reducing costs and building value





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Trevor Lee,
Director of Buildings

Cost and Value

- **Estimating the costs of sustainable architecture**
  - **This year**
  - **Future years**
- **Estimating the value of sustainable architecture**
  - **Innovative clients (now)**
  - **Mainstream clients (future)**

Costs - The Learning Curve

- ✘ **Not the current "loose usage" of individual education and training**

- ✓ **Overall cultural, technological and skill advancement within an economic niche**
  - – Also called **"Experience Curves"**
  - – **"Experience Curves for Energy Technology Policy",** © OECD/IEA, 2000

The Learning Curve

The experience curve equation

The trend line in Figure 1.1 is a fit of a power function to the measured points. It is this line which is commonly referred to as the "experience curve". The curve is described by the following mathematical expression.

$$\text{Price at year t} = P_0 * X^{-E}$$

"P_0" is a constant equal to the price at one unit of cumulative production or sales. In Figure 1.1, P_0 is the price at 1 MW of cumulative sales and is equal to 32 US$(1992)/$W_p$. "X" is cumulative production or sales in year t. X in Figure 1.1 is the sum total in MW of all PV-Modules sold world-wide until the year t. For instance, in the year t = 1992 the price is 5.9 US$/$W_p$ and the sum of all sales until 1992 is 340 MW. "E" is the (positive) experience parameter, which characterises the inclination of the curve. Large values of E indicate a steep curve with a high learning rate. The relation between the progress ratio, PR, discussed in the text and the experience parameter is

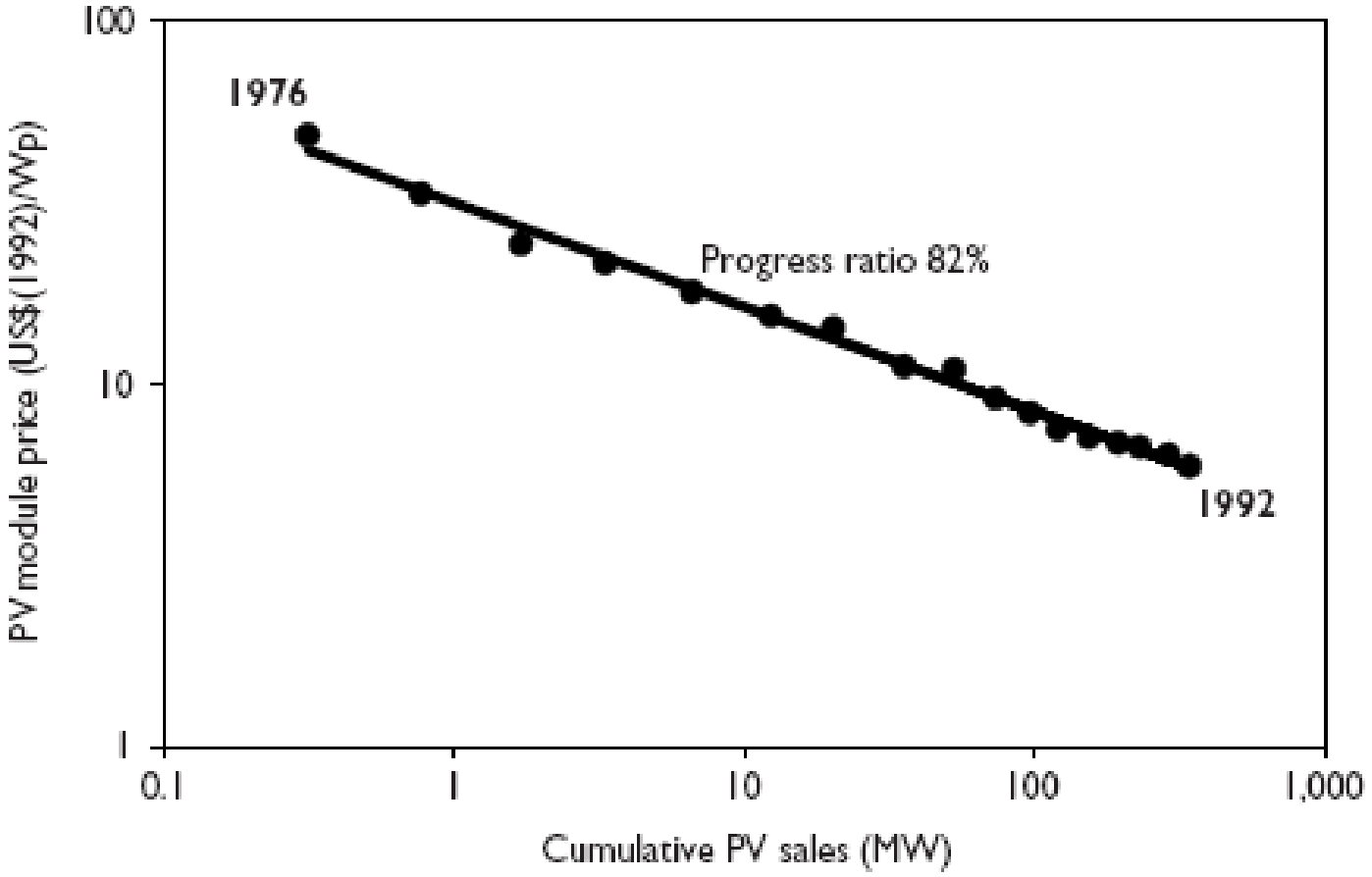
$$PR = [P_0 * (2X)^{-E}] / [P_0 * X^{-E}] = 2^{-E}$$

The experience parameter for the curve in Figure 1.1 is E = 0.29, which gives a progress ratio of $2^{-0.29} = 0.82$ or 82%.

- **Price $_{\text{at year t}} = P_0 * X^{-E}$**
  - **"P_0" is a constant equal to the price at one unit of cumulative production**
  - **"X" is cumulative production or sales in year t**
  - **"E" is the (positive) experience parameter, which characterises the inclination of the curve**

Learning Curve – Photovoltaics (PV)

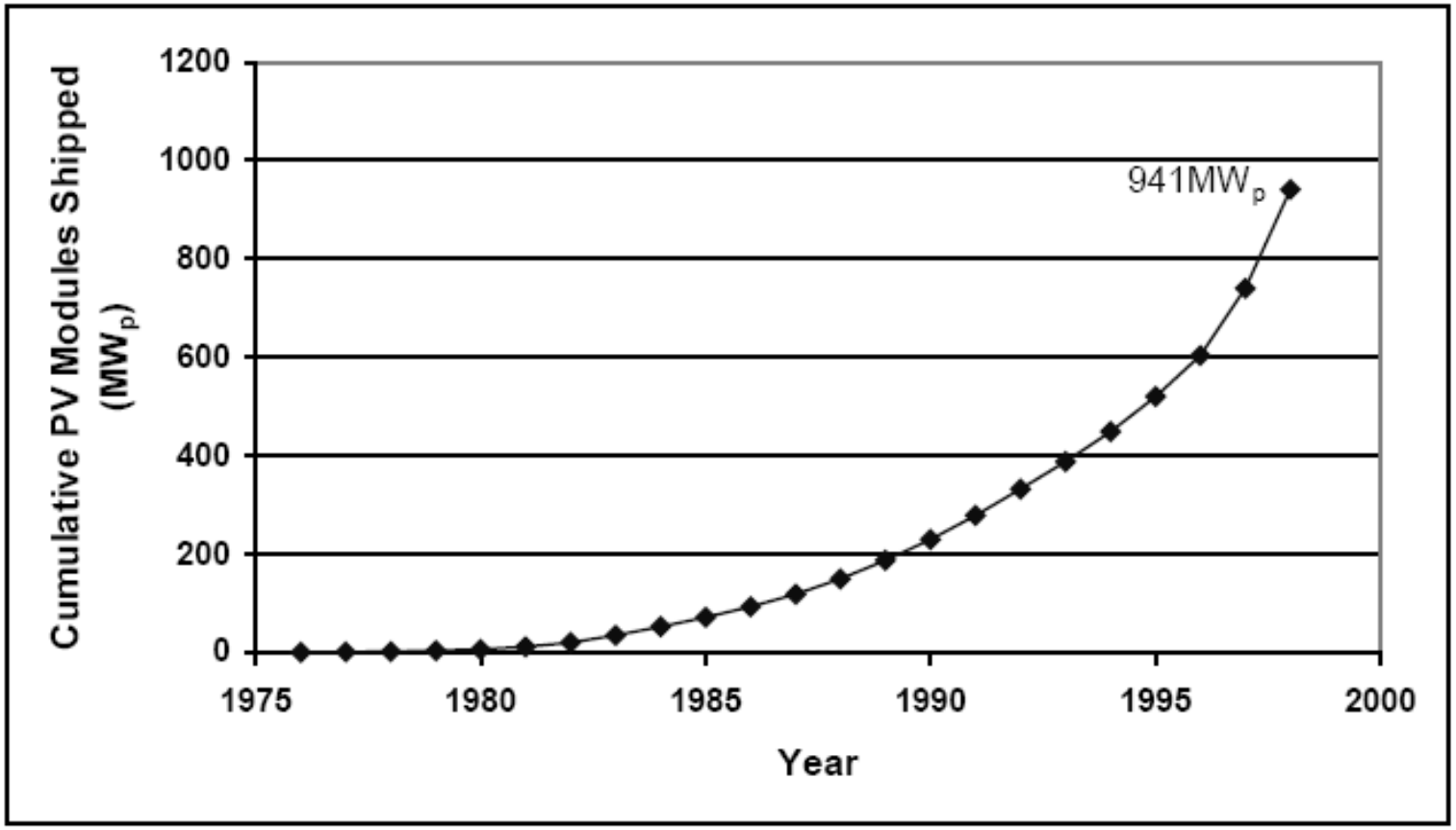
Figure 1.1. Experience Curve for PV Modules, 1976-1992



Learning Curve – Photovoltaics (PV)

- Progress Ratio = PR
- $PR = [P_0 * (2X)^{-E}] / [P_0 * X^{-E}] = 2^{-E}$
- Large values of E indicate a steep curve with a high learning rate.
- The experience parameter for the curve in Figure 1.1 is E = 0.29, which gives a Progress Ratio of $2^{-0.29} = 0.82$ or 82%.

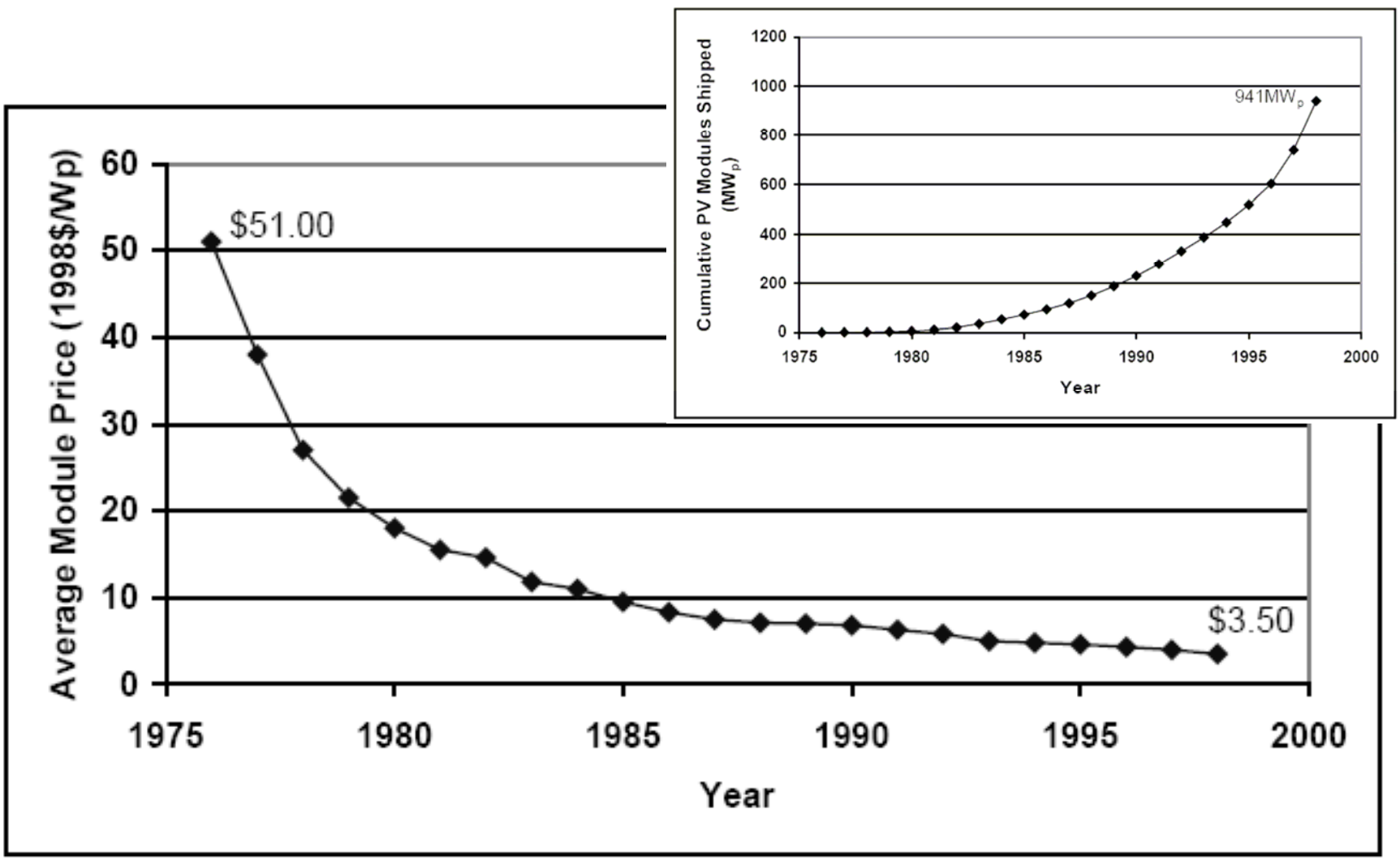
Learning Curve – Photovoltaics (PV)



"Experience Curves of Photovoltaic Technology", 2000

Interim Report IR-00-014, International Institute for Applied Systems Analysis, Laxenburg, Austria

Learning Curve – Photovoltaics (PV)



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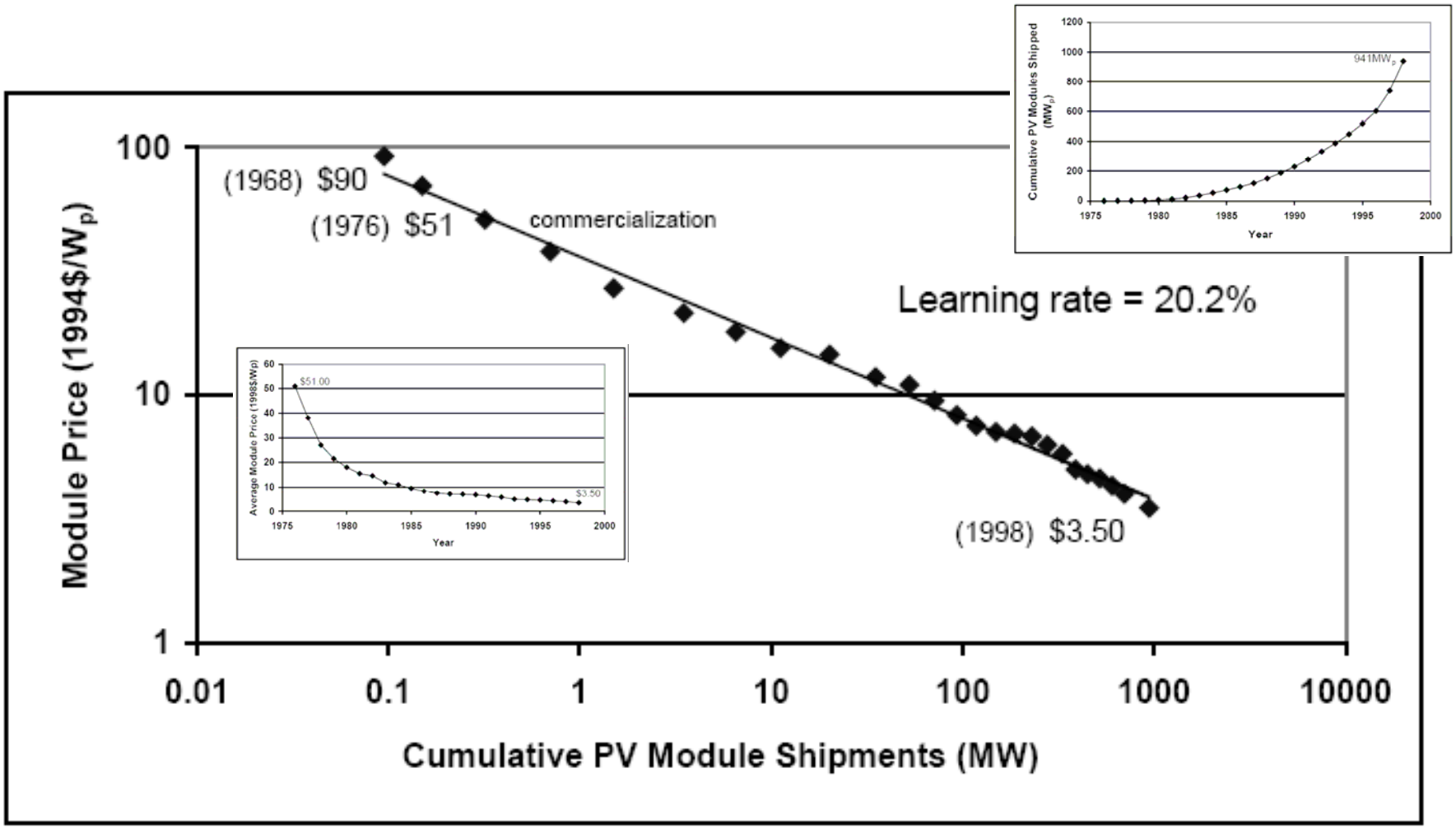
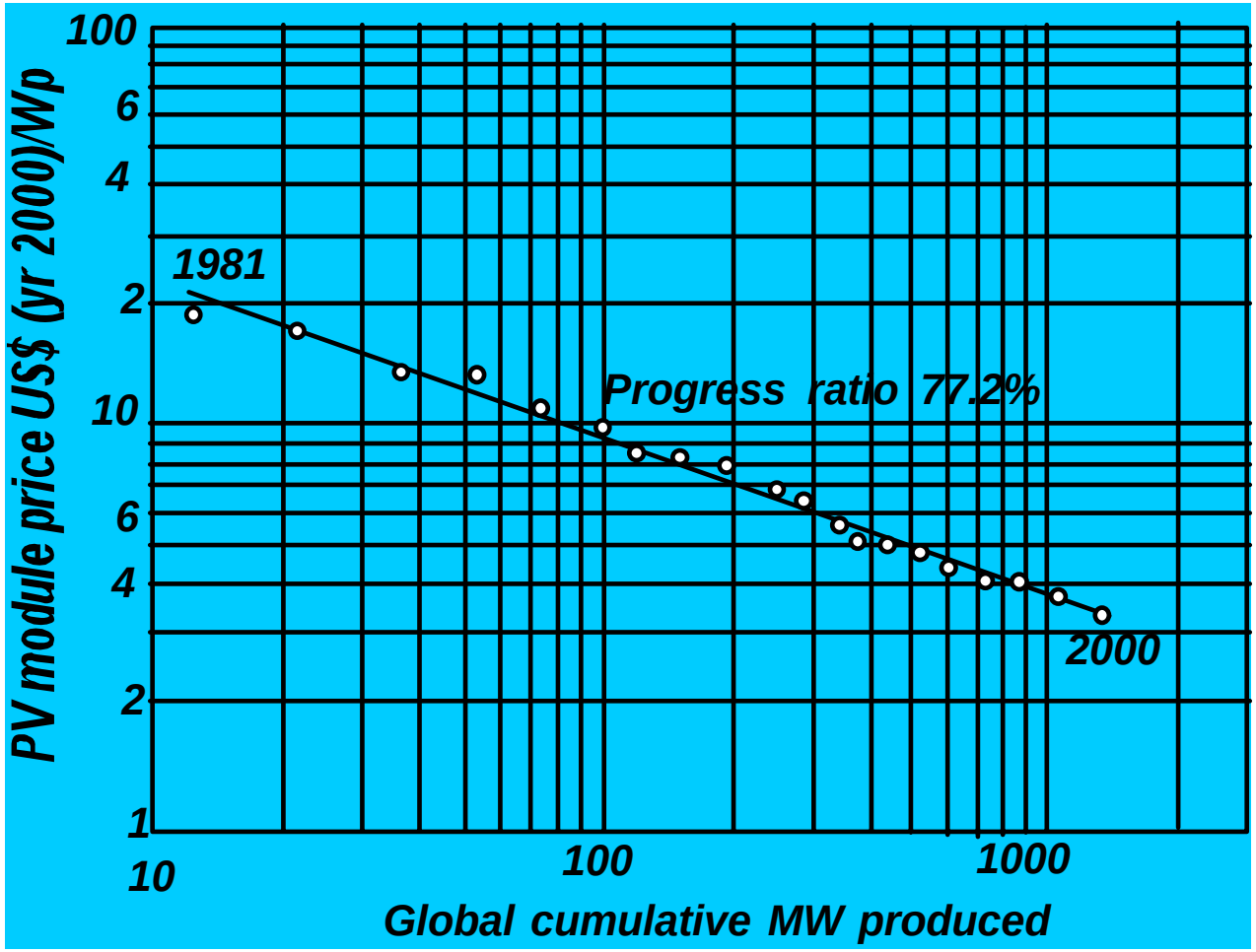
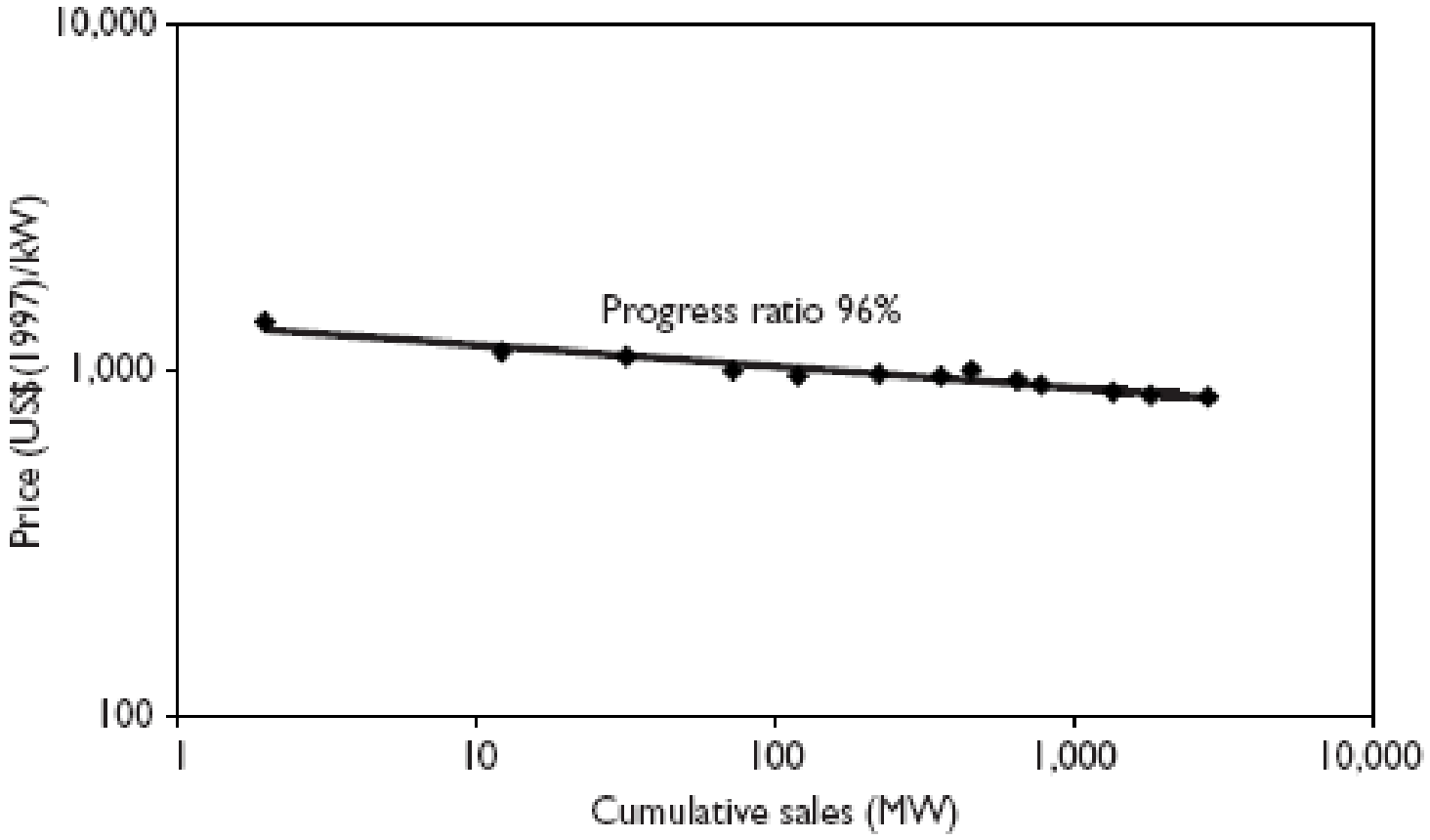


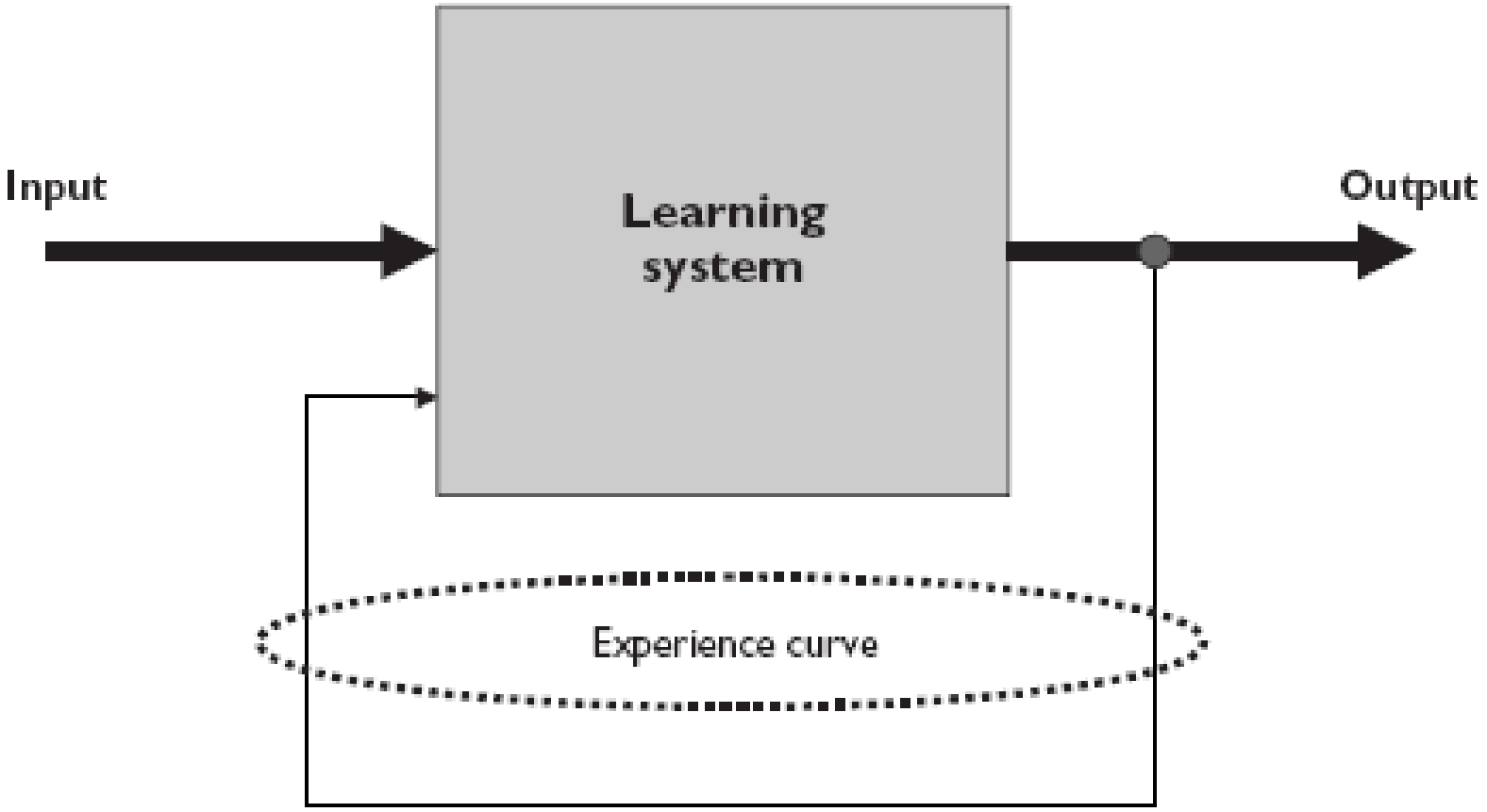
Learning Curve – Photovoltaics (PV)



Learning Curve –
Danish Wind Turbines, 1982-1997



The Learning System



The experience curve is a measure of the efficiency of the feedback, or learning loop, for the system.

The Learning System - Buildings

- **The building industry (especially the housing industry) has an excellent Learning System**
- **Mass (project) housing has excellent scope for learning through repetition in whole buildings**
- **Materials and component industries have excellent learning through repetition in their respective niches**

The Learning System - Regulations

- **This savings-from-learning applies to energy efficiency provisions, as to other requirements, in the BCA**
- **Regulations accelerate the rate of production with learning and cost reductions naturally following on**
- **Estimates of the cost of regulation routinely (and naively) ignore this large economic benefit**

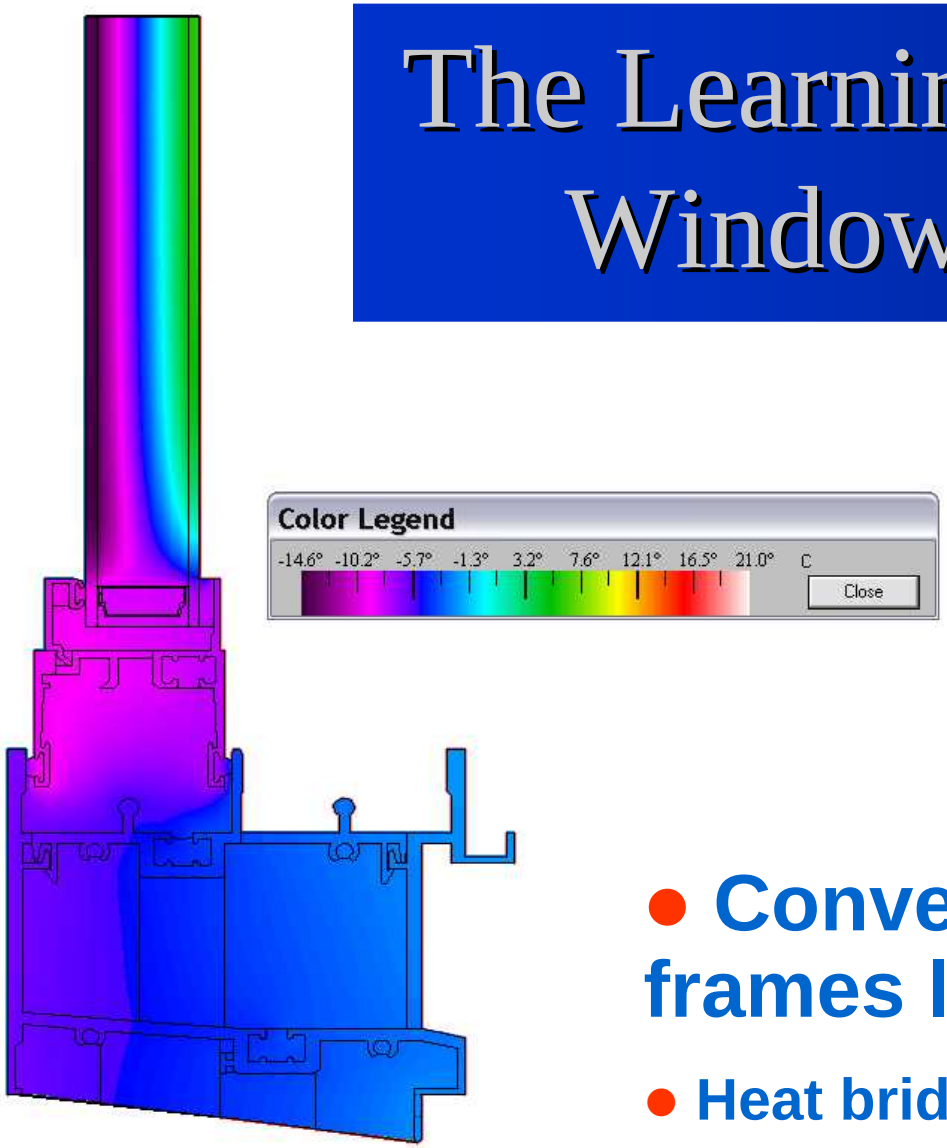
The Learning Curve - Windows

- **Case Study: Double Glazing** (source AGGA)
  - **The price of double glazing has been steadily decreasing over the past 3 years** (since the first BCA housing energy efficiency requirements 2003)
  - **3 years ago volume customers were paying around $19 to $25 per side for 3mm DGUs** (double glazed units)
  - **now paying between $16 & $19 per side - a 15% to 24% reduction**

The Learning Curve - Windows

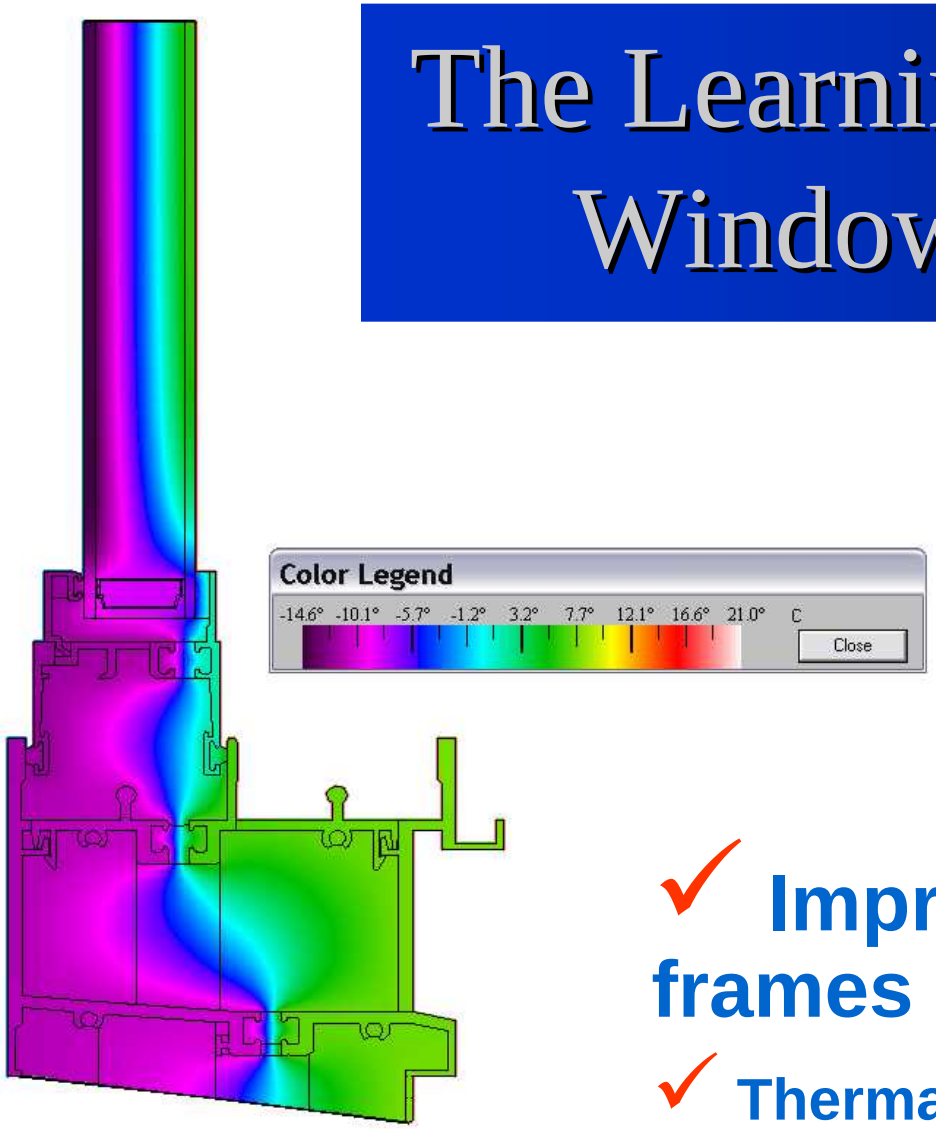
- **Case Study: Advanced Glazing** (source AGGA)
- High performance “Low E” >50% reduction
  - from around $120 - $140/m^2 3 years ago for 4mm toughened to around $60/m^2
- Toughened DGU’s a 36% reduction
  - from around $110/m^2 3 years ago for volume customers to around $70/m^2

The Learning Curve - Windows



- **Case Study: Improving inefficient frames**
- **Conventional aluminium frames leak heat**
  - **Heat bridging with added “fin effect”**
  - **Rated at NFRC standard conditions**

The Learning Curve - Windows



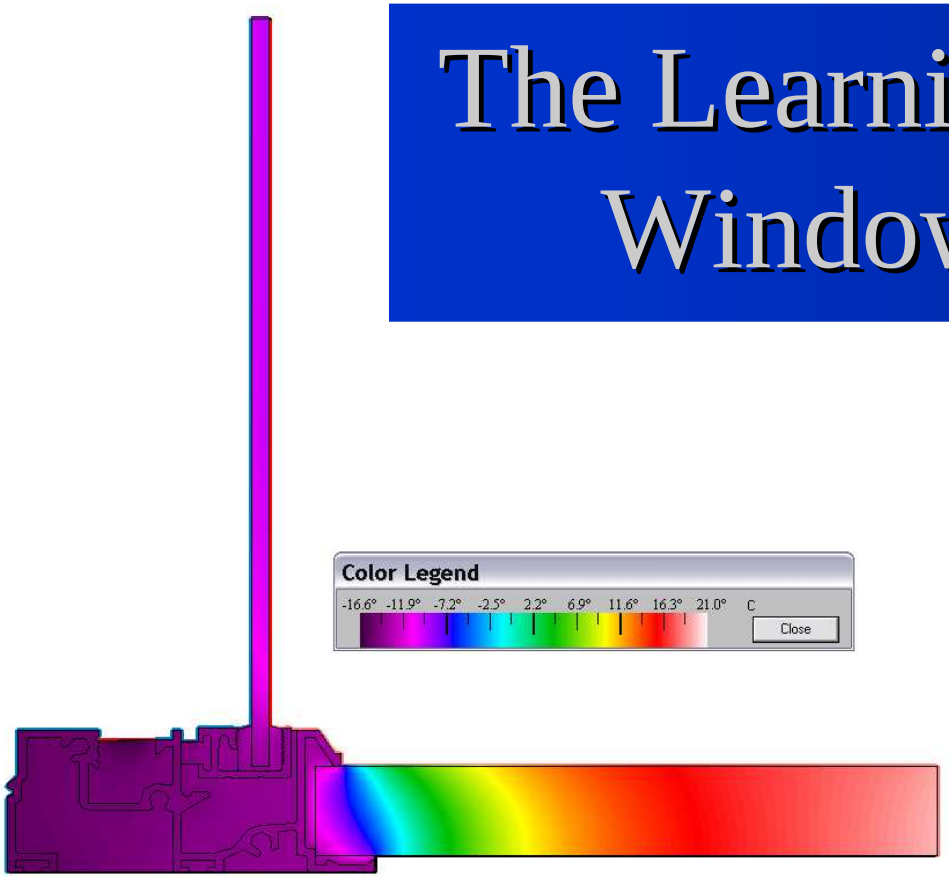
- **Case Study: Improving inefficient frames**

✓ **Improved aluminium frames leak little heat (2003)**

✓ **Thermal break cuts heat bridging**

✘ **Low volume means high cost**

The Learning Curve - Windows



- **Case Study: Improving inefficient frames**

✓ **Improved aluminium frames with timber reveal shielding also leak little heat (2006)**

✓ **Clever detailing with high volume means low cost**

Cost and Value

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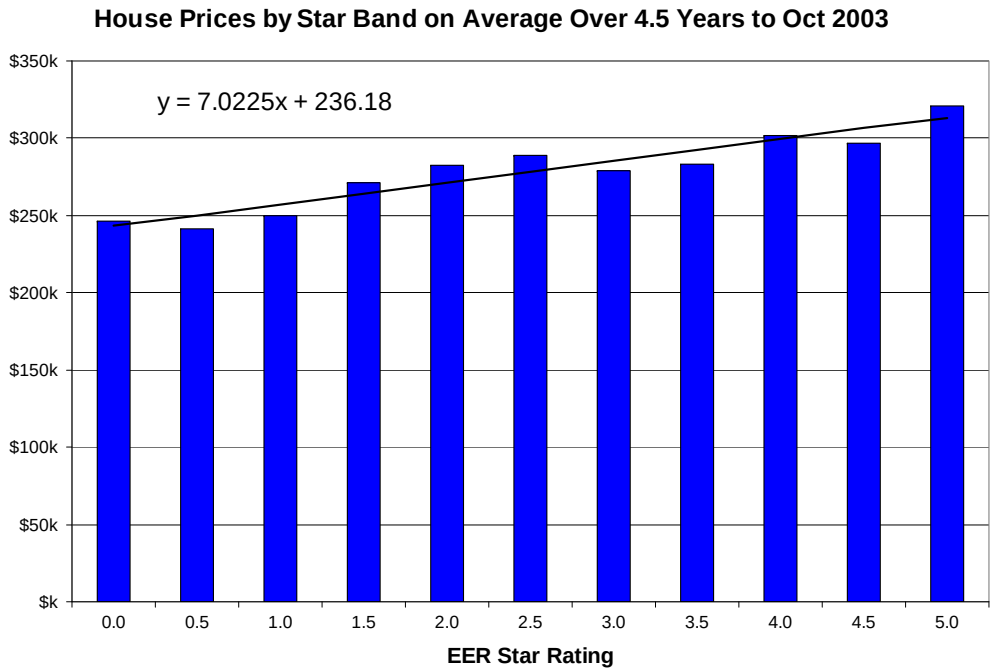
Value – Discerning Customers

Case Study: Low Energy Housing

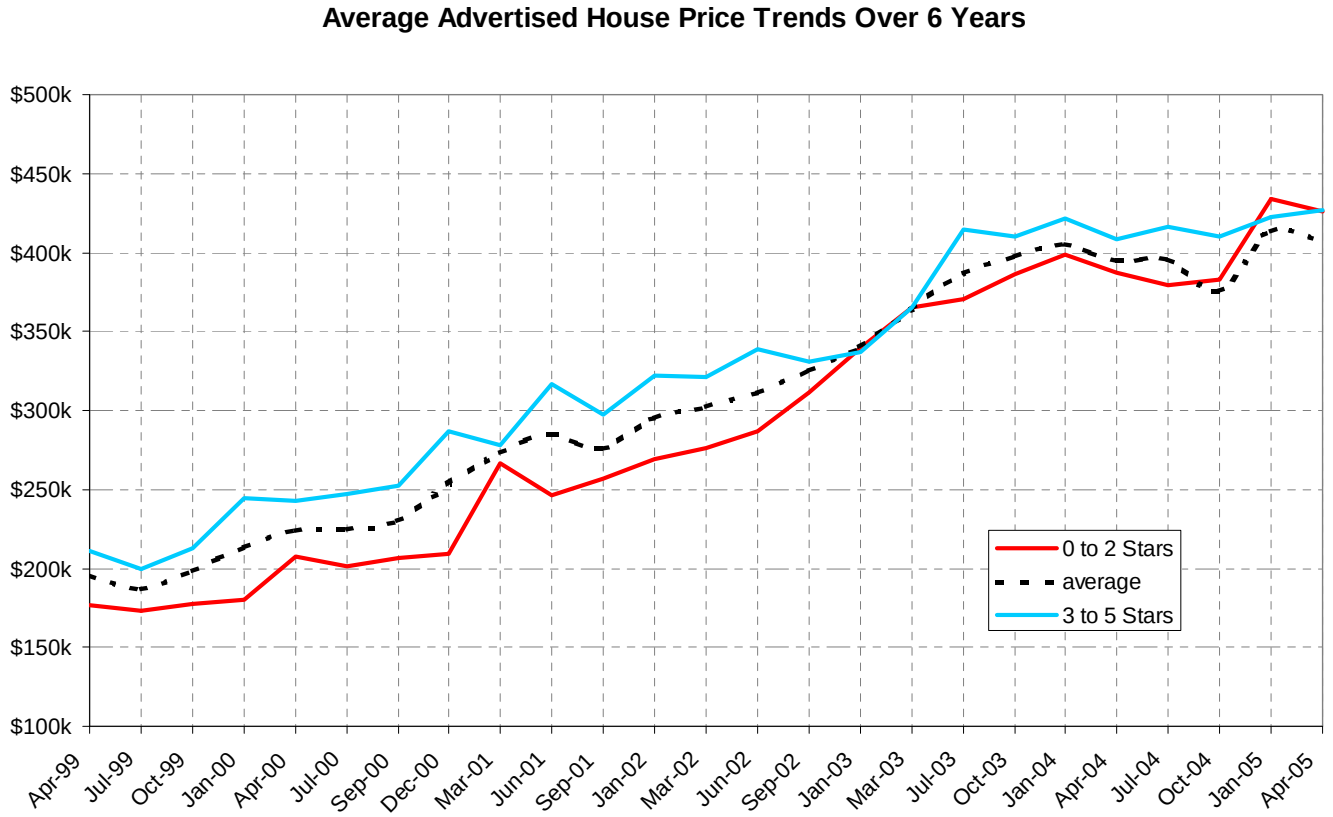


Prepared by **Energy Partners** from advertised house prices (C.T.) since the start of the EER(SOP) Act

y = 7.0225x + 236.18 means $7,000 per half-star

Value – Discerning Customers

Case Study: Low Energy Housing



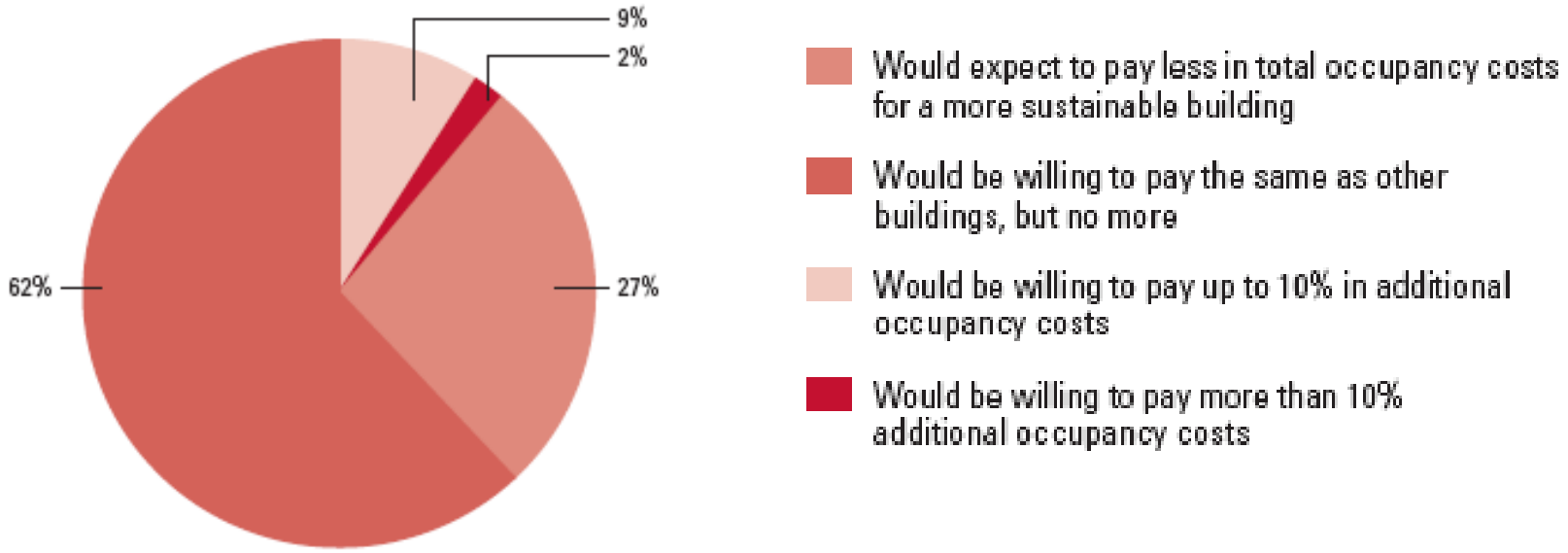
(C) Prepared by **Energy Partners** from advertised house prices (C.T.) since the start of the EER(SOP) Act

Value – Discerning Customers

Case Study: “Green” Offices

Value – Discerning Customers

Case Study: “Green” Offices



Will tenants pay more for a sustainable building?

JLLS Corporate Real Estate Impact Survey (CREIS) for 2005

Value – Discerning Customers

Case Study: "Green" Offices

A grade asset Central CBD, Sydney 30,000 sqm NLA Single tenanted.	
Gross Effective Rent	Unchanged at $560/sqm
Outgoings	Reduced by $3.32sqm, $146.68
Upon Lease Expiry	Allow 3 months letting up (50% Retention)
Capitalisation Rate	Unchanged at 6.75%
Capitalisation Approach	$178.0m
DCF Approach	$181.0m
Adopted Value	$180.0m
Capital Expenditure Yr 1	$720,115

These initiatives have added $3.0M in capital value, representing a return of almost 10 times the investment.

NGACs add to the value of energy savings in office upgrades (ignored by JLLS)

NGACs = NSW&ACT Greenhouse Abatement Certificates

Conclusion – Costs and Value

- **We are still in the early (steep) stages of the Learning Curve for Sustainable buildings**
- **Technological advances, skill enhancement and economies of repetition will continually decrease the cost of Sustainabilty**
- **Energy efficient houses already command a premium in the ACT market**
- **“Green” offices reduce outgoings and build capital value**

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