Developing Energy Efficiency and Cost Projections of Future Building Technologies for NEMS

Ed Barbour
Navigant Consulting, Inc
1801 K Street
Washington D.C.

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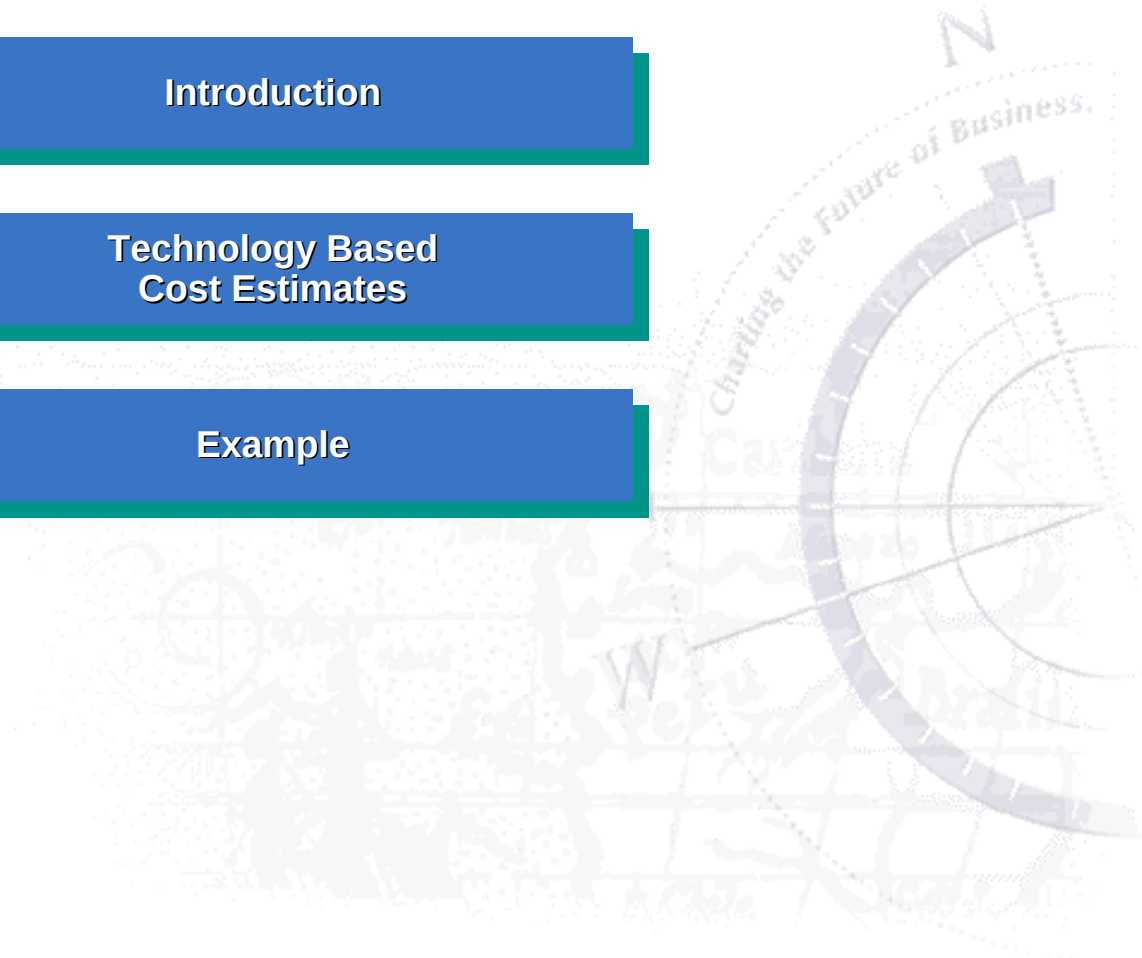
Agenda

- Introduction
- Technology Based Cost Estimates
- Example



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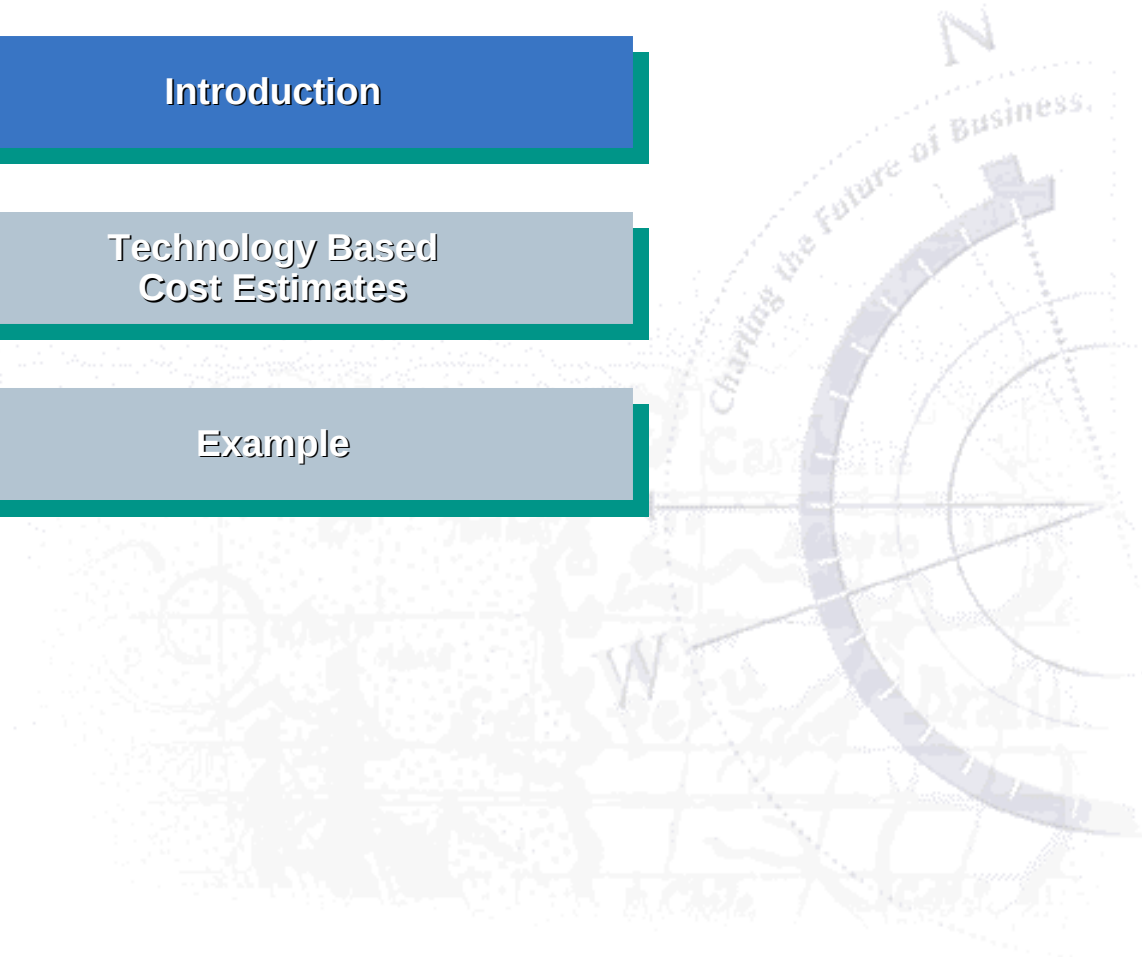

Navigant Consulting, previously Arthur D. Little, has helped EIA develop performance/cost characteristics for Building Equipment.

- Last analysis created a 2000 baseline
  - Review of literature, standards, installed base, contractor, and manufacturer information
- Forecast of technology improvements that will become available over the next twenty years
  - Review of trends in standards, product enhancements, R&D
  - Projected impact of product improvements and enhancement to technology
  - Estimated costs and volume of these improvements

The performance/cost characterization of end-use equipment developed assists EIA in projecting national primary energy consumption.

Input from government, R&D organizations, and manufacturers, was used to project product enhancements concerning equipment performance and cost attributes.

- Varied sources ensure a balanced view of technology progress and the probable timing of commercial availability.
- Technology developments impact performance and cost forecasts.
- Technology forecasting involves many uncertainties.

In general, projections were made assuming that more efficient, potentially available technologies penetrated the market from 2005 to 2020 through evaluating:

- Economies of production
- Established sales and distribution network

The scenarios examined in developing performance/cost characteristics include incremental (reference case) and advanced (high tech case) adoption.

- Below are definitions for the terms used in characterizing the status of each technology.
  - 2000 Current Standard: the minimum efficiency required by current standards.
  - Typical: average product being sold in the particular timeframe.
  - High: the product with the highest efficiency available in the particular timeframe.

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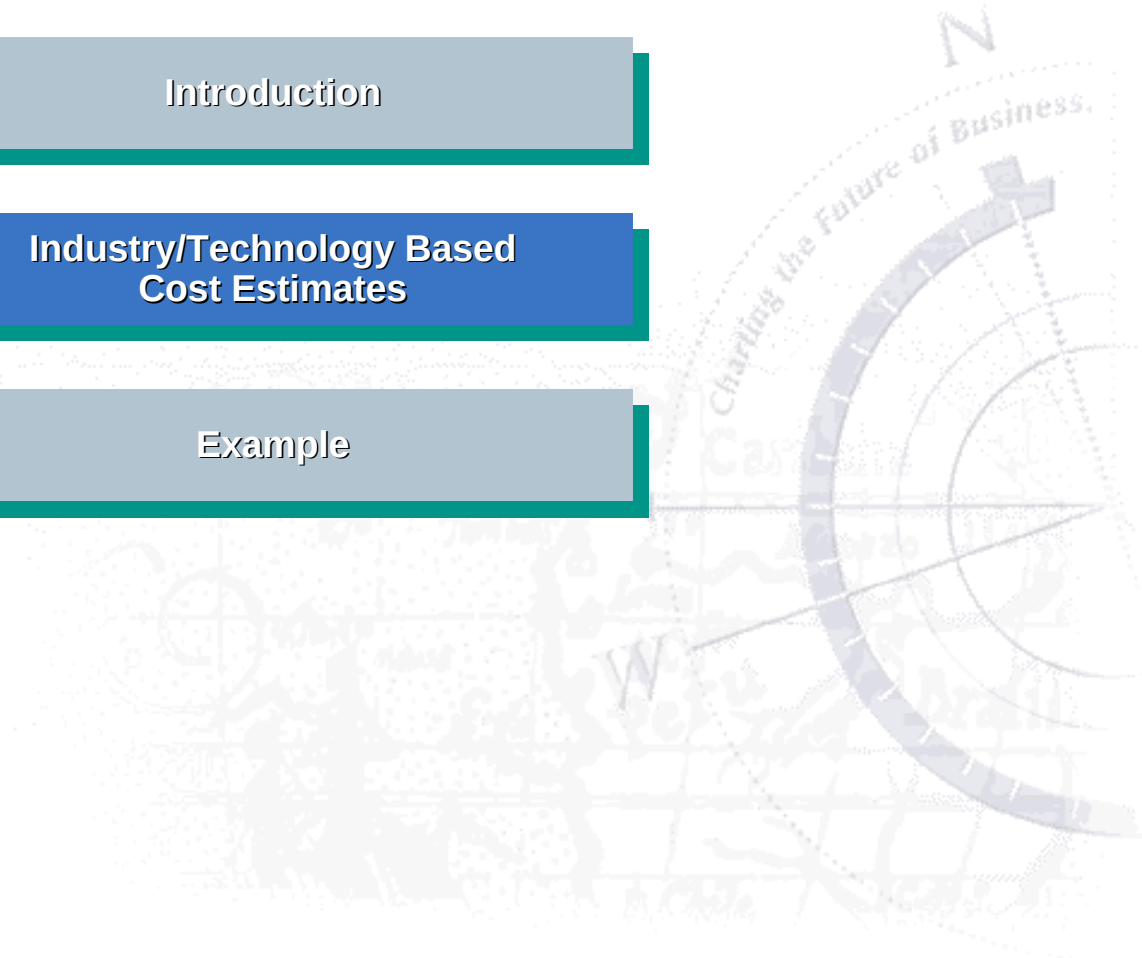
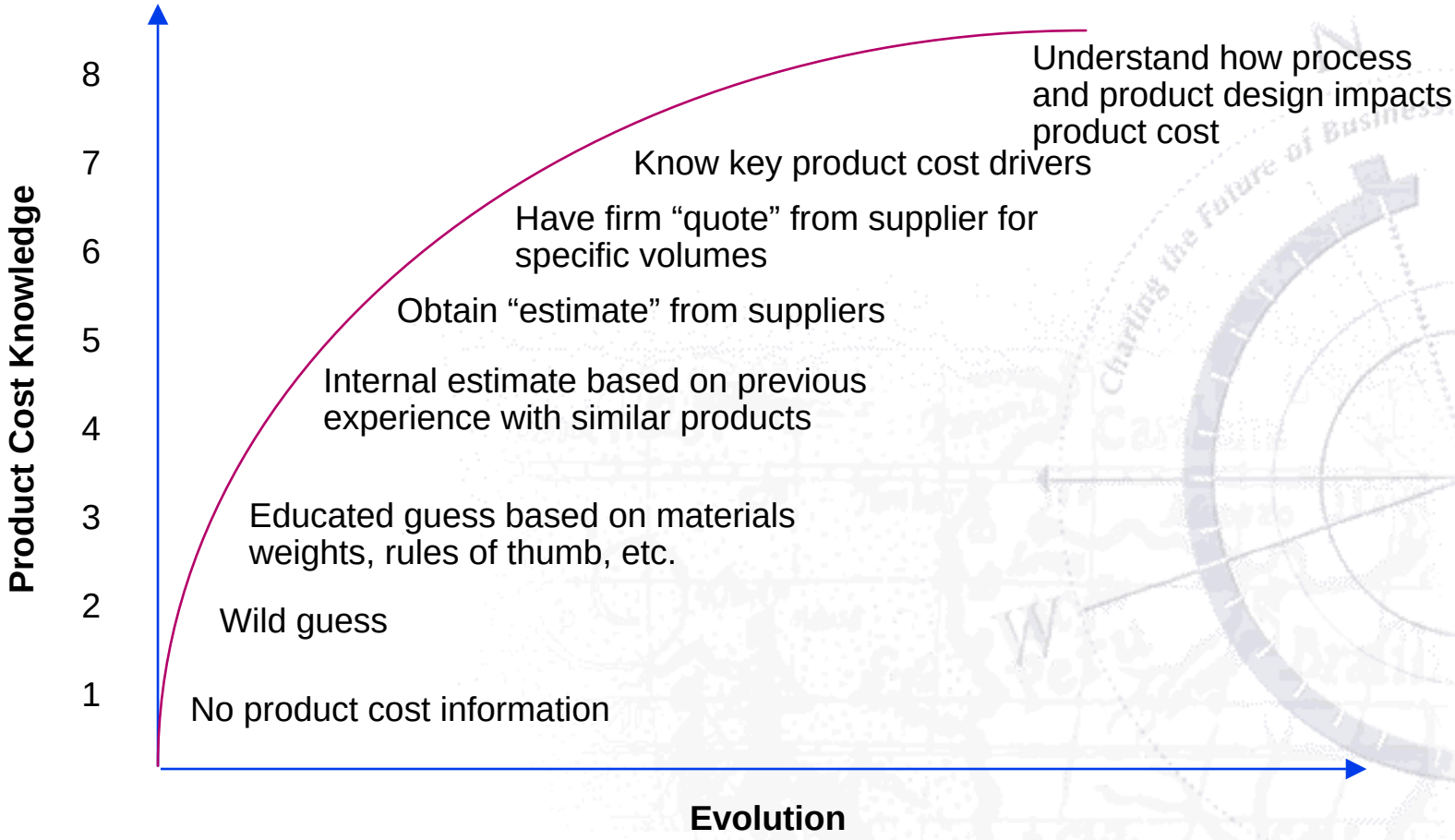
- **Industry/Technology Based Cost Estimates**
- Example



By working with manufacturers and vendors, as well as the many previous technology studies for DOE, we can begin to develop equipment characteristics.

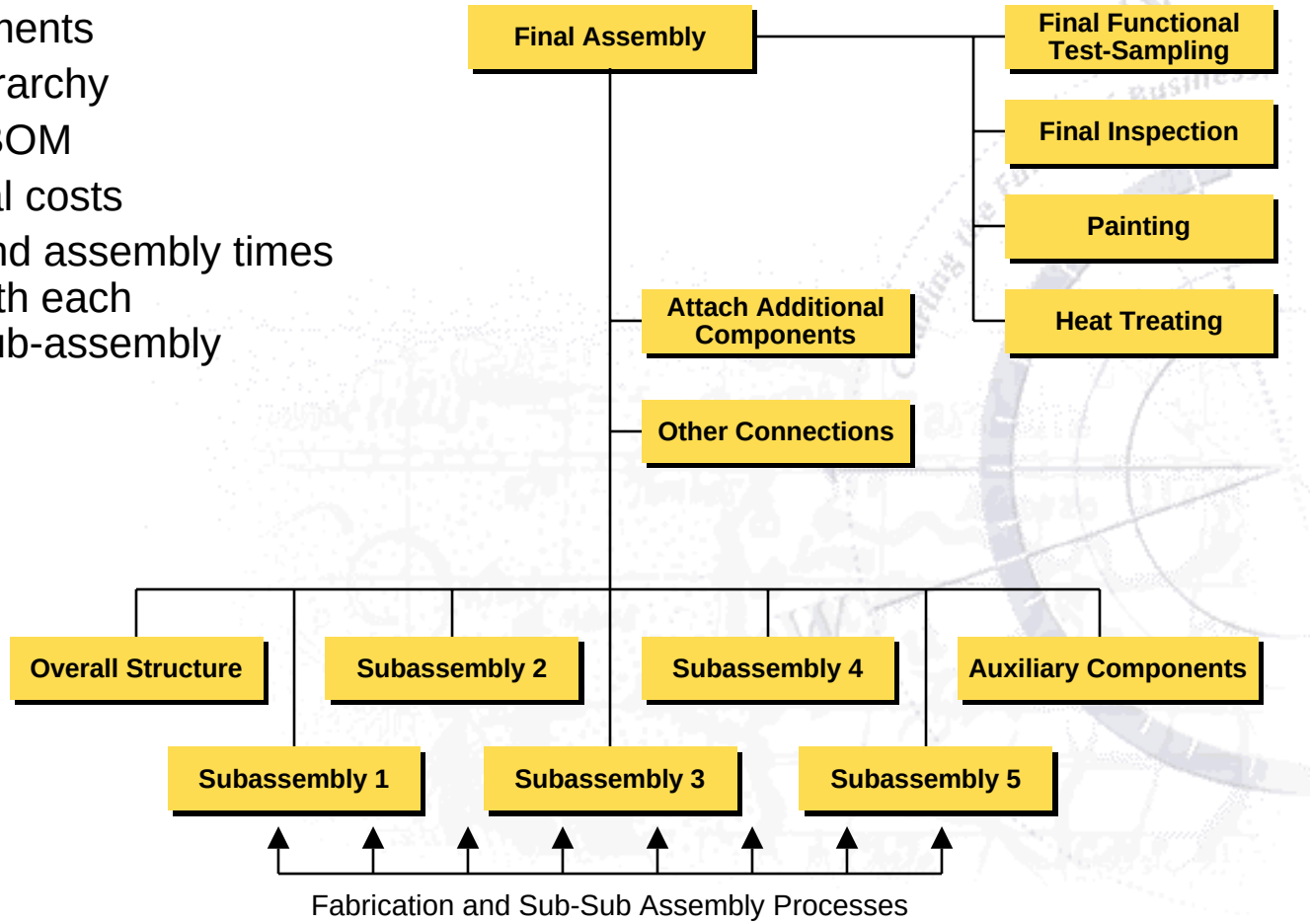
New equipment characteristics	Description/Assumption	Data Sources
Typical Capacity	Size of equipment, units vary by equipment type	Interviews with installers, distributors, GAMA, ARI, AHAM
Equipment cost	Retail cost of equipment	Interviews with installers, distributors, Current Industrial Reports, Trade Associations
Installation cost	Cost of equipment installation, materials and labor	Interviews with installers, distributors, Current Industrial Reports, Trade Associations
Maintenance and operations cost	Cost of preventive maintenance and annualized repair costs	Interviews with installers, distributors, Current Industrial Reports, Trade Associations
Efficiency	Efficiency of equipment, units vary by equipment type	Product literature, ARI,GAMA, AHAM

Developing cost data for building equipment often relies on varying degrees of product cost knowledge

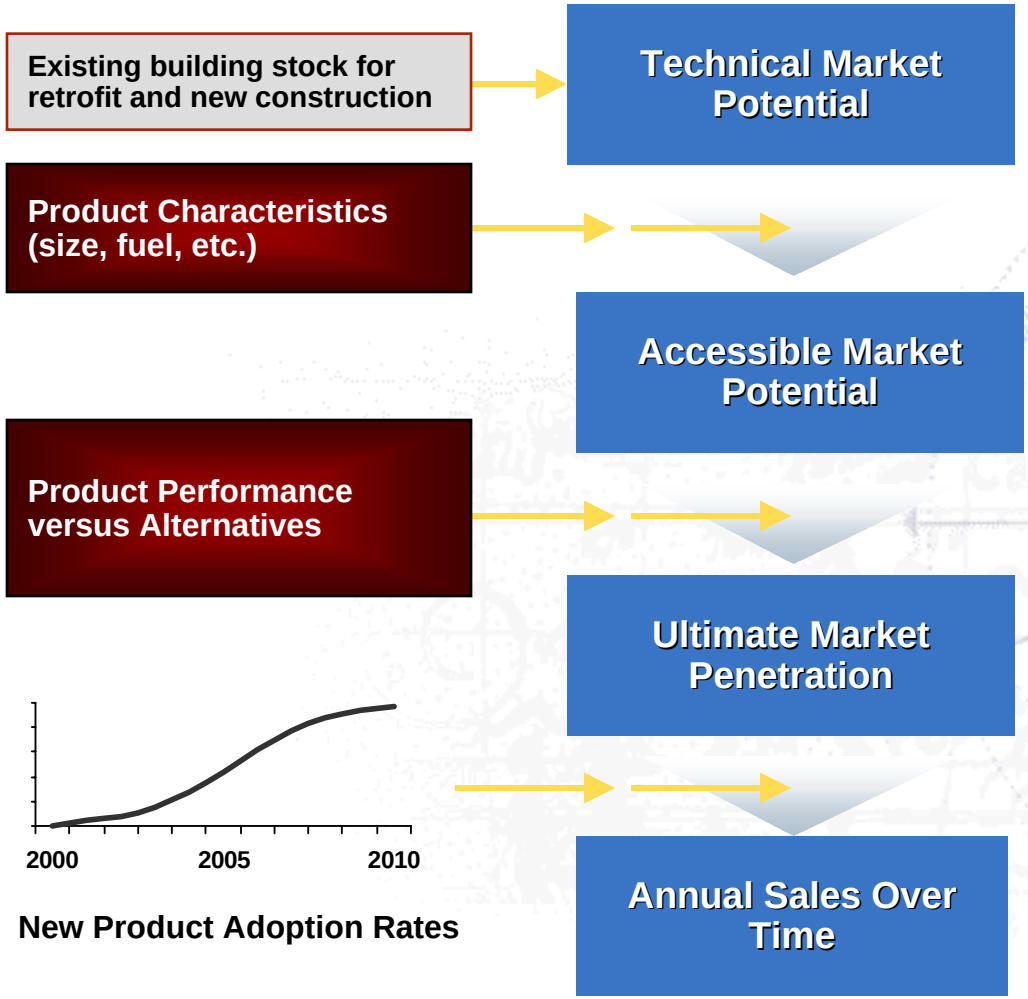


We use product-based cost models to establish baseline costs and evaluate alternative product concept or design variations.

- Cost Model Elements
  - Assembly hierarchy
  - "Structured" BOM
  - Direct material costs
  - Fabrication and assembly times associated with each component/sub-assembly

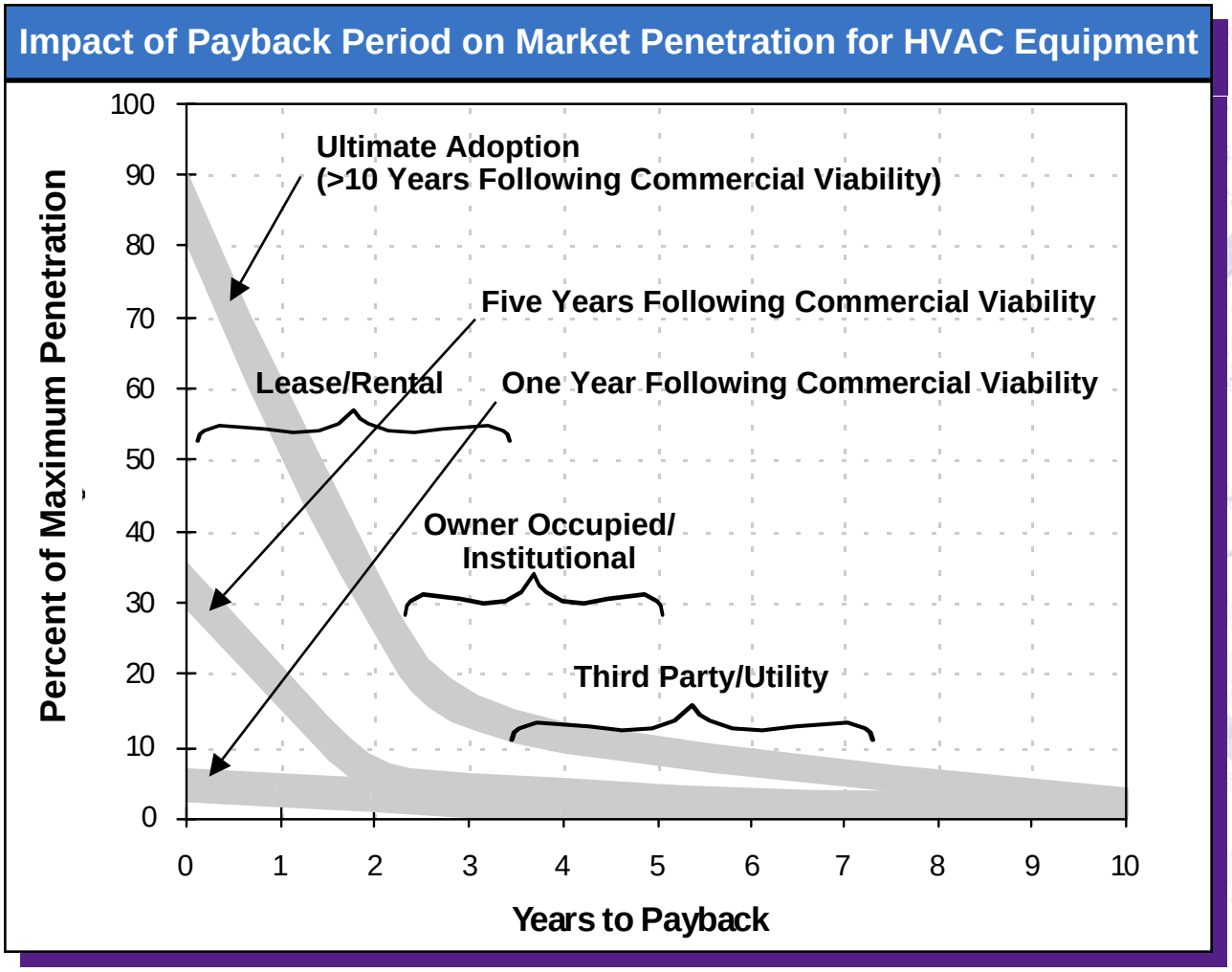


Analysis of available products begins with bottoms-up building data uses a systematic screening process determine the likely size of the market, hence volume and potential price.



New Product Adoption Rates

Market penetration for a new technology can also be estimated based on payback analysis, as illustrated here for energy technologies deployed in commercial buildings.



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Below are the estimates in performance/cost for residential water heaters in 2005.

	Gas-Fired		Electric		Heat Pump	
	Typical	**High**	**Typical**	**High**	**Typical**	**High**
Typical Capacity (gal)	40	50	52	52	52	52
Energy Factor	0.60	0.86	0.90	0.95	2.0	2.6
Average Life (yrs)	9	20	14	14	12	12
Retail Equip. Cost	$200-$250	$1,500	$240-$260	$300-$400	$975	$750
Total Installed Cost	$380-$400	$2,000	$480-$500	$420-$450	$1,175	$1,100
Annual O&M Cost	$50	$50	$50	$50	$75	$75

	Solar
	Typical
Typical Capacity (sq. ft)	40
Overall Efficiencies	50% of Water Heating Load
Average Life (yrs)	20
Retail Equip. Cost	$1,700-$2,000
Total Installed Cost[1]	$2,200-$3,200
Annual O&M Cost	Negligible

[1]These product costs for an active, indirect or closed loop system; include tank and back-up system.

Each estimate is based on the best available information on the future technology and market.

	Gas-Fired	
	Typical	**High**
Typical Capacity (gal)	40	50
Energy Factor	0.60	0.86
Average Life (yrs)	9	20
Retail Equip. Cost	$200-$250	$1,500
Total Installed Cost	$380 -$400	$2,000
Annual O&M Cost	$50	$50

- Gas-Fired: The new federal standard coming into effect in January 2004 will have an EF of 0.59 for a 40-gallon water heater.
- Additionally, costs have been added in the out years (2005 and beyond) to account for new flammable vapor resistant designs and a new blowing agent for the insulating foam used in the water heaters.

Each estimate is based on the best available information on the future technology and market.

	Electric	
	Typical	**High**
Typical Capacity (gal)	52	52
Energy Factor	0.90	0.95
Average Life (yrs)	14	14
Retail Equip. Cost	$240-$260	$300-$400
Total Installed Cost	$480-$500	$420-$450
Annual O&M Cost	$50	$50

- Electric Resistance: The new standard coming into effect in January 2004 will have an EF of 0.90 for a 52-gallon water heater.
- Costs have been added in the out years (2005 and beyond) to account for a new blowing agent for the insulating foam used in the water heaters.
- The highest efficiency electric resistance water heater is not likely to see any efficiency improvement due to thermal limits and diminishing returns on controlling heat loss.

Advanced/potential future technologies look at the current research and development being conducted.

	Heat Pump	
	Typical	**High**
Typical Capacity (gal)	52	52
Energy Factor	2.0	2.6
Average Life (yrs)	12	12
Retail Equip. Cost	$975	$750
Total Installed Cost	$1,175	$1,100
Annual O&M Cost	$75	$75

- Since 1990, heat pump water heater (HPWH) technology has advanced in efficiency and has been reduced in capacity to reduce cost.
- However, the high first cost still precludes a large market penetration.
- The future 2.0 EF HPWH assumes a smaller compressor with 40% less heating capacity than any used in existing heat pump water heater products (and with about 25% of the heating capacity of a typical electric resistance hot water heater), leading to reduced cost at a lower EF. This product is currently under development by DOE.

Advanced/potential future technologies look at the current research and development being conducted.

	Solar
	Typical
Typical Capacity (sq. ft)	40
Overall Efficiencies	50% of Water Heating Load
Average Life (yrs)	20
Retail Equip. Cost	$1,700-$2,000
Total Installed Cost[1]	$2,200-$3,200
Annual O&M Cost	Negligible

- The typical annual efficiency (35-40%) of the Solar Water Heating (SWH) system (thermal output divided by solar input) will vary significantly depending on location.
- The typical collector area of 40 ft^2 is based on systems in the Southern and Western U.S. where the majority of SWH systems are installed. Colder areas such as Wisconsin would use 64 ft^2 collector and a secondary water/glycol heating loop.
- These installed costs are for systems in a Southern climate. An equivalent system installed in the Northeast would cost $3,500-$4,000, due to the requirements for freeze protection and additional collector area. Costs vary widely depending on collector quality and type of system.
- The retail cost for 40 square feet flat plate collectors is in the $750-$950 range.

An example of a typical data sheet (for Residential Electric Resistance Water Heater)

	1999	2000	2000			2005		2010		2020	
	Installed Base	Current Standard	Low	Typical	High	Typical	High	Typical	High	Typical	High
Typical Capacity (gal)	52	52	52	52	52	52	52	52	52	52	52
Energy Factor	0.83	0.86	0.86	0.88	0.95	0.90	0.95	0.90	0.95	0.90	0.95
Average Life (yrs)	14	14	14	14	14	14	14	14	14	14	14
Retail Equip. Cost	$182	$182	$182	$182	$350-$450	$240-$260	$300-$400	$240-$260	$300-$400	$240-$260	$300-$400
Total Installed Cost	$337	$337	$337	$337	$470-$490	$480-$500	$420-$450	$480-$500	$420-$450	$480-$500	$420-$450
Annual O&M Cost	$50	$50	$50	$50	$50	$50	$50	$50	$50	$50	$50

A total of 31 technologies were evaluated as part of the study.

- Residential Gas-Fired Water Heaters
- Residential Electric Resistance Water Heaters
- Residential Heat Pump Water Heaters
- Residential Solar Water Heaters
- Residential Gas-Fired Furnaces
- Residential Hydronic Heating System (Boilers)
- Residential Room A/C
- Residential Central A/C
- Residential Air Source Heat Pumps
- Residential Ground Source Heat Pumps
- Residential Gas Heat Pumps
- Residential Refrigerator/Freezer
- Residential Cooktops and Stoves (Gas)
- Residential Clothes Washers
- Residential Dishwashers

- Commercial Centrifugal Chillers
- Commercial Gas-Fired Chillers (Water Cooled)
- Commercial Reciprocating Chillers
- Commercial Rooftop Units (A/C Units)
- Commercial Gas-Fired Furnaces
- Commercial Electric Boilers
- Commercial Gas-Fired Boilers
- Commercial Oil-Fired Boilers
- Commercial Gas Water Heaters
- Commercial Electric Resistance Water Heaters
- Commercial Booster Water Heaters
- Commercial Gas-Fired Instantaneous Water Heaters
- Commercial Rooftop Heat Pumps
- Commercial Natural Gas-Fired Engine-Driven Rooftop A/C
- Commercial Office Equipment
- Commercial Fuel Cells