Advances In and Applicability of Heat Pump Water Heating Technology

Presented to:

ACEEE 2007 National Symposium on Market Transformation

Omni Shoreham in Washington, D.C. — March 20, 2007

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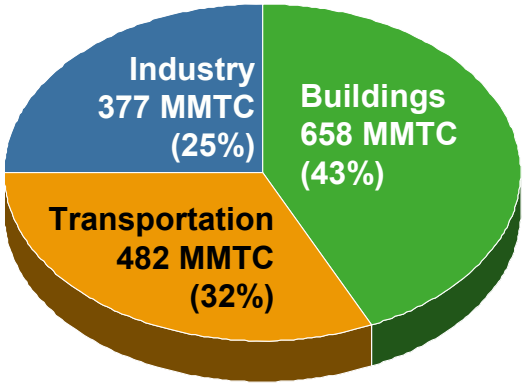
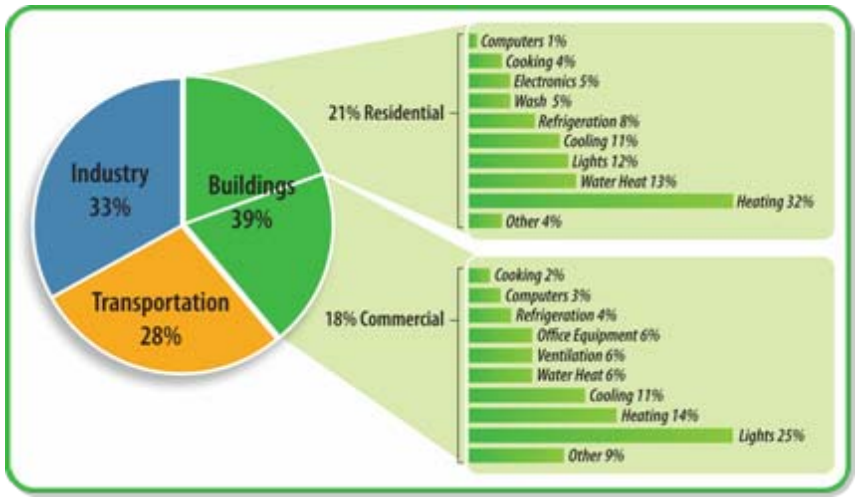
Importance of Buildings & Water Heating

43% of U.S. Carbon Emissions

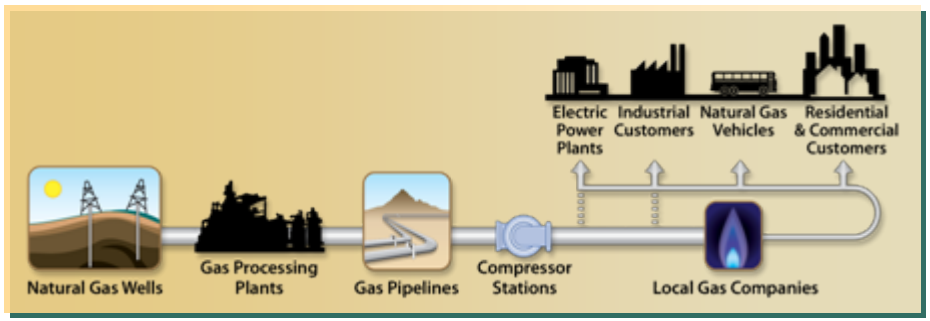


39% of U.S. Primary Energy Consumption

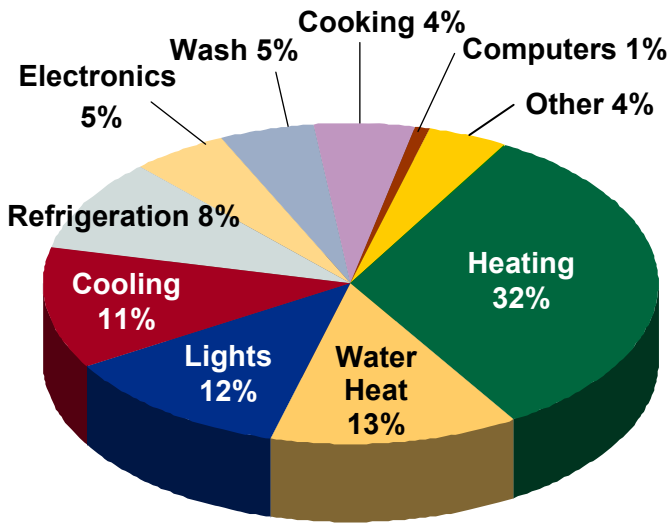


71% of U.S. Electricity

53% of U.S. Natural Gas



Large WH Savings Potential



2.8 Quads

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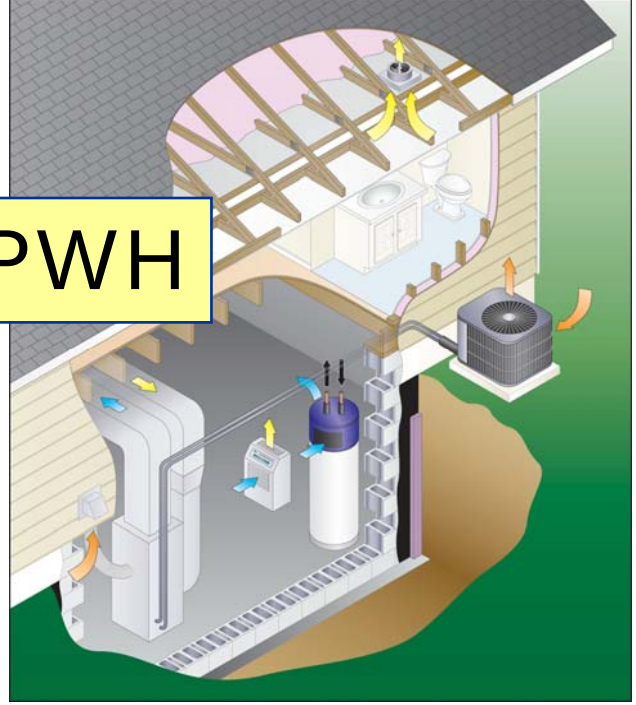
HPWHs Around the World

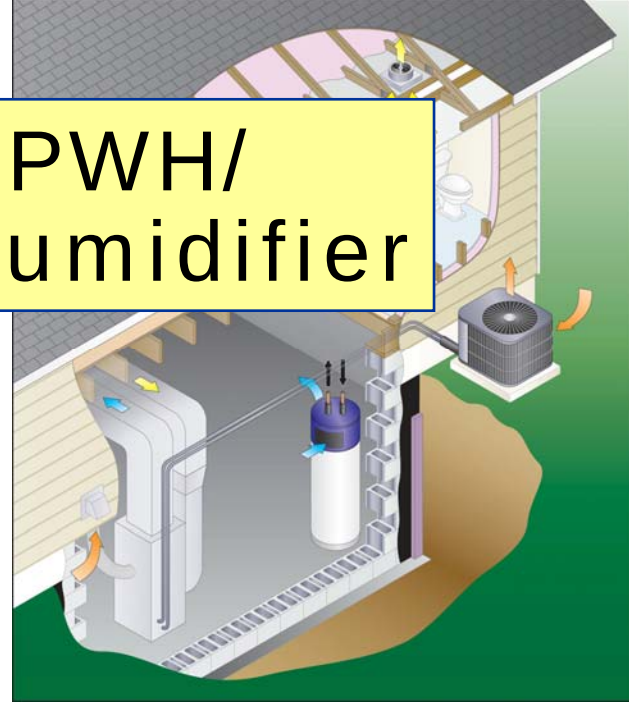
- Manufactured in Japan, China, Australia, Austria, U.S.
- Substantial sales in Japan (300,000/yr with CO_2 refrig.)
  - High time-of-use (off-peak 6¢/kWh, on-peak 22¢/kWh) e-rates
  - Significant ratepayer/government incentives
- U.S. energy savings potential is large, remains untapped
  - Potential to displace ~4.5 million electric storage WHs annually
  - Potential even larger when gas prices are volatile and high
  - Efficiency (energy factor – EF)
    - Electric storage WHs: NAECA min EF = 0.90 (50 gal), best avail. = 0.95
    - HPWHs: EF = 2.0+
  - Status: technical success (EF, durability), pricey, market failure
    - Add-On: Nyle & E-Tech will produce only for quantities
    - All-in-One: EMI WattSaver off the market

Options

1. HPWH

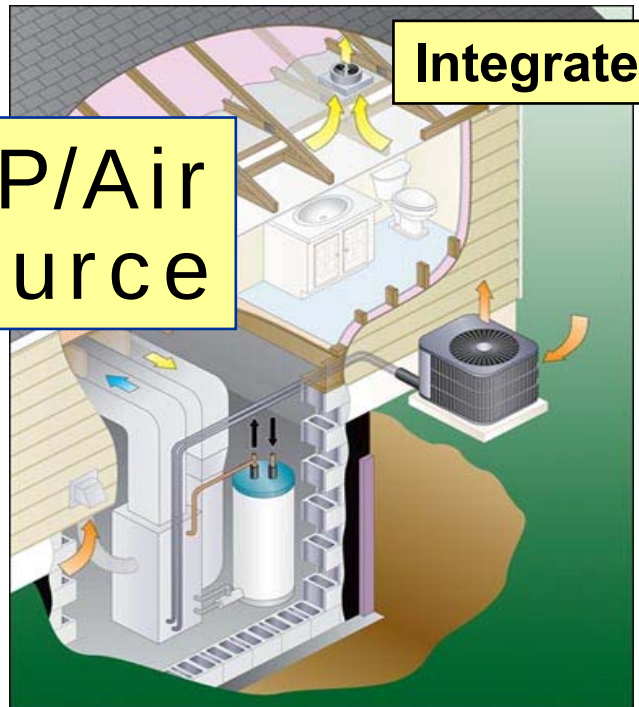


2. HPWH/ Dehumidifier

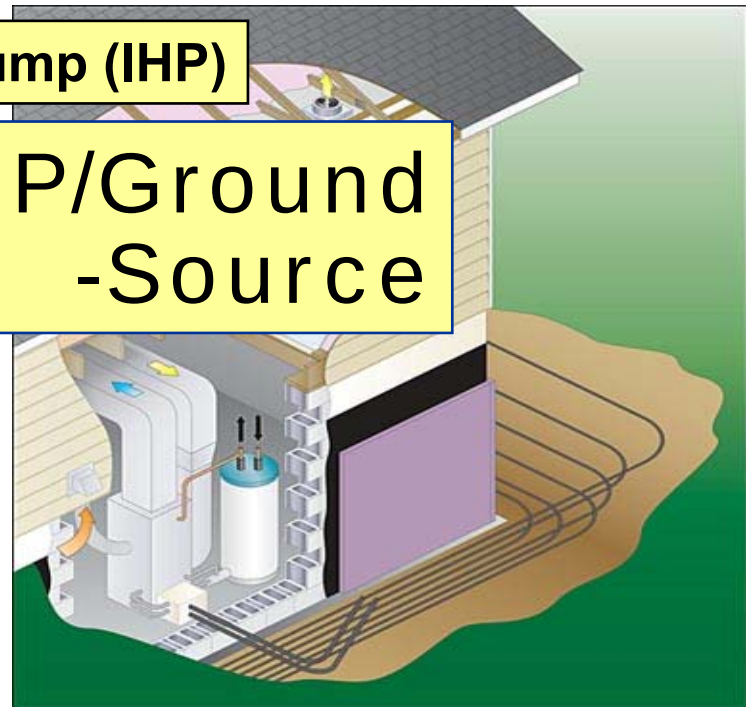


Integrated Heat Pump (IHP)

3. IHP/Air -Source



4. IHP/Ground -Source



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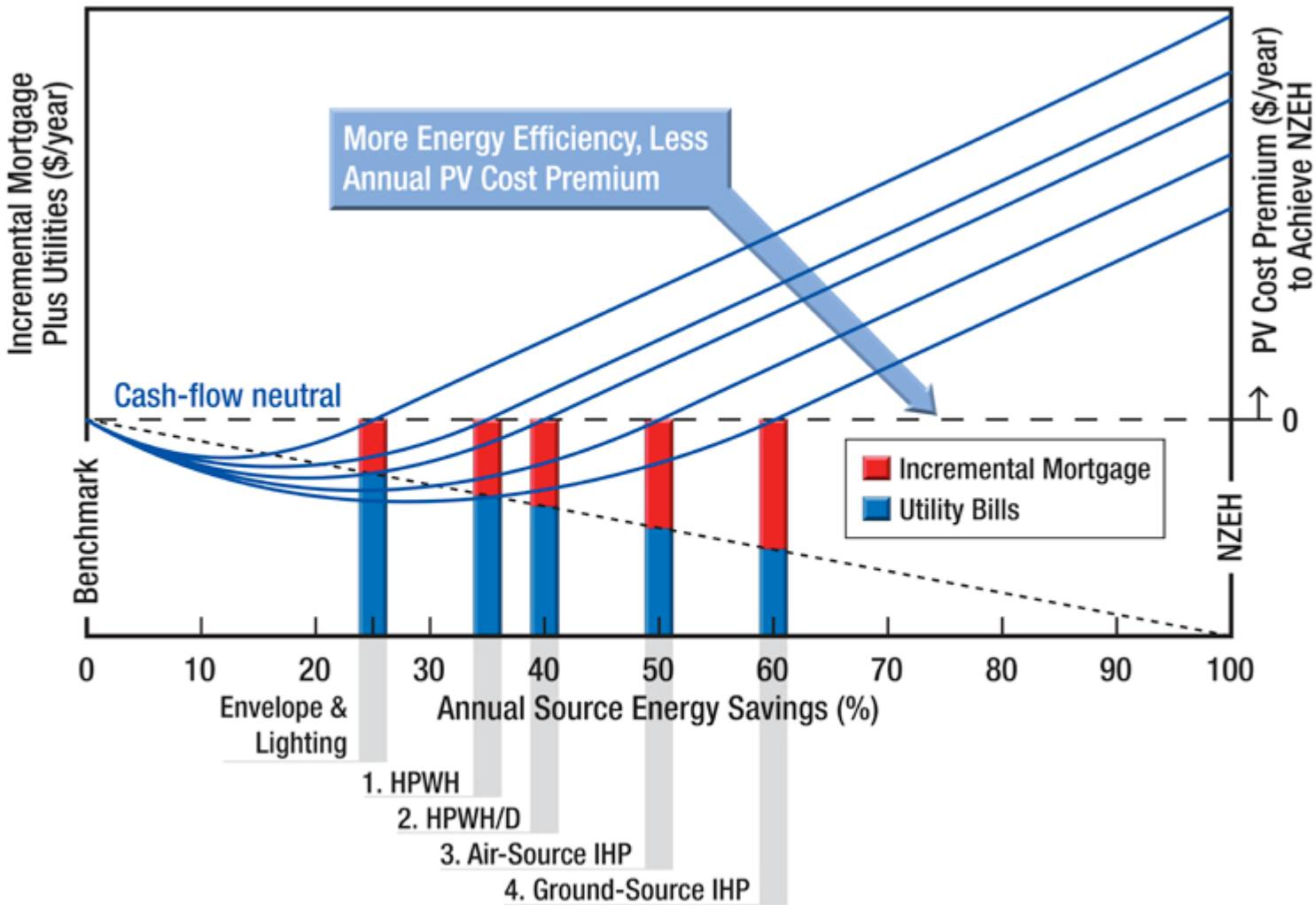
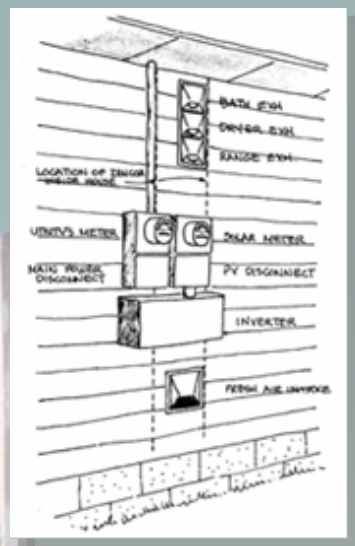
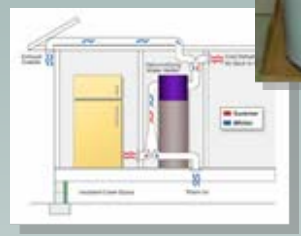
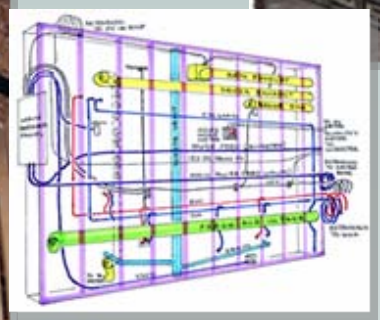
Net Zero Energy Home (NZEH) Progress (Atlanta, Approximate)



Home Near ORNL ~50% of Way to NZEH With Energy Efficiency (All-Electric, ~70¢/day)







Better Envelopes Create Equipment Challenges

High-R, airtight envelopes are game-changing:

- Active ventilation required
- Active dehumidification required
- Heating/cooling lower, water heating relatively more important

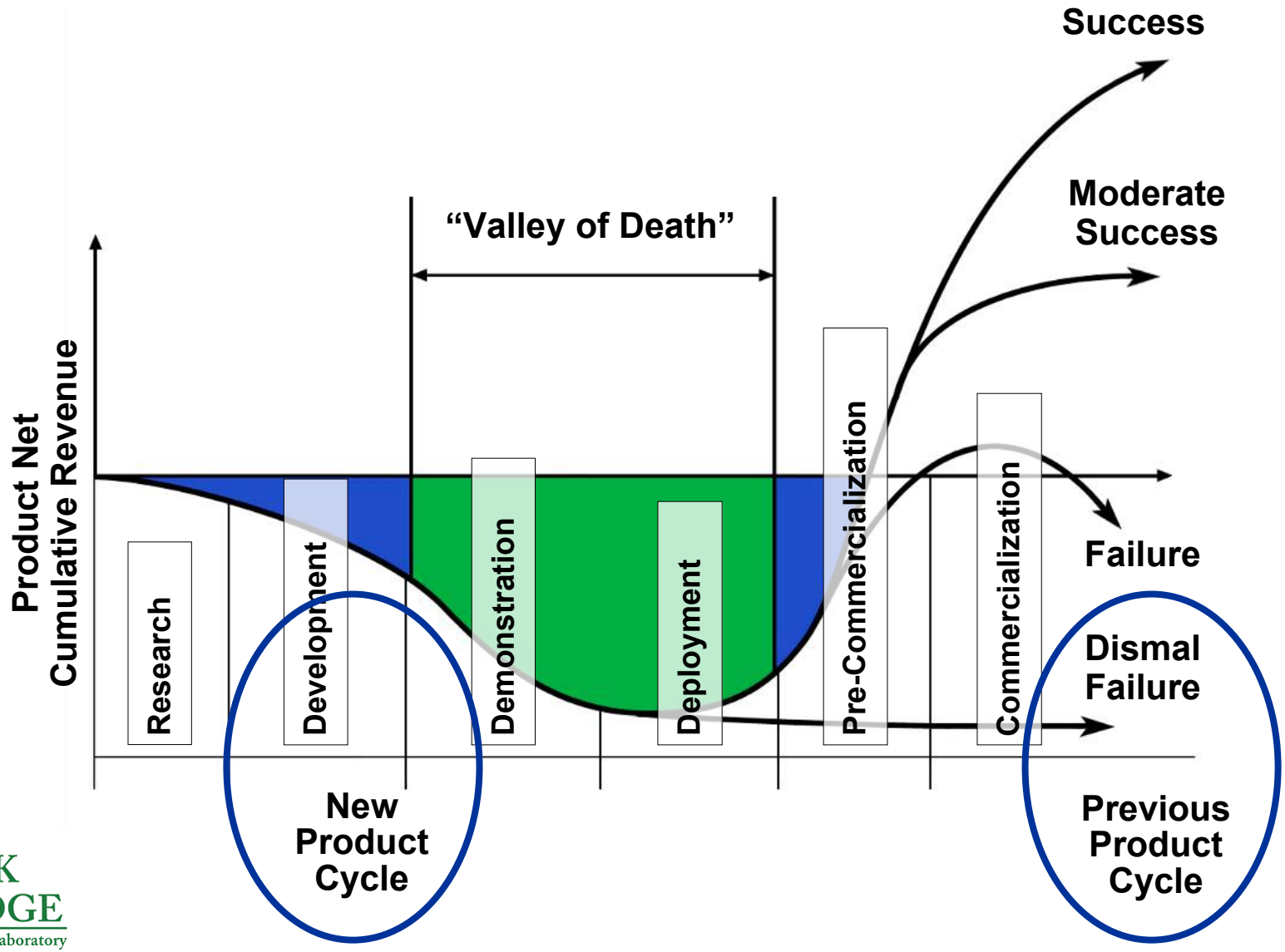
Only modest efficiency improvement potential with today's dis-integrated equipment:

- Heat pump (HP) for heating (H) & cooling (C)
- "Air-cycler" controls on HP and bath fan for ventilation (V)
- Stand-alone dehumidifier (D), or several
- Water heater (WH)

Partly/fully integrated heat pump options for WH

- Heat pump water heater (HPWH)
- Heat pump water heater/dehumidifier (HPWH/D)
- Fully integrated heat pump (IHP), air- or ground-source

The Previous HPWH Product Cycle Failed But One or More New Ones May Be Starting



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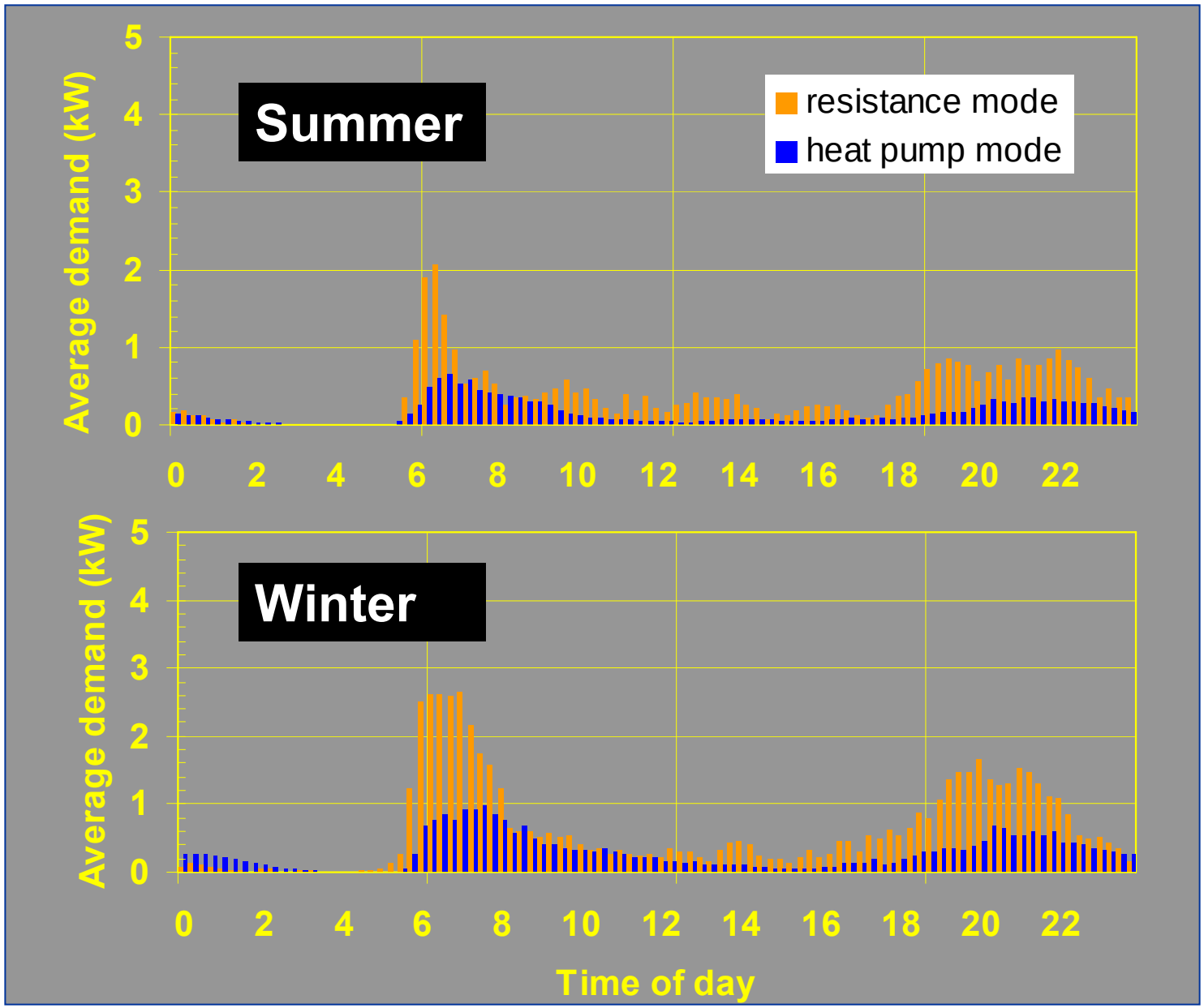
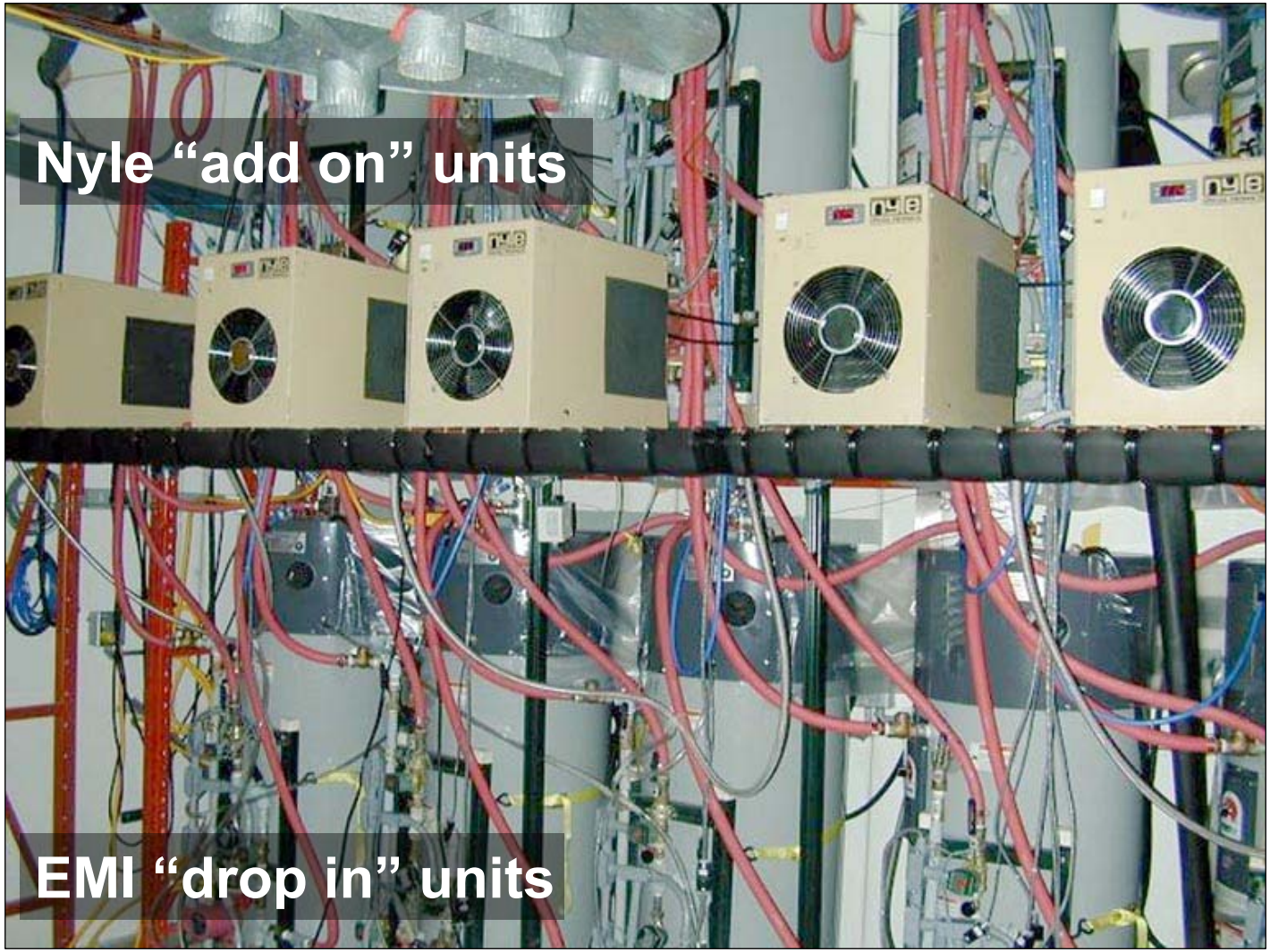
Previous HPWH Performed Well

- EF = 2.4
- Field test in conjunction with 11 utilities (16 sites)
  - Units generally operated well, participants satisfied
  - No problems with mechanical components
  - Control sensor problem diagnosed and corrected (no recurrences)
  - 55% energy savings (average), range: 1350 – 3280 kWh/yr
  - Variation due to supply water T, unit location, occupant use pattern
  - Diversified demand profile desirable (next slide)
  - Evaluation results at **http://web.ornl.gov/sci/btc**
  - “In Hot Water” Newsletter at **http://inhotwater.org**

HPWH Demand (No Special Controls)



Previous HPWHs Were Durable



Post-Durability-Test Examinations Found Nothing Unexpected

Accelerated life testing simulated 7-10 years of real-world operation

Post-mortem examinations of units:

- **No compressor performance degradation**
- **No appreciable oil deterioration**
- **“Mild” wear, principally on crank bushing**
- **Minimal tank scale**
- **Condenser attachment OK**

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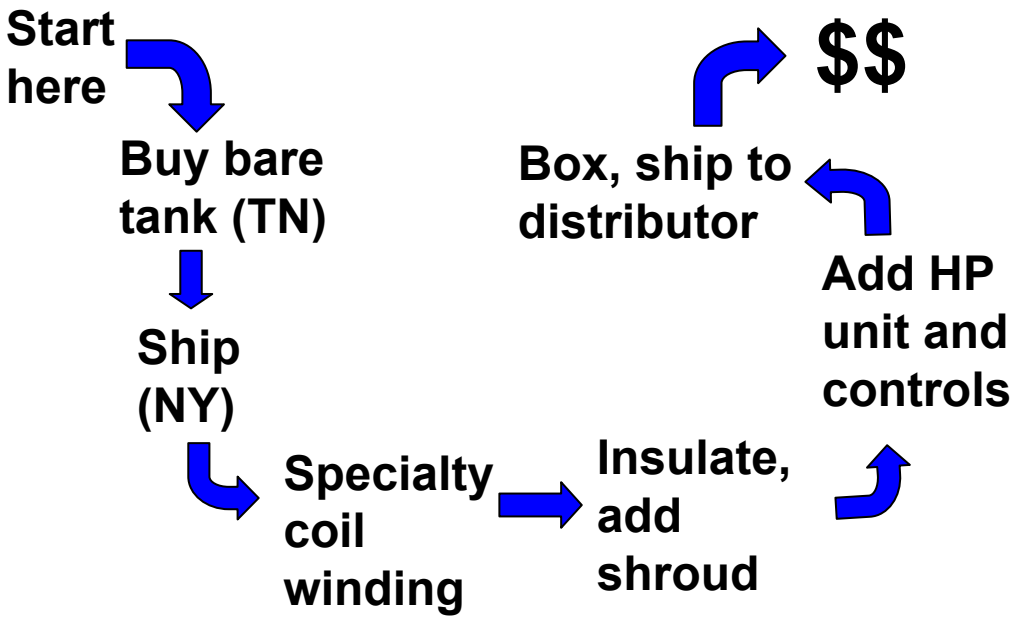
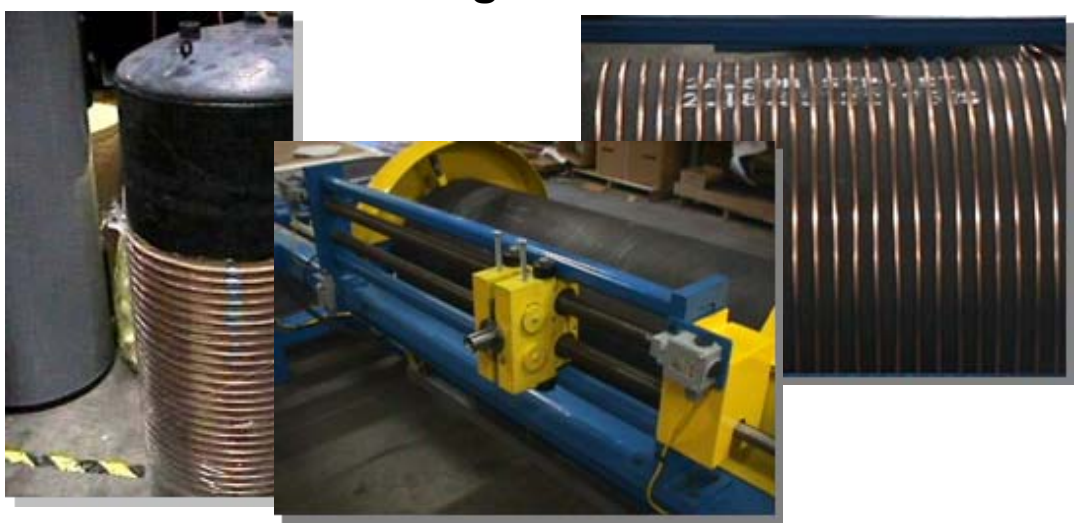
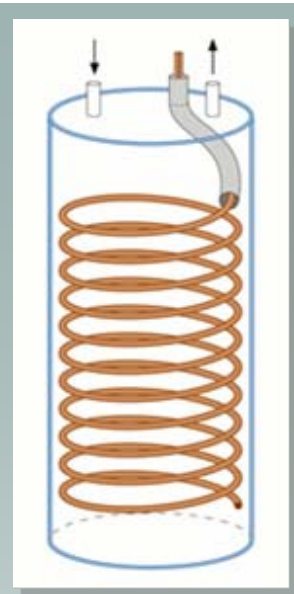
Previous HPWHs Were Too Costly at $1500 Installed





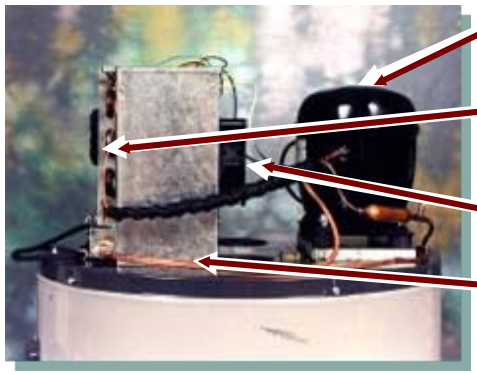
Immersed Concentric Tube Condenser Is One Cost Reduction Option Being Explored



- Start with the standard mass produced tank
- Affix a swirled sleeve in an opening
- Push in the condenser to form helix
- Sleeve shape determines pitch/diameter of helix
- Builds “ship-in-a-bottle”

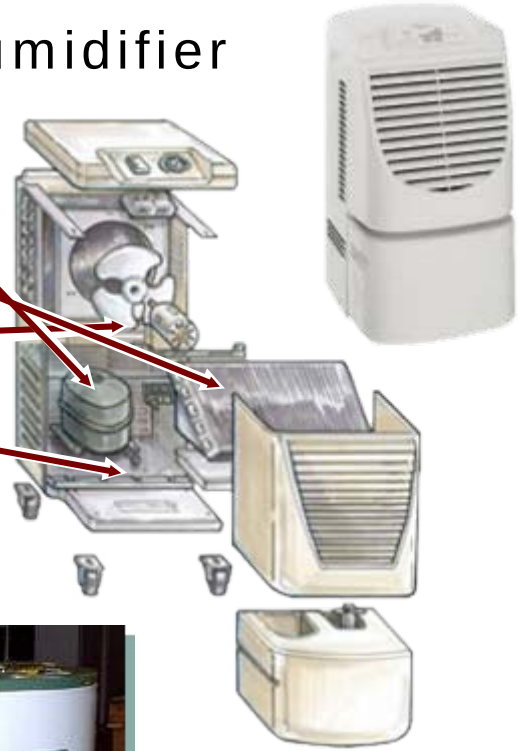
The 1st HPWH/D Unit Is being Demonstrated

HPWH

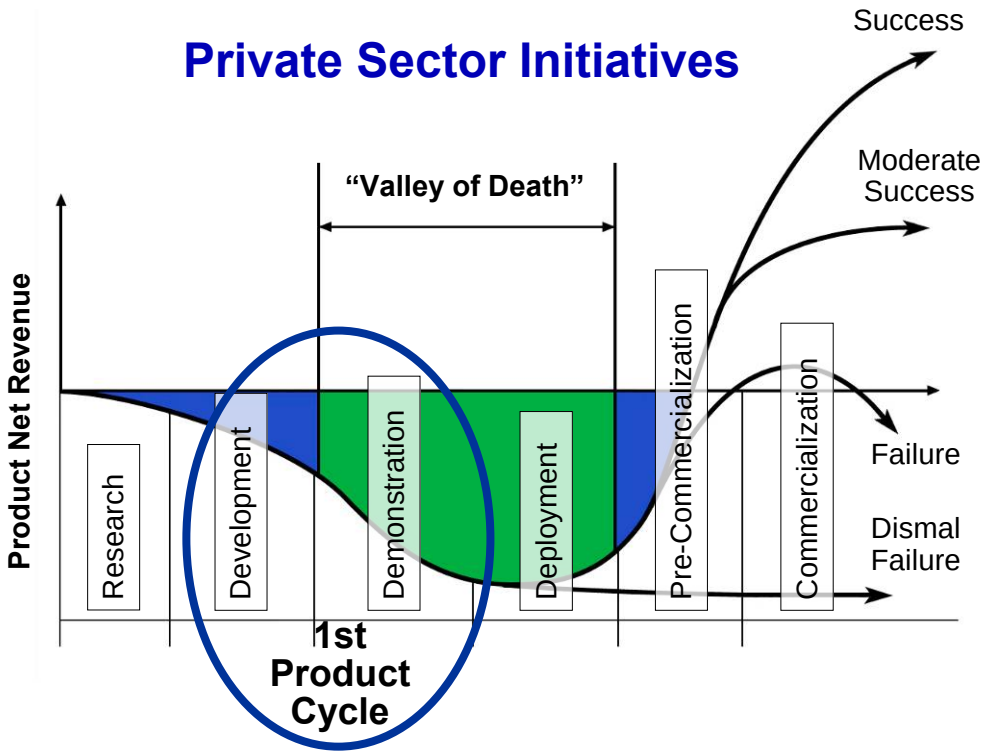


Compressor
Controls
Evaporator
Condenser
Fan
Chassis

Dehumidifier

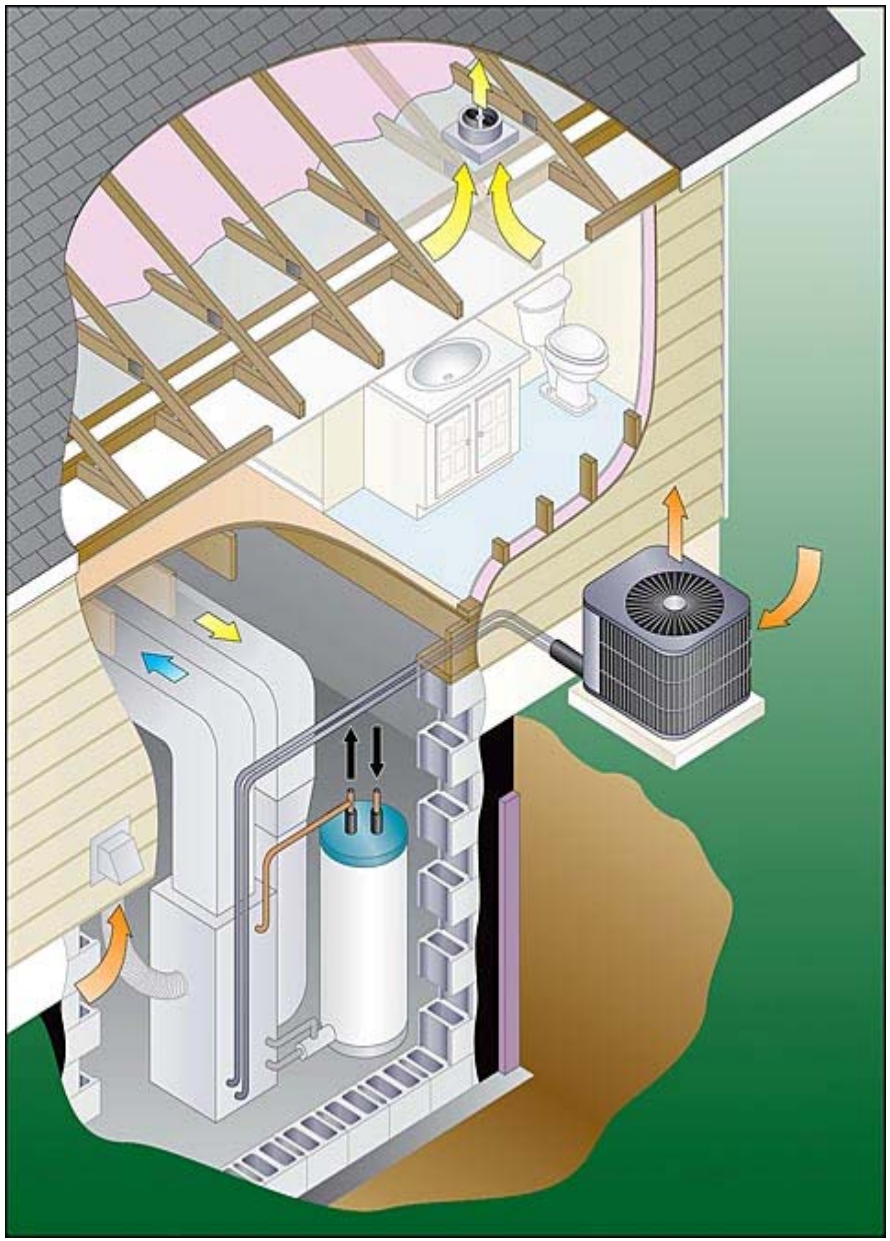


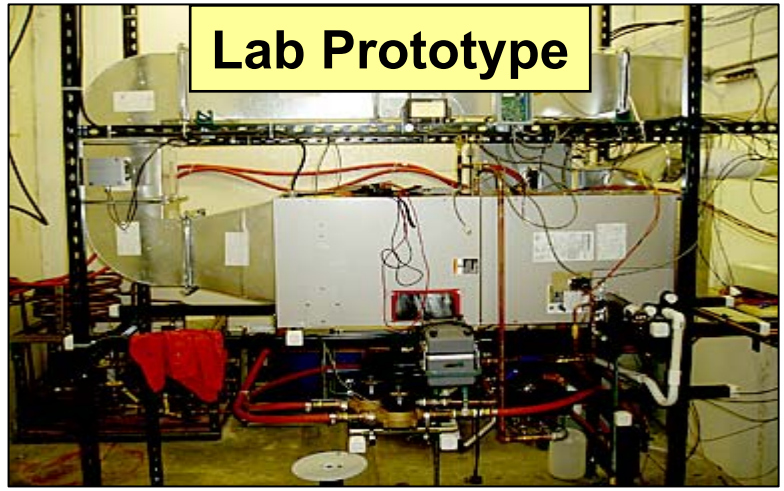
Private Sector Initiatives

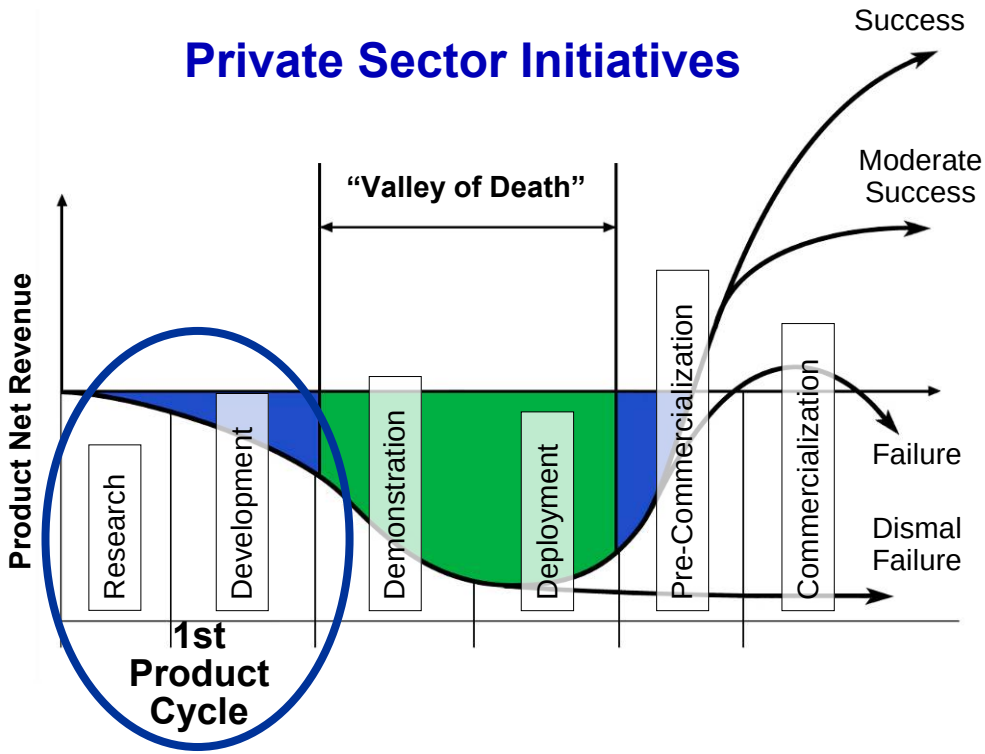


HPWH/D currently in field test

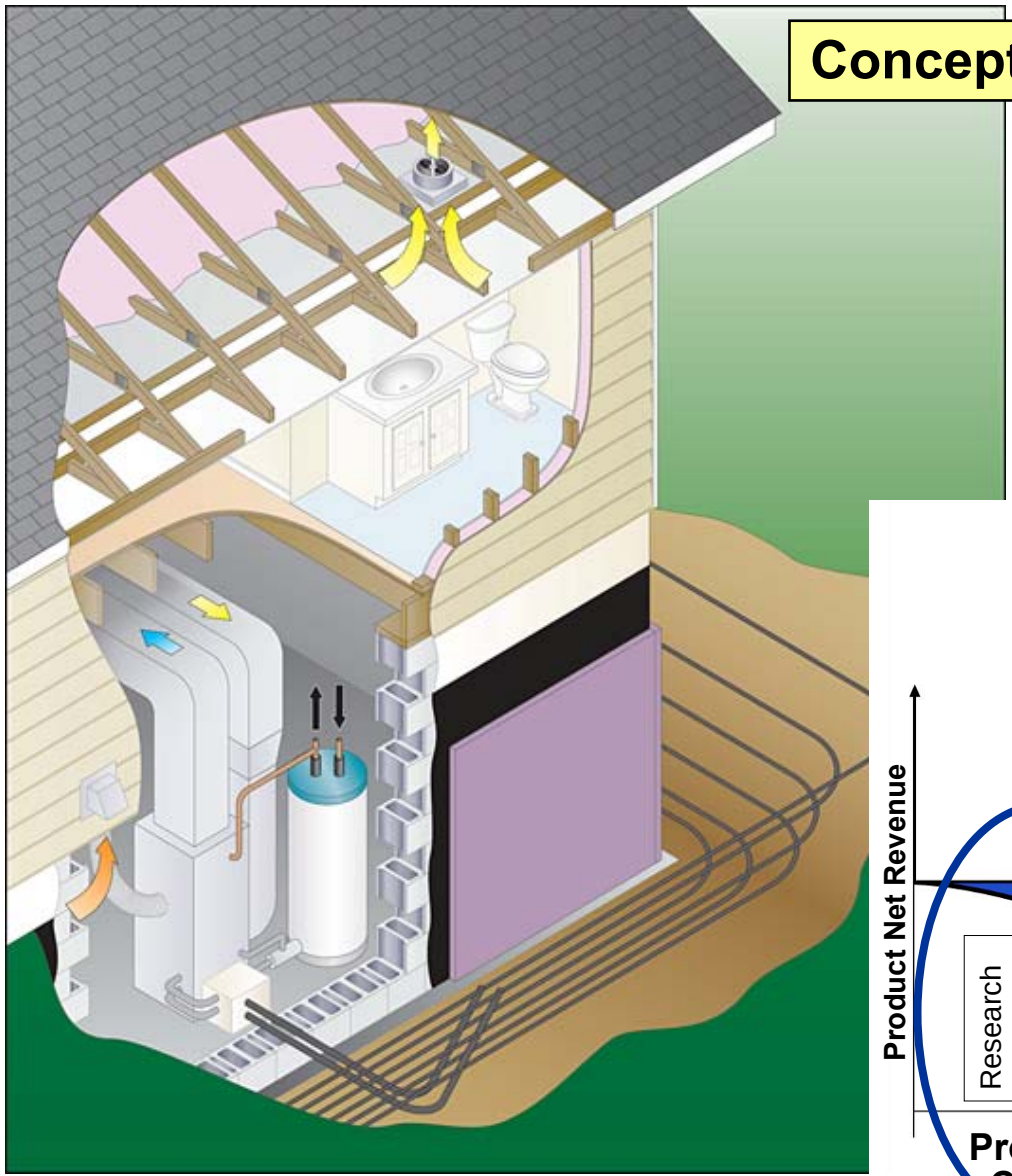
Air-Source IHP Is Seeking Industry Partners



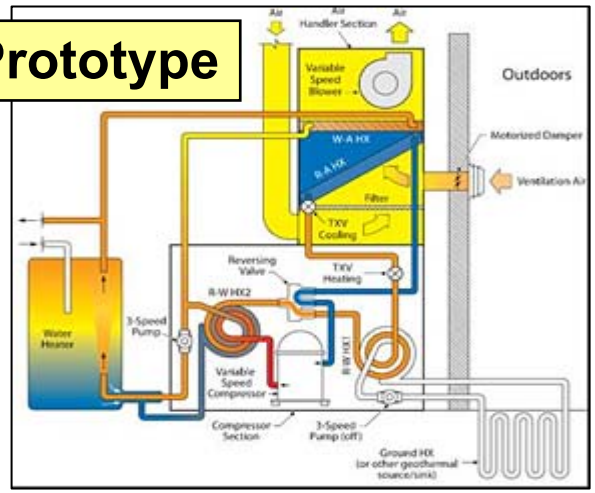




Ground-Source IHP Seeking Industry Partners



Conceptual Prototype



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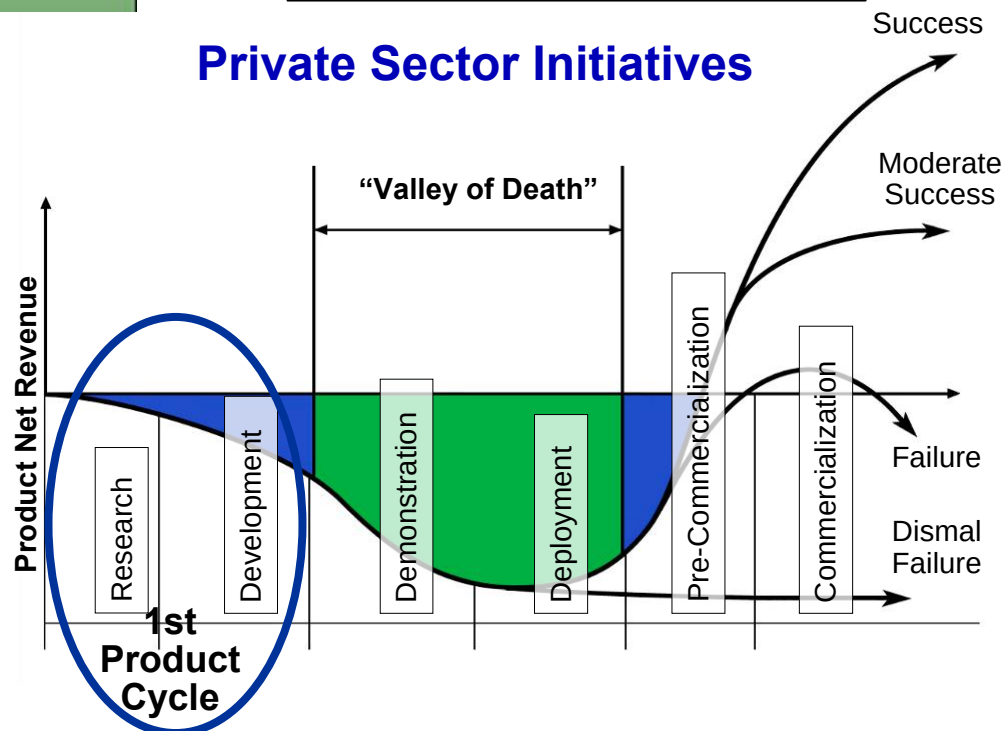
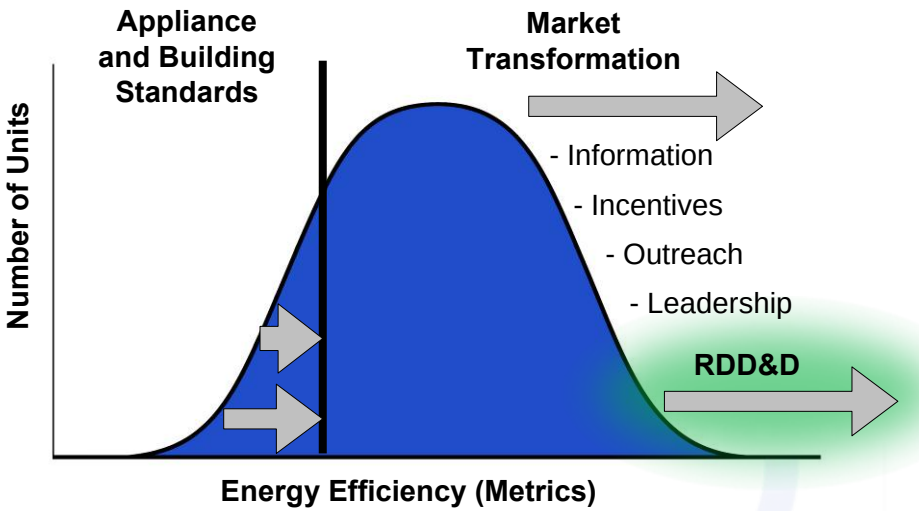


Market Transformation is the Key to Success

Public Sector Initiatives



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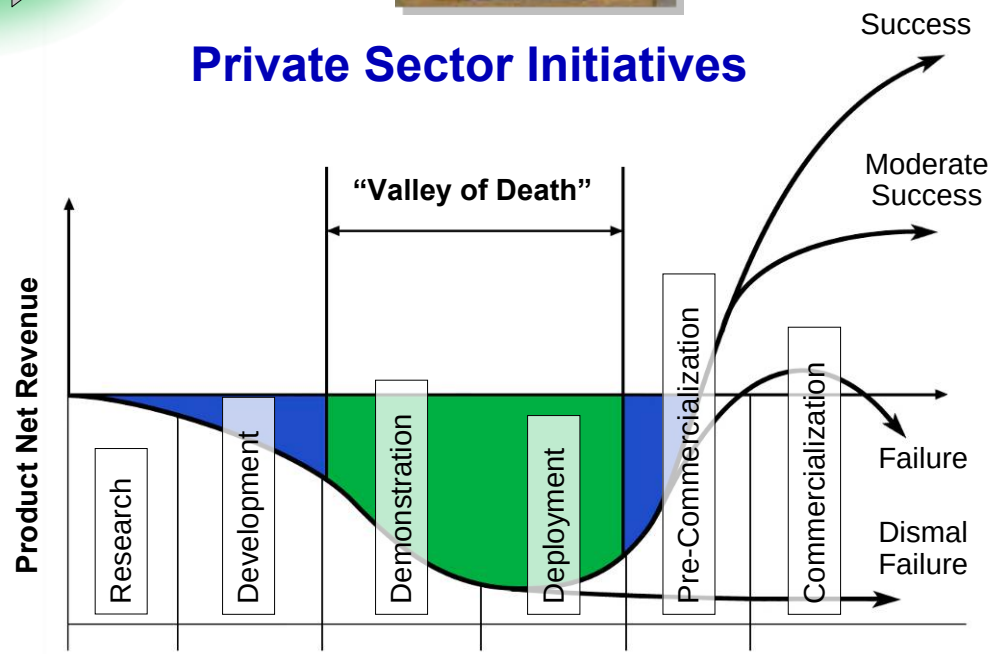

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For More Information

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