Heat Pump Supply Chains and Manufacturing Competitiveness Considerations

2016 Building Technologies Office Peer Review

CEMAC
Clean Energy Manufacturing Analysis Center

CLEAN ENERGY MANUFACTURING ANALYSIS CENTER

www.manufacturingcleanenergy.org/

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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Project Summary

Timeline:

Start date: October 2014

Planned end date: January 2016

Key Milestones

1. Milestone: Prioritization of top heat pump technologies: Collaboration with BTO and CEMI using metrics and data from BTO strategic analysis outcomes; 1/15
2. Milestone: Global market & manufacturers data; 8/15
3. Final for heat pumps analysis: Executive summary & annotated slide deck; 1/16

Budget:

Total Project $ to Date:
- DOE: $400k
- Cost Share: $0

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Key Partners:

Oak Ridge National Laboratory, technology advisors

Project Outcome:

What are the current and future opportunities for thermal non-vapor compression heat pumping technologies in comparison to conventional systems?

What drivers (market, regulatory, technology, or cost) are most impacting the adoption of these heat pumping technologies today in the US?

Are there unique, value-adding, or enabling portions of the heat pumping technology supply chain that the US already has, or could capture?

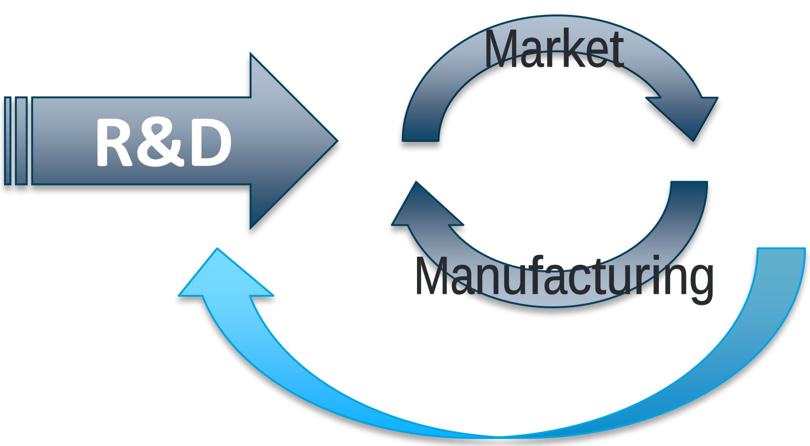
Purpose and Objectives

Problem Statement: What is the global and domestic market for heat pumps and what are the opportunities for greater domestic manufacturing.

Target Market and Audience: Provide insights to DOE and other decision-makers about the opportunities to target R&D decisions for greater market deployment and domestic manufacturing.

Impact of Project:

- To help BTO identify research, development, and demonstration (RD&D) needs at points along the value chain
- Support BTO's goals of increasing the deployment of energy-efficiency technologies through evaluation of market and cost barriers
- Identification of the key factors behind manufacturing location decisions



Approach

Approach:

- Global supply chain assessment
- Comparative cost analysis
- Analysis of the impact of other factors (e.g., policy, quality, shipping)

Key Issues:

- What are the current and future opportunities for thermal non-vapor compression heat pumping technologies in comparison to conventional systems?
- What drivers (market, regulatory, technology, or cost) are most impacting the adoption of these heat pumping technologies today in the US?
- Are there unique, value-adding, or enabling portions of the heat pumping technology supply chain that the US already has, or could capture?

Distinctive Characteristics: The CEMAC approach goes beyond traditional technoeconomic and market analysis to determine R&D target areas that will enhance deployment and domestic manufacturing.

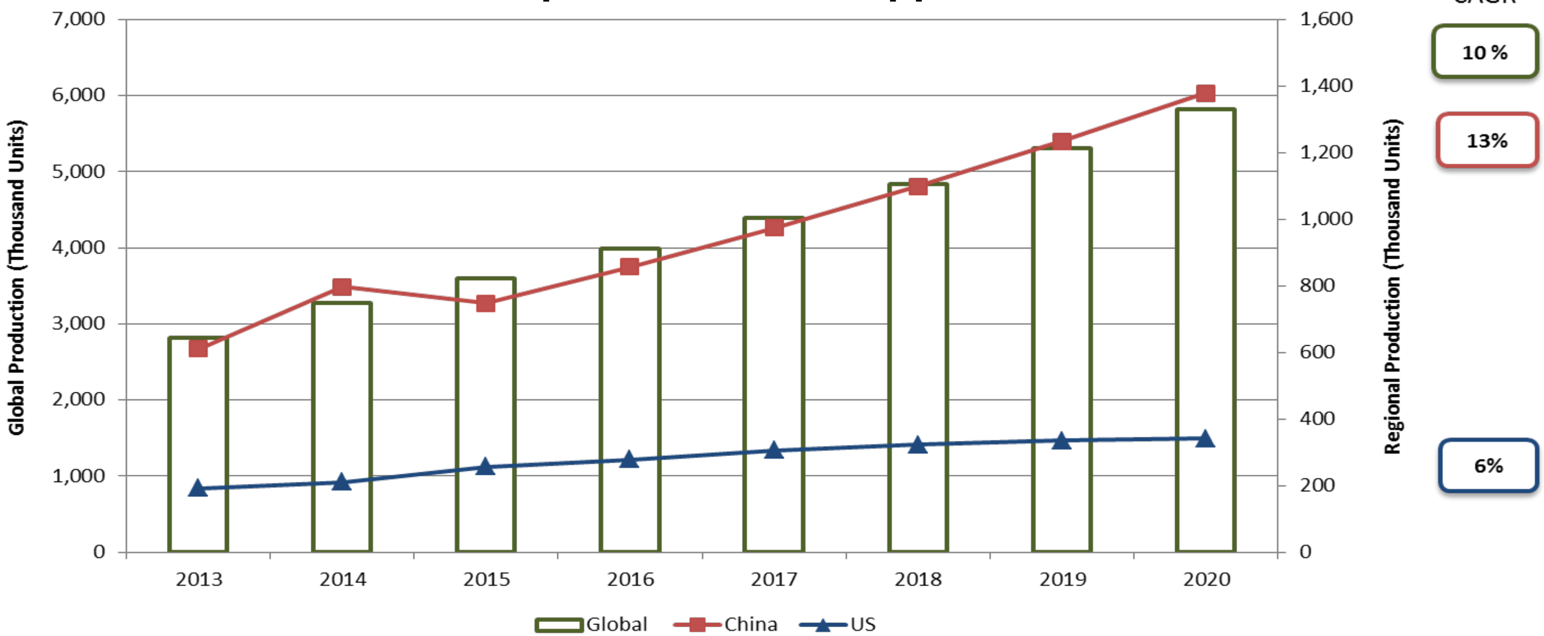
Progress and Accomplishments

Accomplishments:
- Defined global demand of conventional heat pumping technologies
- Mapped manufacturing production and capacity
- Mapped global trade
- Identified areas of highest cost contribution (materials)
- Calculated global cost for manufacturing key components
- Identified non-cost factors that could contribute to manufacturing competitiveness and greater market deployment
  - Policies
  - Impact of transportation logistics on supply chain
  - Steel capacity
  - Quality

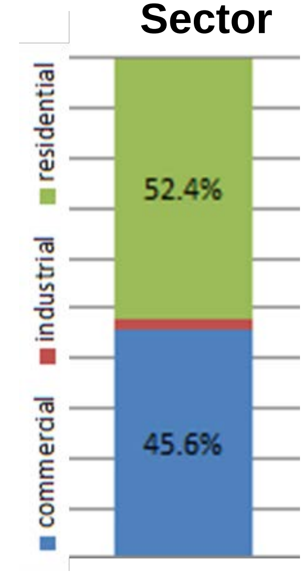
Lessons Learned: While heat pump technologies offer very significant energy efficiency savings, domestic deployment is slow but could be increased by leveraging U.S. manufacturing capacity, transportation logistics, steel capacity, and quality requirements.

Heat Pump Demand and Regional Growth Projections

Global Heat Pump Demand – All Applications



Global Market Sector



- Forecasted compound annual growth rate (CAGR) in global heat pump demand is expected to be approximately 10% through 2020, with regional demand varying.
- If demand estimates are met, today's manufacturing capacity will be fully utilized before year end 2017.
- U.S. electricity and natural gas heat pump demand modeled primarily by upfront unit cost
- Majority of heat pump demand is expected to remain in residential applications, with commercial uses also growing.
- Increasing demand for commercial applications is currently greatest in Europe and China .

Sources: QY Research (2015); EIA (2015).

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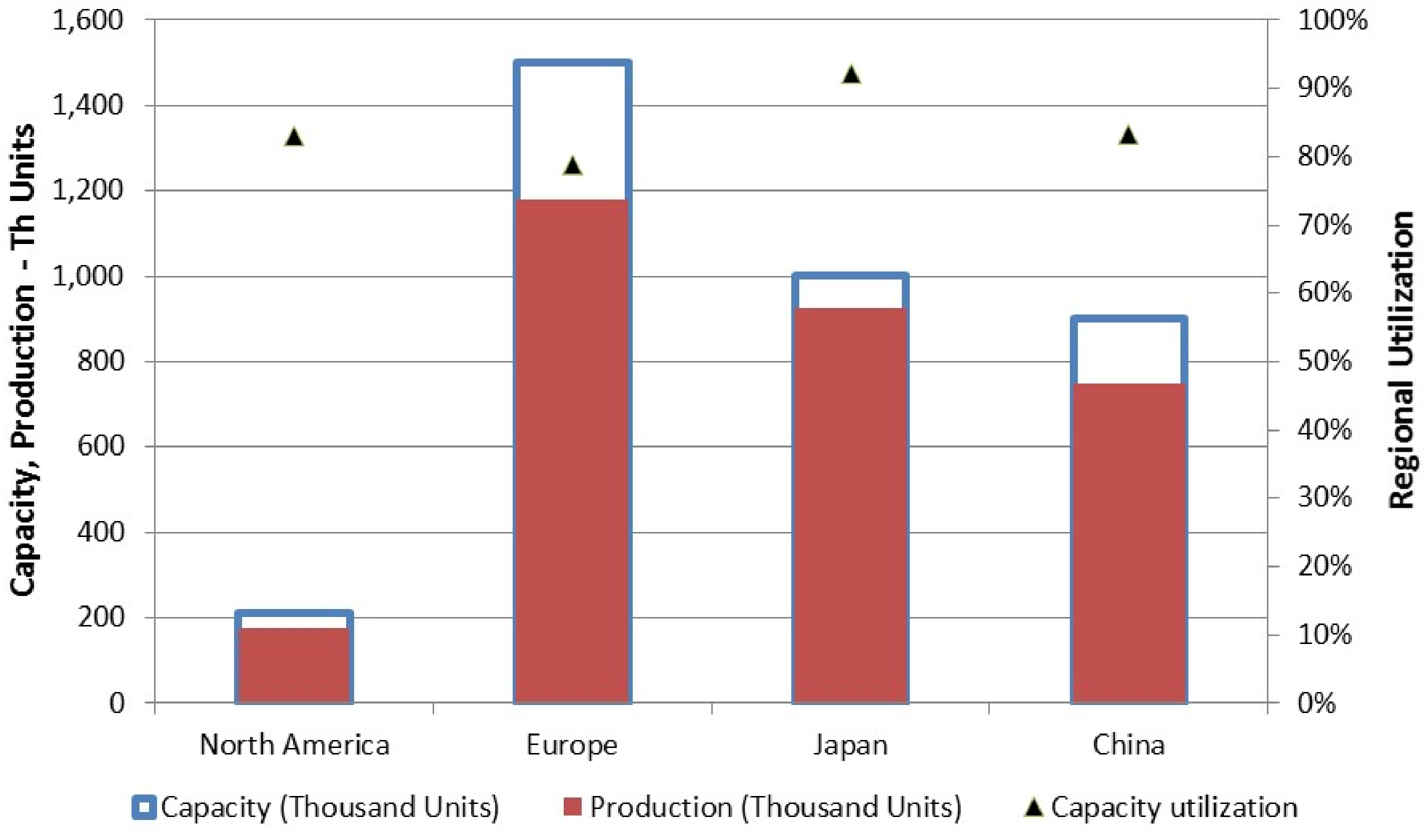
Manufacturing Capacity: Europe, China have most installed – and most available for growth

2015 Regional Heat Pump Manufacturing Capacity and Utilization



- To sell into the U.S. market (primarily ducted heating), an EU player used to selling domestically would require retooling - and units would need additional testing to meet US efficiency standards

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Heat Pumps that are Manufactured For Export Flow Mostly to Europe

- Most heat pumps manufactured in Europe and Asia are for domestic consumption
- U.S. is the dominant exporter
- Europe imports more heat pumps than they export
- Increase in market uptake in U.S. must compete with demand from other countries

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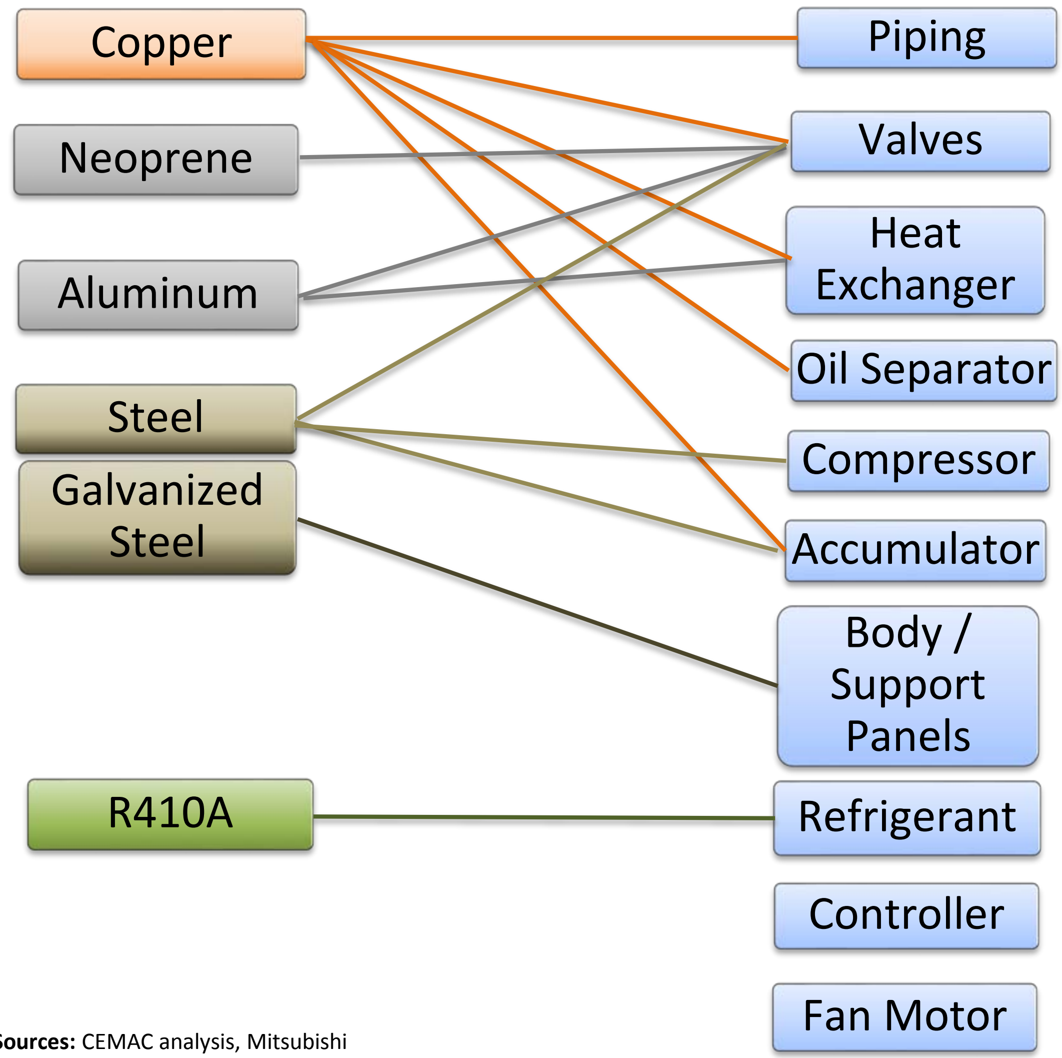
Materials of Construction – Dominated by Steel

Major Materials and System Components
Electric Air Source Heat Pumps

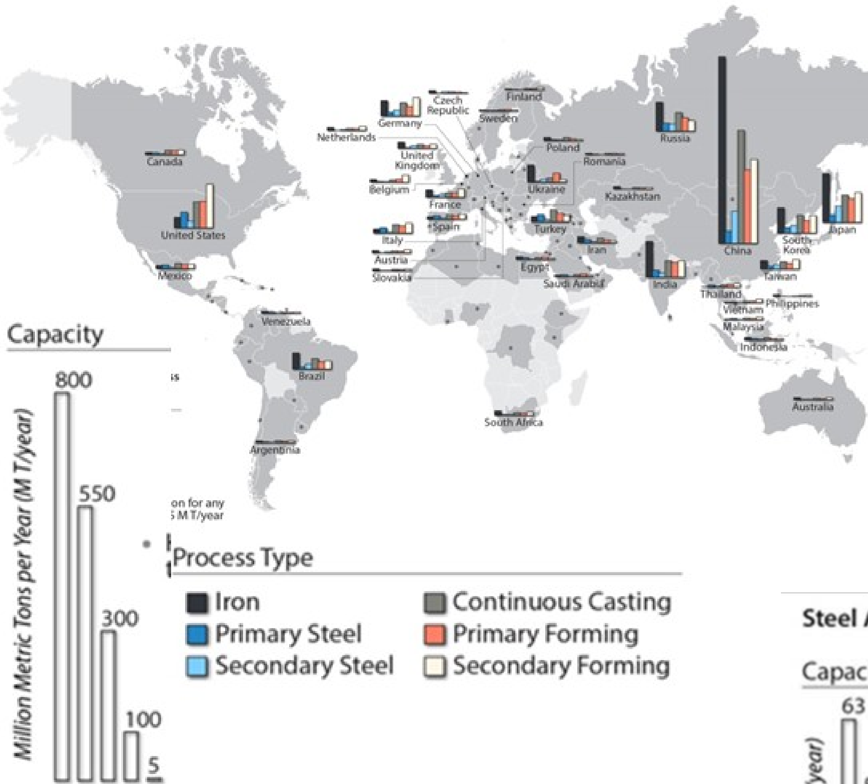


Sources: CEMAC analysis, Mitsubishi

- Heat pump components are commoditized, i.e., they compete on lowest price
- Innovation not likely to move state of current technology
- Existing manufacturing capacity dominates (i.e., capital already invested)
- Leverage of air conditioning market offers best opportunity for U.S. manufacturing growth
- Steel supply chain dominates cost structure

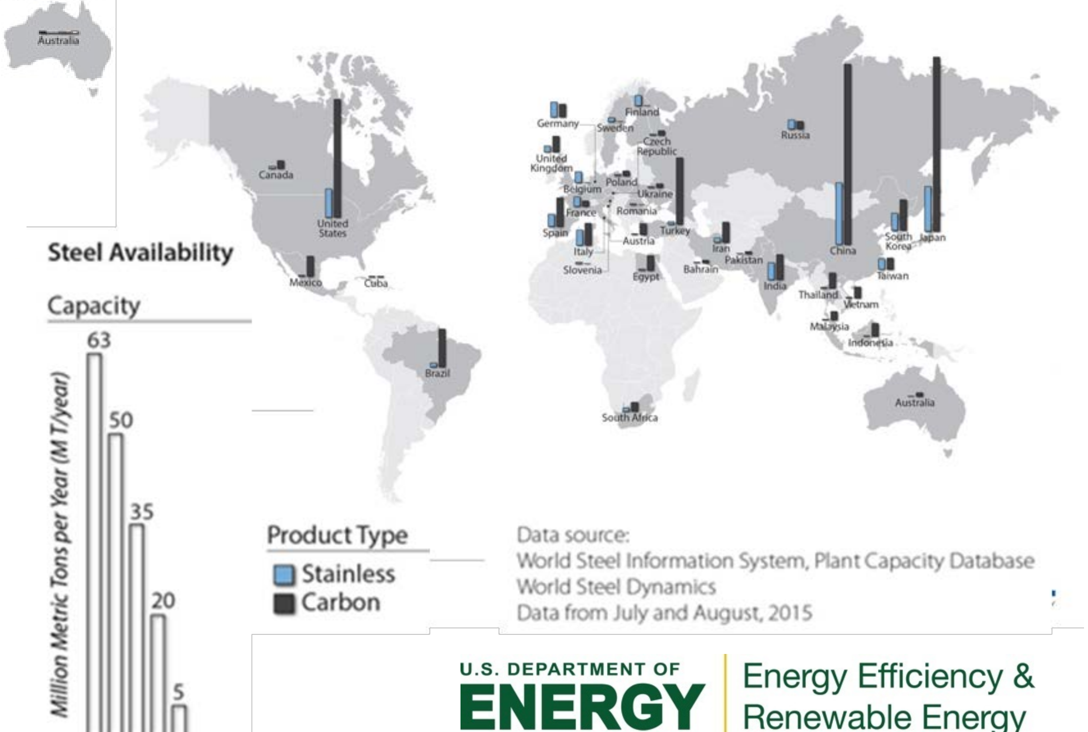
Global Steel Manufacturing Supply Chain

China and Japan dominate iron processing; US has significant primary steel processing



Steel and A/C manufacturing capacity can facilitate scale-up for a greater market uptake

Locations of steel manufacturing by type commonly used in heat pumps



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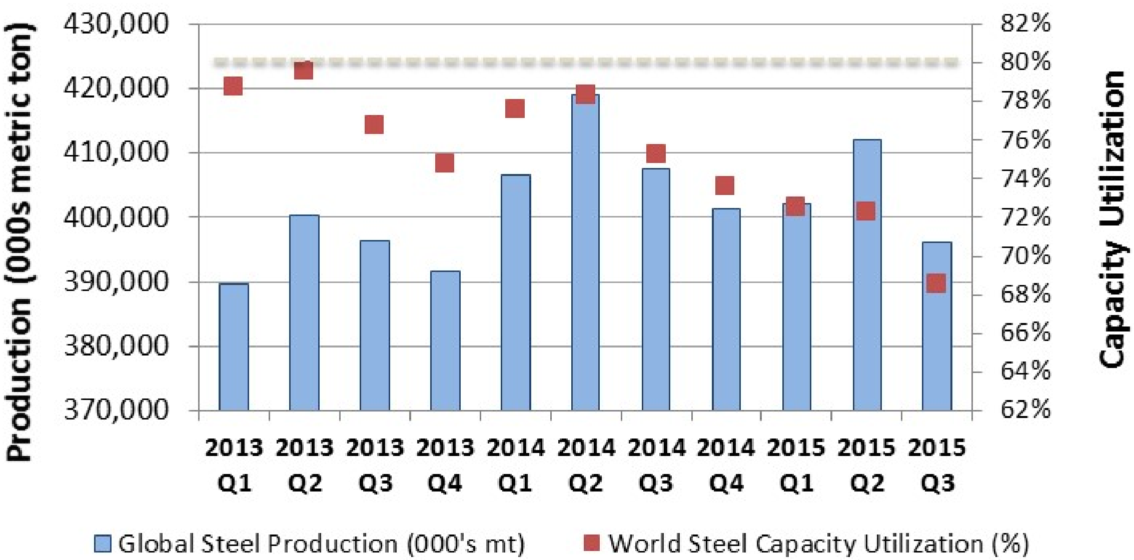
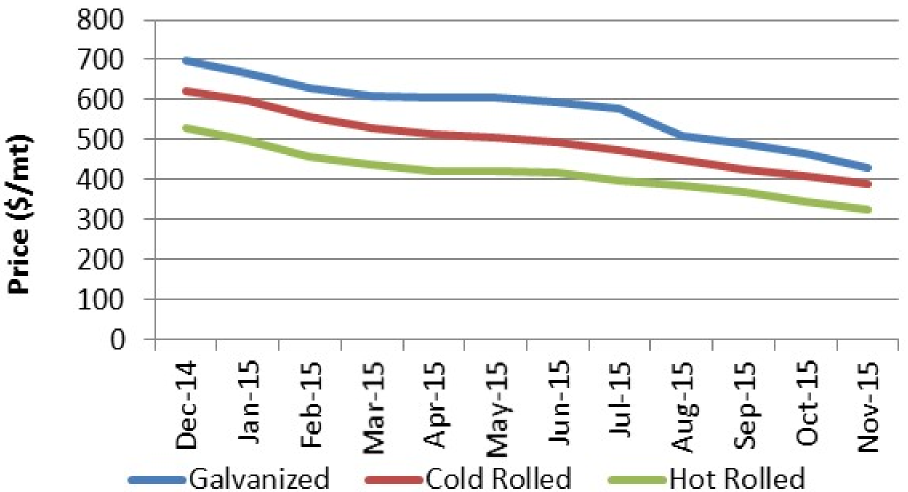
Global Steel Production & Prices are Dropping

- Global capacity utilization has decreased >13% over 2014 as production slows [as of October 2015, China (down 2.1%), the U.S. (down 8.8%) and Japan (down 3.8%)].
- Average prices for flat steel products have declined approximately 38% over 2014
- Signals opportunity for lower costs and greater market growth for heat pumps





Sources: Bloomberg

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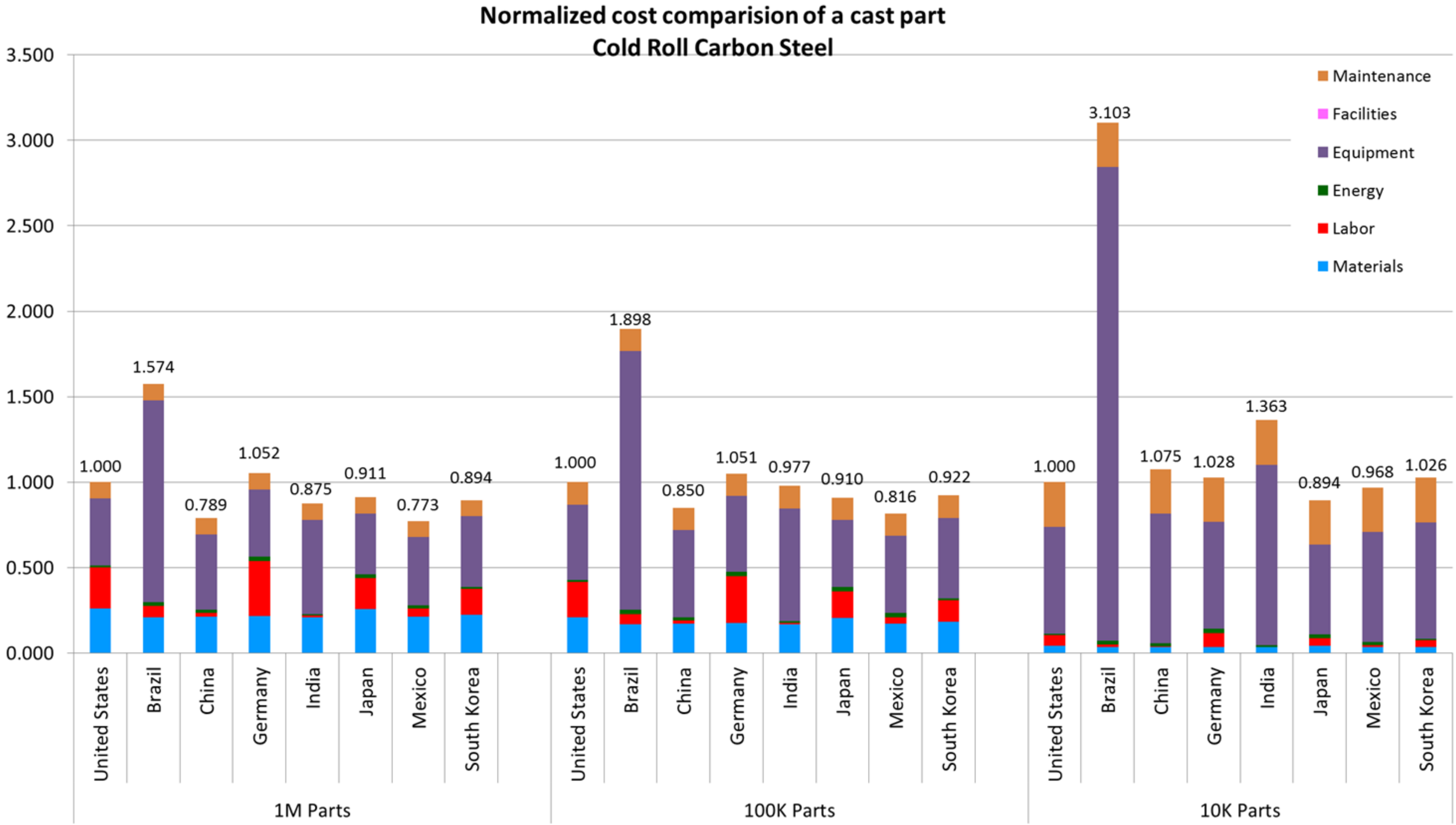
Global Manufacturing Cost of Cast Steel Components



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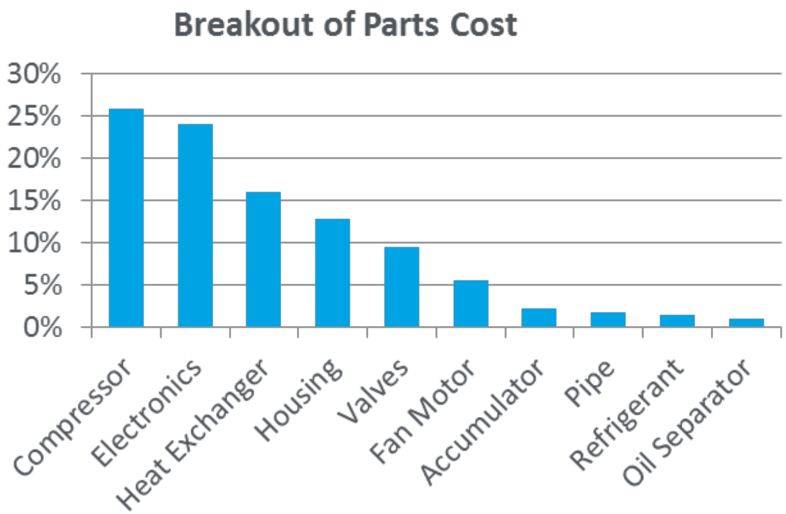
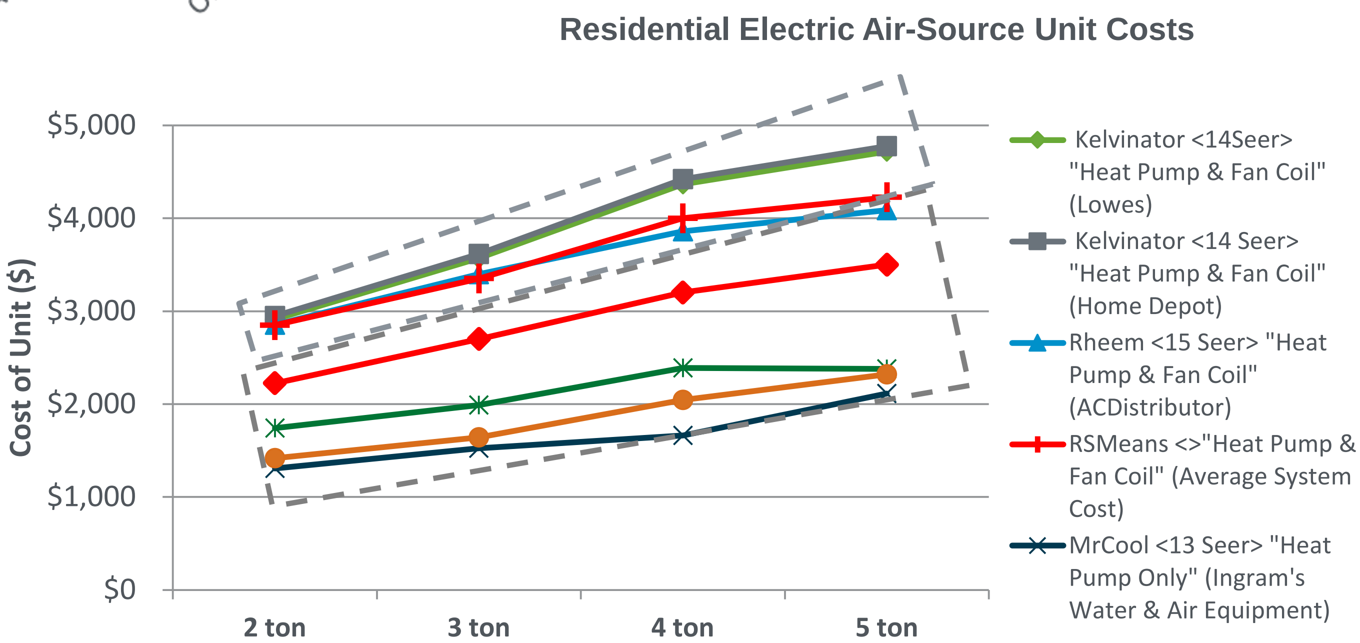
Cost and Contribution to Total Cost

3 parts comprise 2/3 of the cost of an Electric Air Source Heat Pump



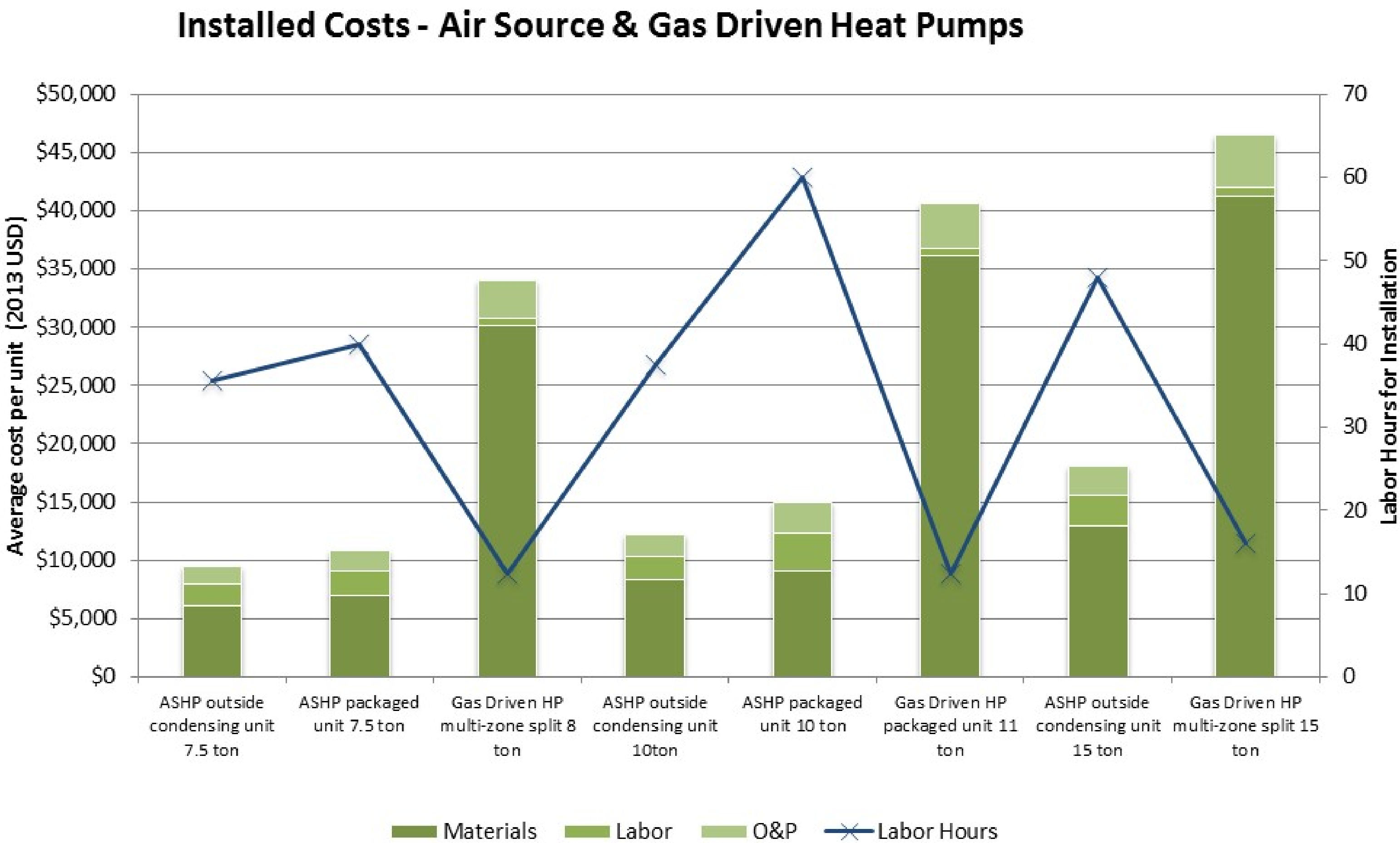
Costs are based on a ductless system typical of heat pumps installed in Asia and Europe – and which could be installed in newer U.S. construction.

Model Represented: Mitsubishi MXZ-8B48NAR1



Source: RS Means, Home Depot website

Materials Costs Dominate U.S. Heat Pump Costs



- The cost of the heat pump unit itself is 3 times more for a gas-driven absorption unit than an air-source unit of the same size.
- Installation time (and labor cost) is more significant for air-source unit installation

Source: RS Means Building Construction Cost Book, 2015 ed.

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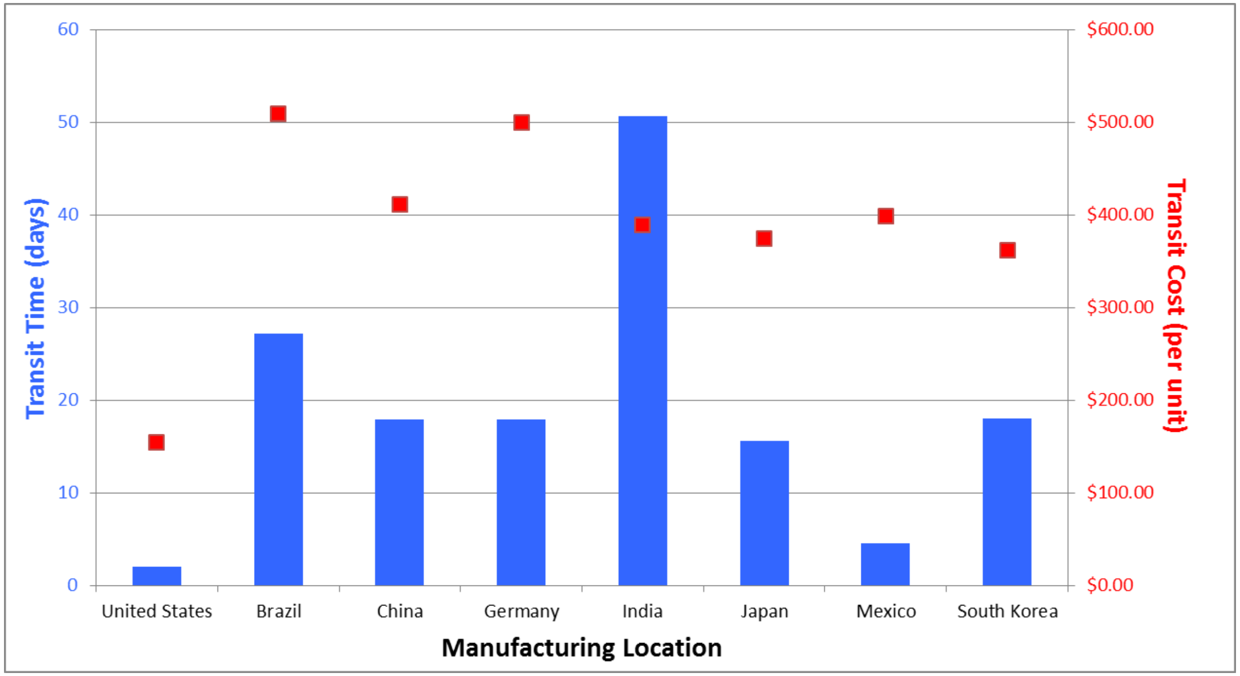
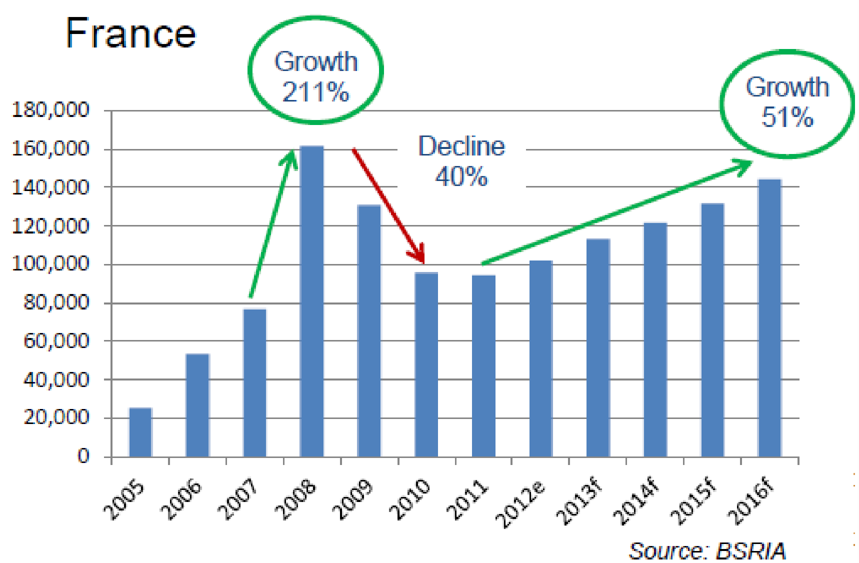
Other Factors Affecting Manufacturing Location Decisions

- Policy and regulatory contexts: Current U.S. policies are not the driving force of technology innovation (SEER standard now exceeded)
- Grid reliability => metal forming is electricity intensive
- Shipping logistics and the associated supply chain delays, inventory costs, and product lead time
- Access to talented workforce important for absorption, adsorption, and Vulleumier systems
- Access to low cost energy (for steel manufacturing)
- Component quality: compressor quality drives heat pump efficiency
- Manufacturing economy of scale; existing mfg capacity for A/C units reduces cost of growth for heat pumps

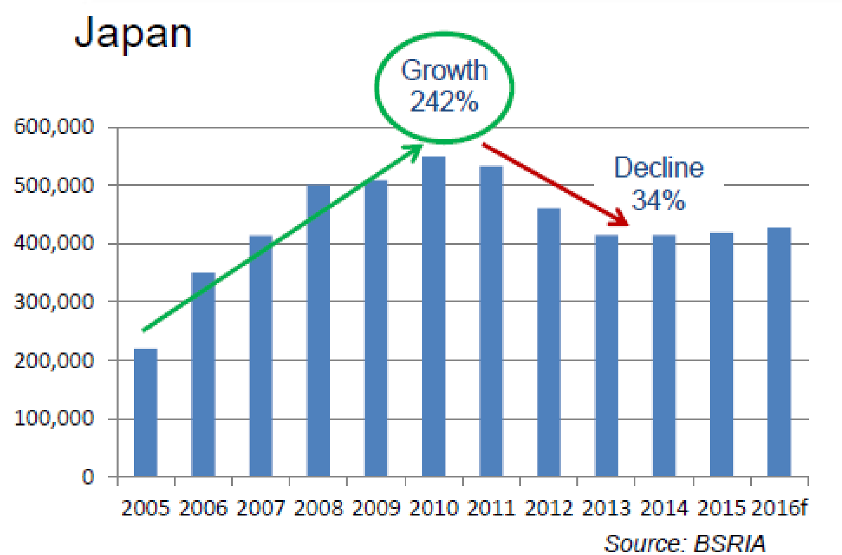
- Shipping, export, and import costs are, on average, 6-12% of the unit's cost.
- An example 3-ton residential unit requires at least 51 days to arrive from Mumbia, India - but the most expensive route on a per-unit costs was from Rio de Janeiro, Brazil
- Shipping time also has an effect on costs down the supply chain



Incentives Have had a Noticeable Effect on Adoption



- Raise of tax credit to 50% in 2006
- Reduction of tax credit to 25% in 2010, 15% in 2012
- Added 40% tax credit for solar hot water HP in 2010, now 15% as of 2014
- Increased electricity price in 2010



- Government financial support offered for installation of CO_2-based HPWH (ECO CUTE)
  - Started in 2002, stopped in 2012
- Heat Pumps qualify toward country GHG/energy targets (ECO points)

Source: BSRIA (2014)

Project Integration and Collaboration

Project Integration: CEMAC staff have received data and market characteristic inputs from the U.S. HVAC industry, and used this to inform the analysis.

Partners, Subcontractors, and Collaborators: Researchers from ORNL and NREL have provided market and technical guidance

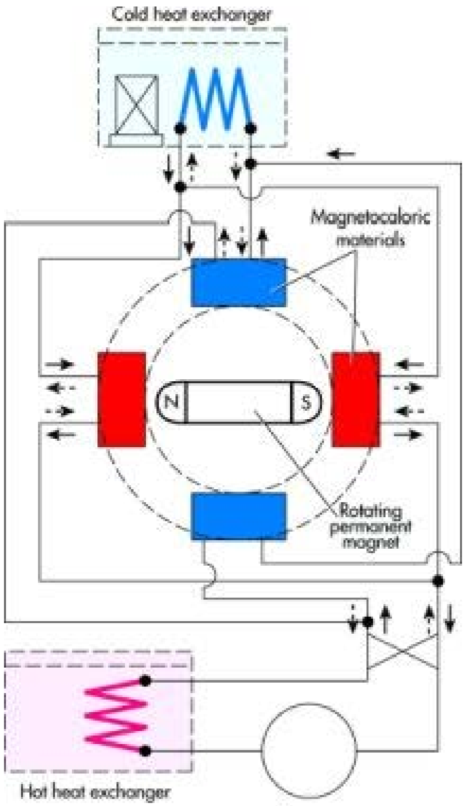
- Electric air-source heat pumps
- Adsorption non-vapor compression heat pumps
- Absorption non-vapor compression heat pumps
- Vuilleumier non-vapor compression heat pumps
- New: magnetocaloric refrigeration (not reported here)

Communications: Webinars with DOE, presentations to CEMAC advisory committee (including GE and Whirlpool), CEMAC Annual Meeting (3/16), published takeaways factsheet, published slide deck

Next Steps and Future Plans

Current work is focusing on magnetocaloric refrigeration

- Global air conditioning market ~$100B/yr
  - Does not include refrigerators, vehicles or other vapor compression devices
- Magnetocaloric systems offer potential energy savings over vapor compression of 20-35%[1]
- Climate-friendly refrigerants (no HFCs)
- Less noise and vibration than compressor based systems
- Potential for US manufacturing?



Rotary magnetic refrigeration, typical schematic

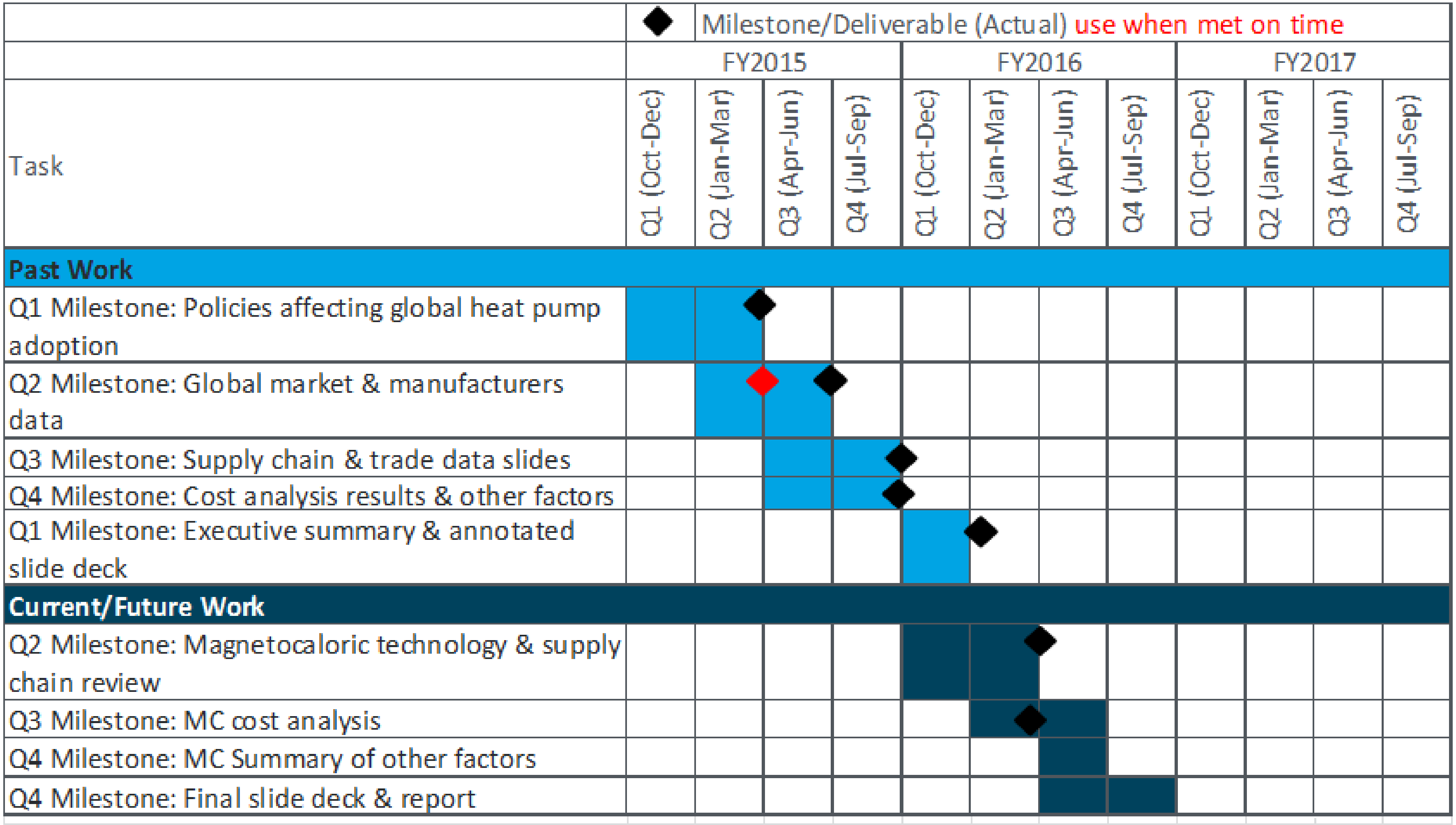
REFERENCE SLIDES

Project Budget

Project Budget: $200k for heat pumps, $200k for current magnetocaloric refrigeration analysis
Variances: No variations in budget
Cost to Date: $260k spent out of $400k total
Additional Funding: None, although original $200k was received by EERE Office of Strategic Programs

Budget History					
FY14 – FY 2015 (past)		FY 2016 (current)		FY 2017 – Future (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$200k	$0	$200k	0	Unplanned	

Project Plan and Schedule



Analysis of heat pumps complete; magnetocaloric refrigeration analysis in-progress