Industrial Heat Pump Market Transformation –

Andrew Hoffmeister
Neal Elliott
Paul Scheihing

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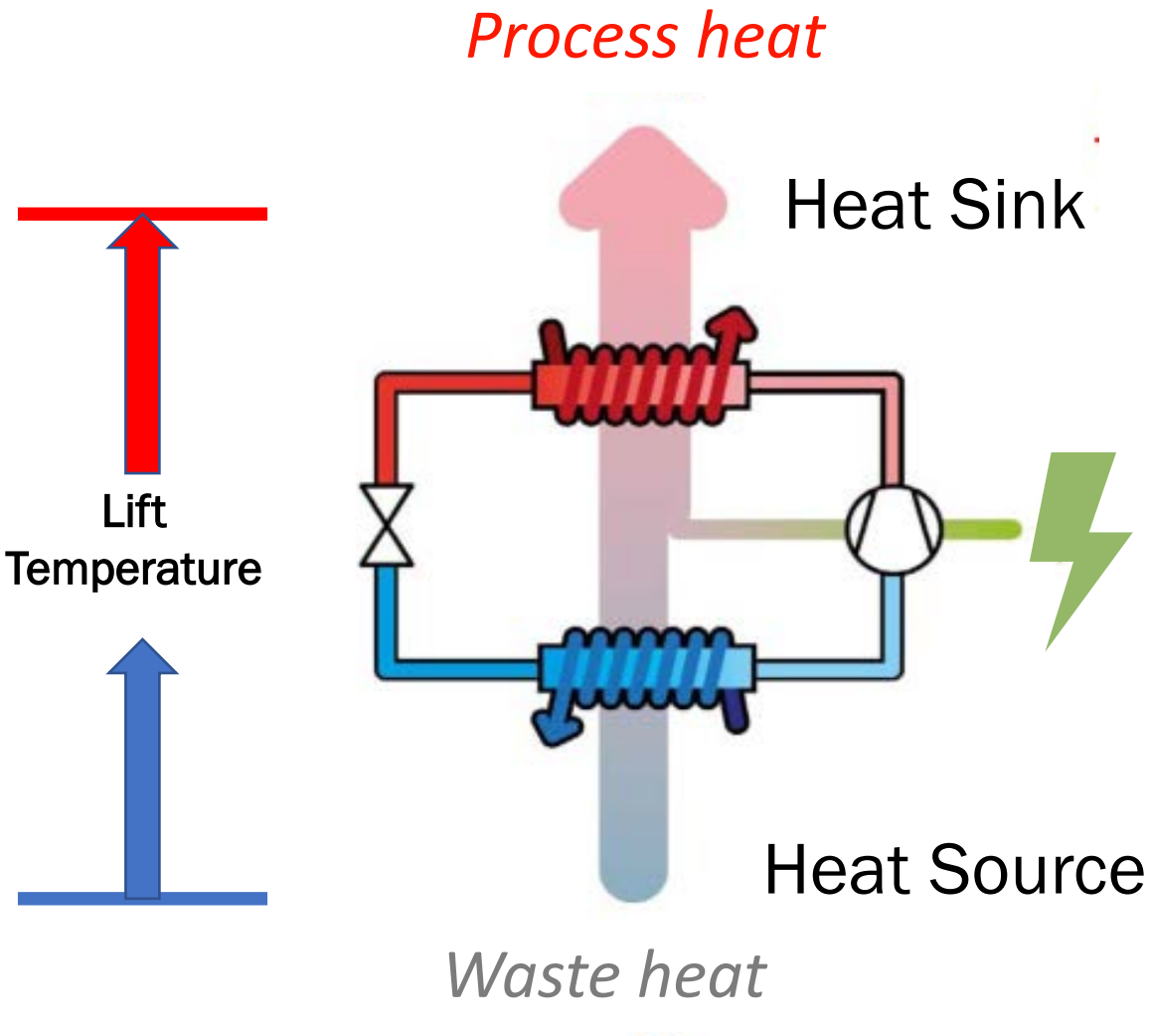
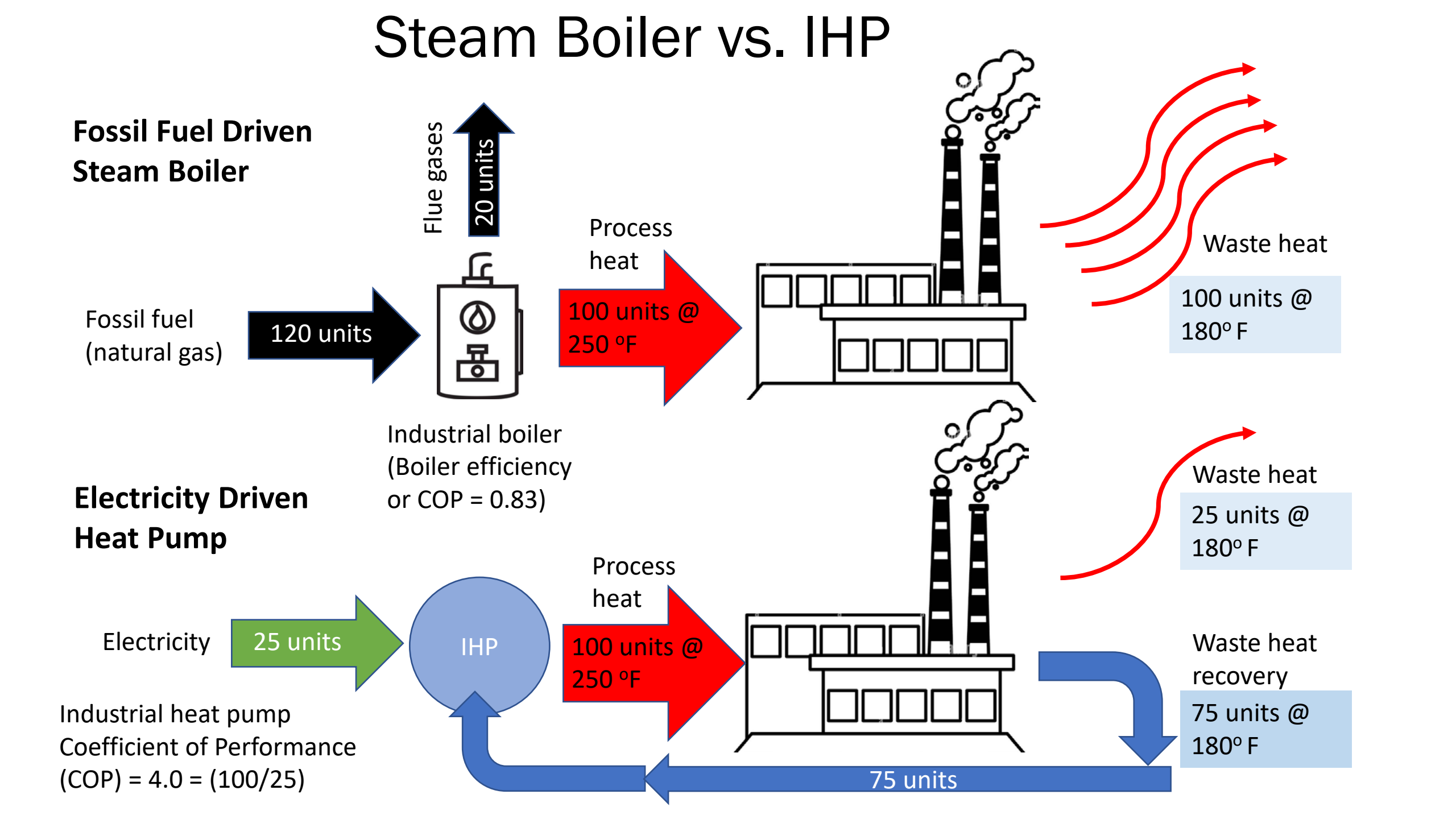
Industrial Heat Pumps (IHPs) Intro

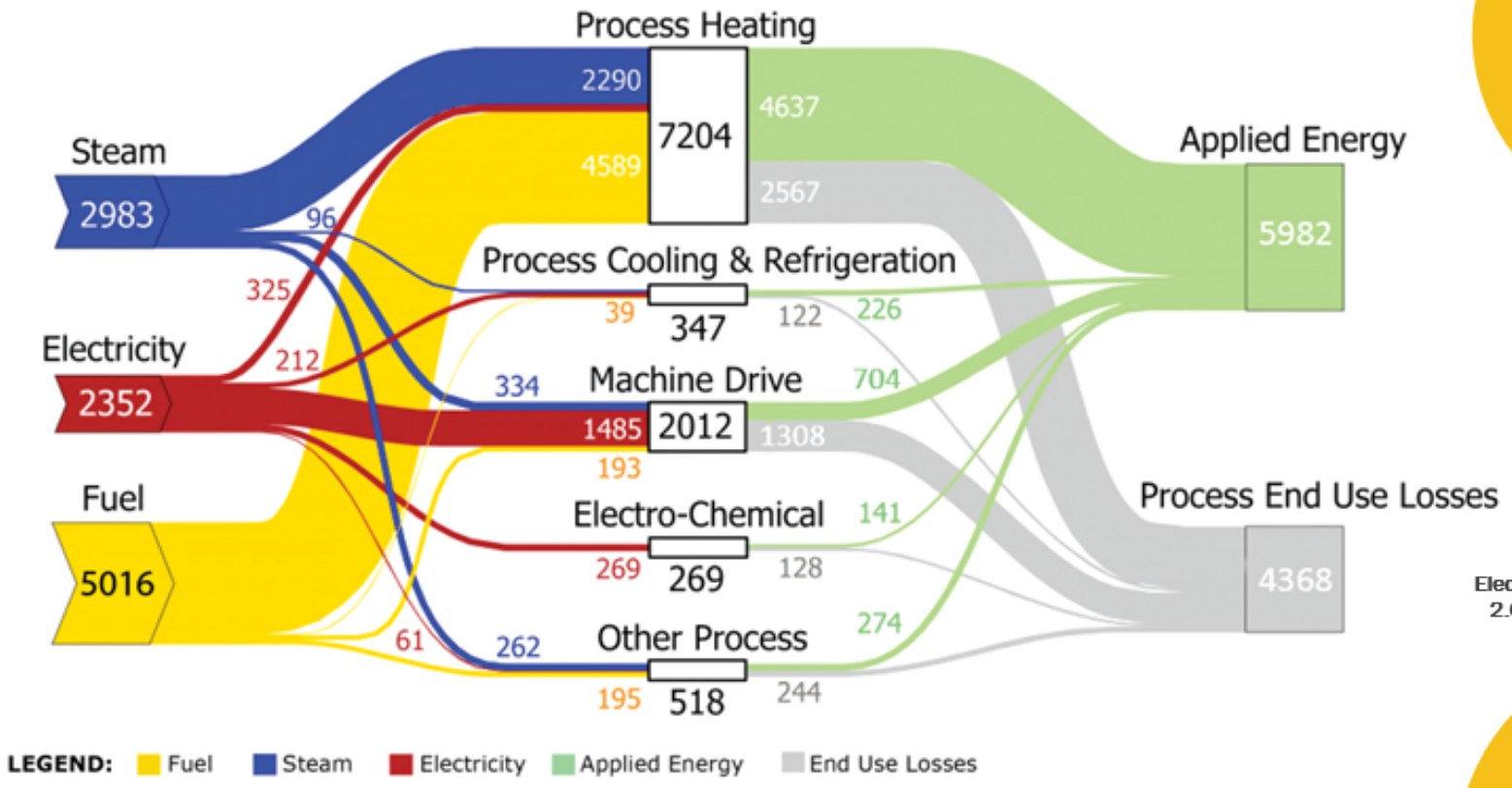
- Can be driven by:
  - Electricity (motor-driven)
  - Steam (steam ejector)
  - Heat-activated (sorption)
- IHPs are those larger than 100kW that move heat up from a lower heat source temperature to a heat sink temperature of greater than 150°F (~65 °C)
- Opportunities to lower operating costs and carbon emissions under favorable conditions



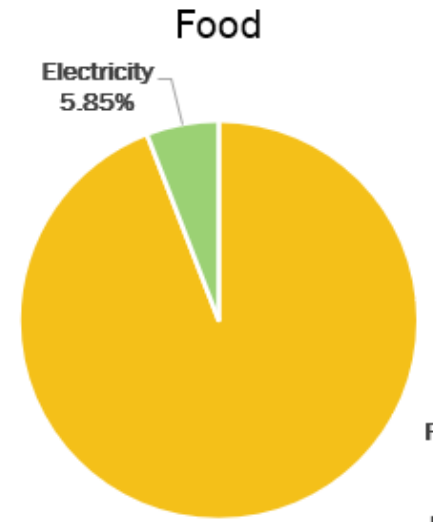
Steam Boiler vs. IHP



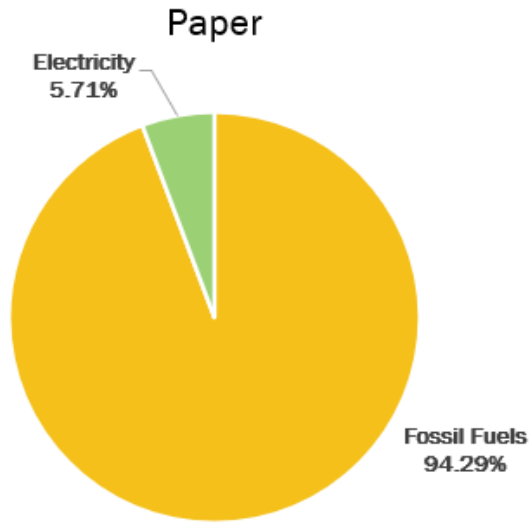
Process Heat Accounts for Most (~70%) Industrial Energy Use

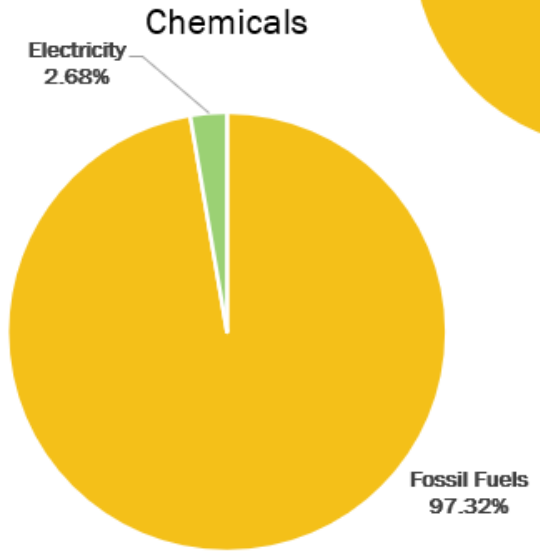


U.S. Manufacturing Sector Process Energy Flow in 2010

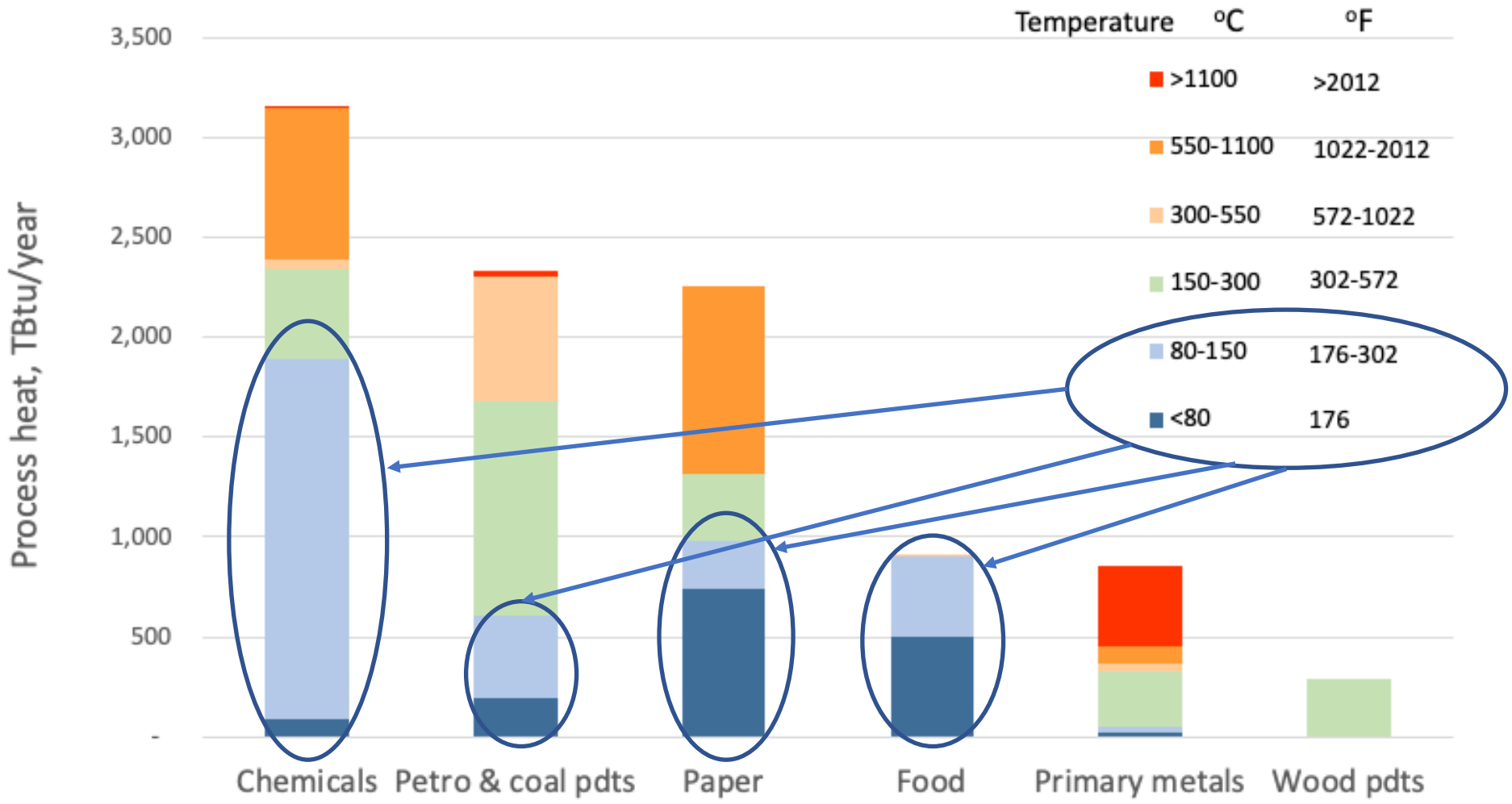


*Process heat fuel consumption for key industries



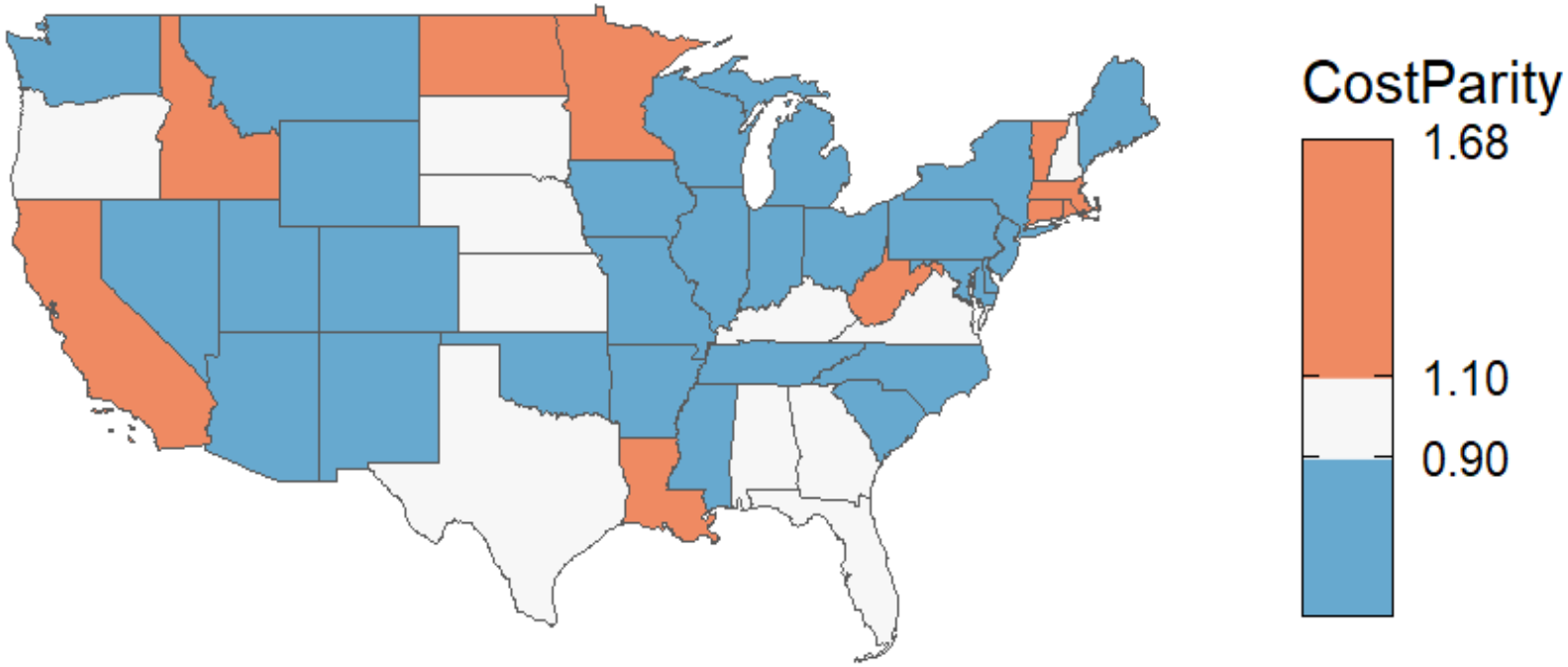


Significant Industrial Process Heat is at or Below 150 ° C



Data Source: McMillan 2019

Many States have Favorable Cost Parity for IHPs



*Propane and RNG make IHP use even more cost-favorable

- Blue states indicate areas where operating an industrial heat pump is likely more affordable than running a natural gas-powered equipment
- Based on electricity/natural gas ratios
- Assumes a COP of 4.0

IHP Research Phase 1: Opportunity Scouting

- Process heat: 51% of industrial on-site energy use. The large, early, cross-cutting GHG reduction opportunity
- Three industry groups -good early focus for IHPs, as they have high amount of process heat < 200° C
  - Food & Beverage
  - Pulp & Paper
  - Chemicals
- IHPs research shows combined potential impact of;
  - Net energy savings 26-32% (427-518 TBtus/year)
  - CO_2 savings 30-43 million tons/year
  - Simultaneous cooling needs met
  - 5 GW-hour/year electricity needed
- Simple paybacks can be under 2 years, depending on electricity/ natural gas price ratio
- Policy enablers can accelerate adoption

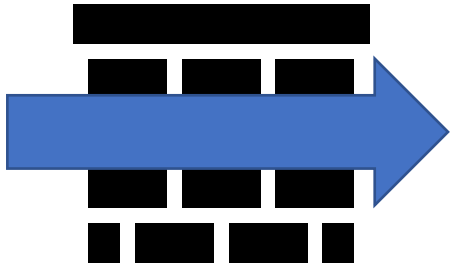
Report: https://www.aceee.org/research-report/ie2201

Website: https://www.aceee.org/industrial-heat-pumps

Market Transformation is Needed in both Supply and Stoking Demand

Where we are:

- End-users have process heat needs that can be met with available IHP tech
- There is **limited commercial availability** of IHPs in the U.S.
- The U.S. has fallen behind the EU and others in IHPs, industrial electrification at large
- New plants are looking to be fueled by 100% carbon-free electricity
- There is limited knowledge on the current potential of IHPs for end-users



Current Barriers

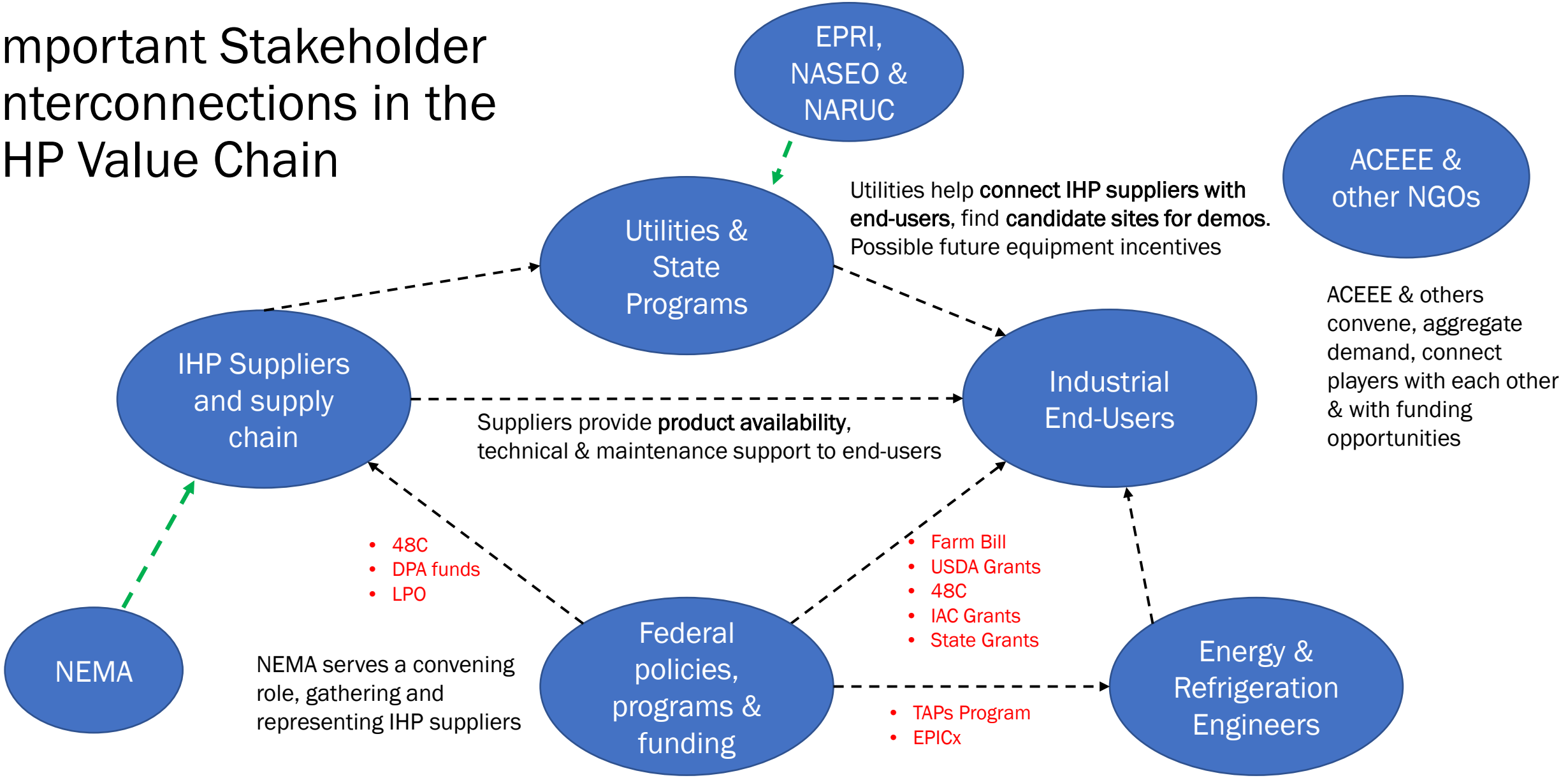
Where we want to go:

- Robust domestic IHP market supported by capable workforce
- IHP implementation at scale in both new and retrofitted facilities
- Decarbonization of process heat, enabling of other solutions (I.E., thermal storage, on-site renewables)
- IHP manufacturing and implementation support equity, create jobs in underserved communities
- Full market awareness of IHP potential

Roles for federal government

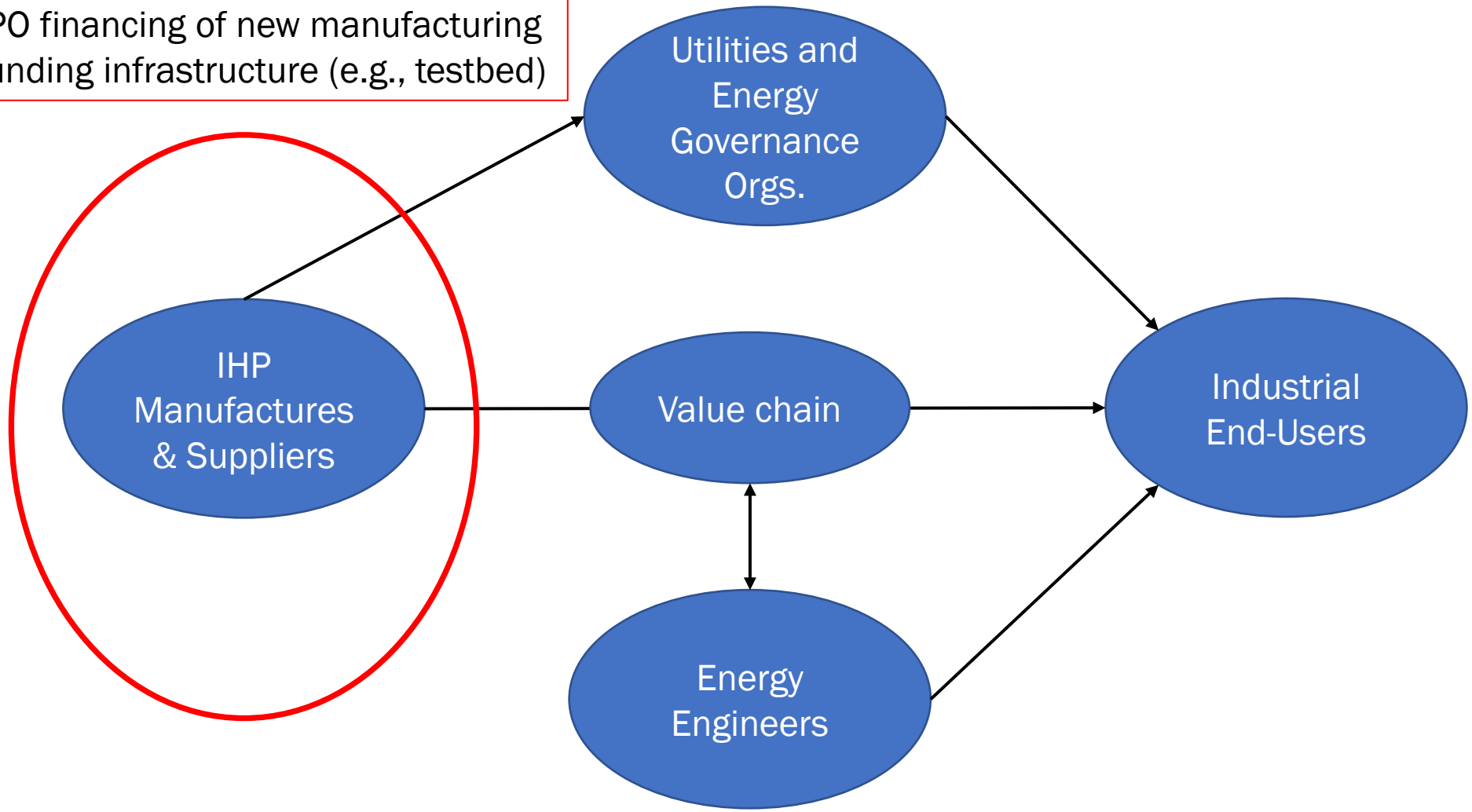
- Support domestic supply (48C, DPA & LPO)
- Build knowledge & expertise in design& installation (USDA-NRCS, EPICx, IACs & TAPs)
- Develop market infrastructure (MESC, IEDO & LPO)
- Support IHP demonstrations (MESC & IEDO)
- Support implementation (MESC, IEDO, LPO & USDA)

Important Stakeholder Interconnections in the IHP Value Chain

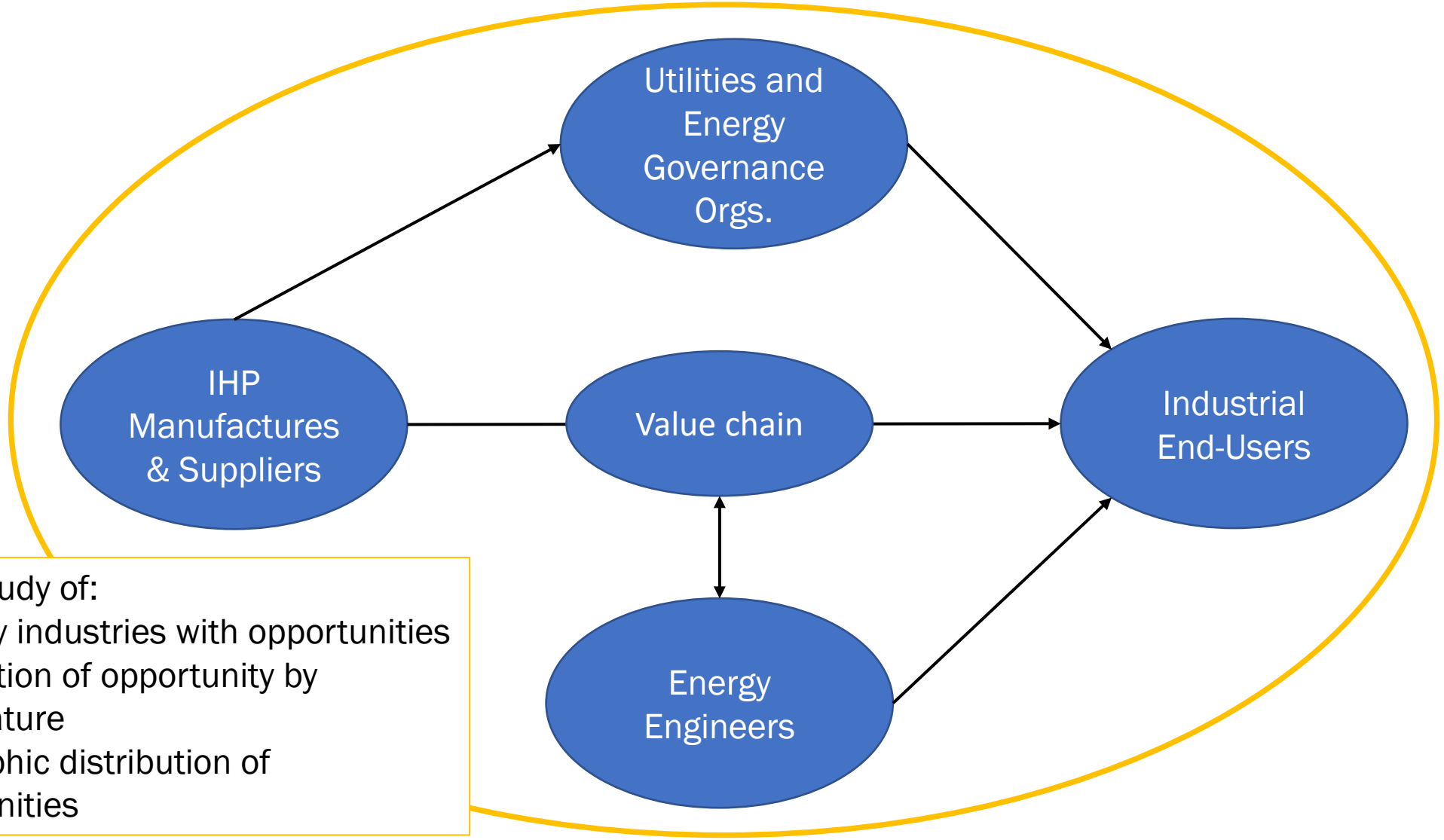


Federal programs & Incentives to Support Domestic IHP Supply

- DPA co-funding
- 48C mfg. tax credits
- LPO financing of new manufacturing
- Funding infrastructure (e.g., testbed)



Market Assessment of IHP Potential

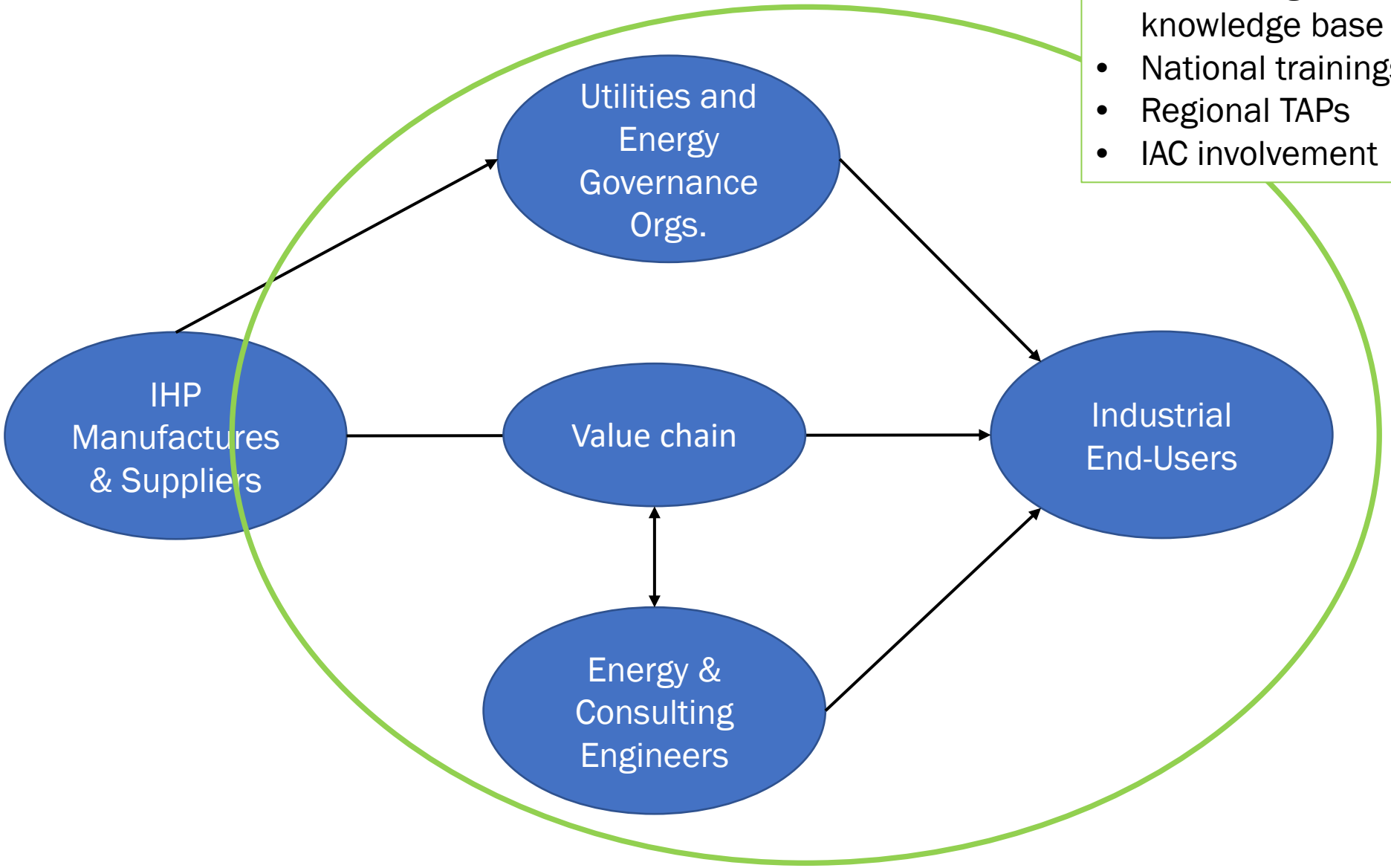


National study of:

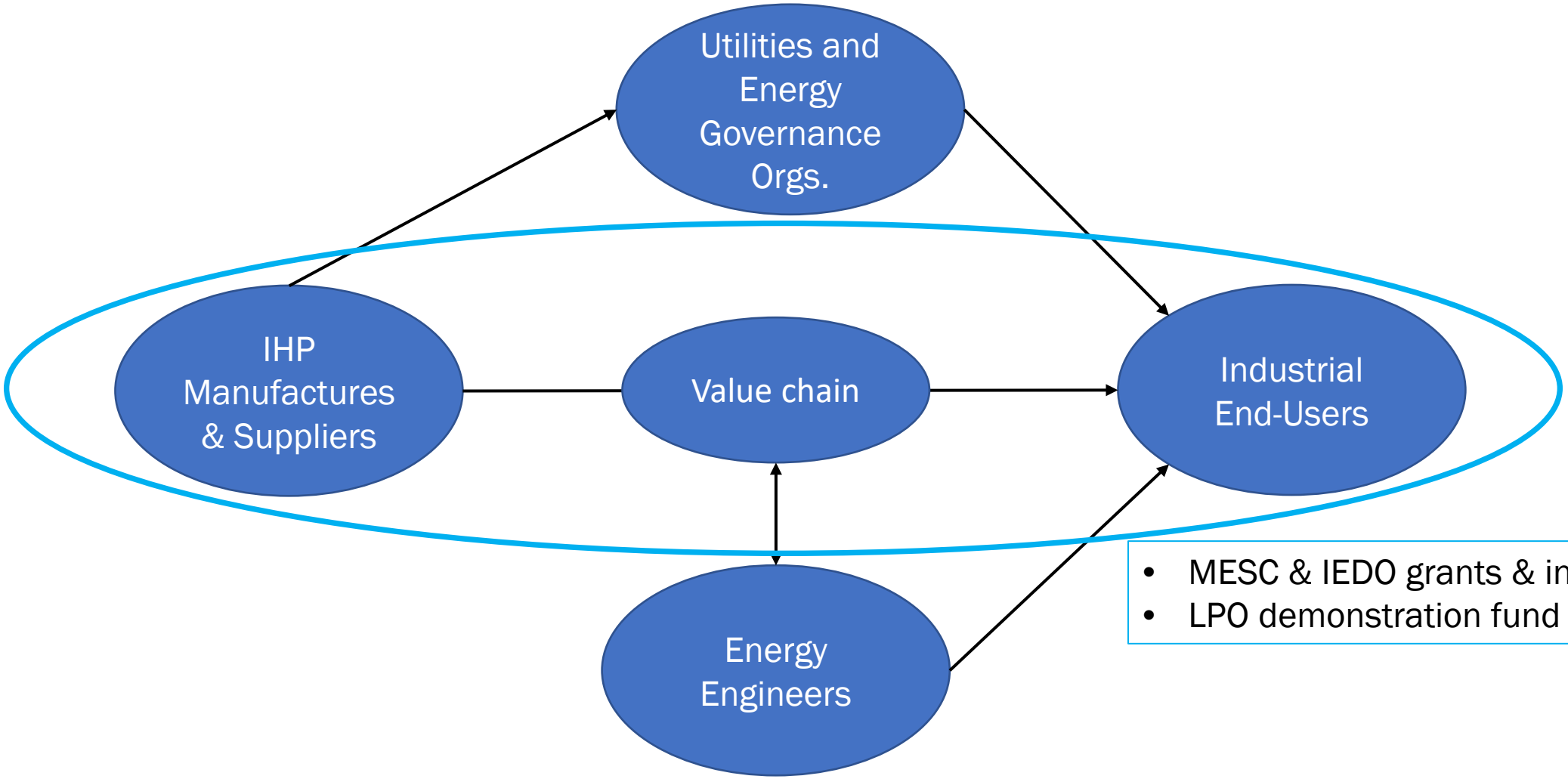
- ID of key industries with opportunities
- Distribution of opportunity by temperature
- Geographic distribution of opportunities

IHP Market Support Programs

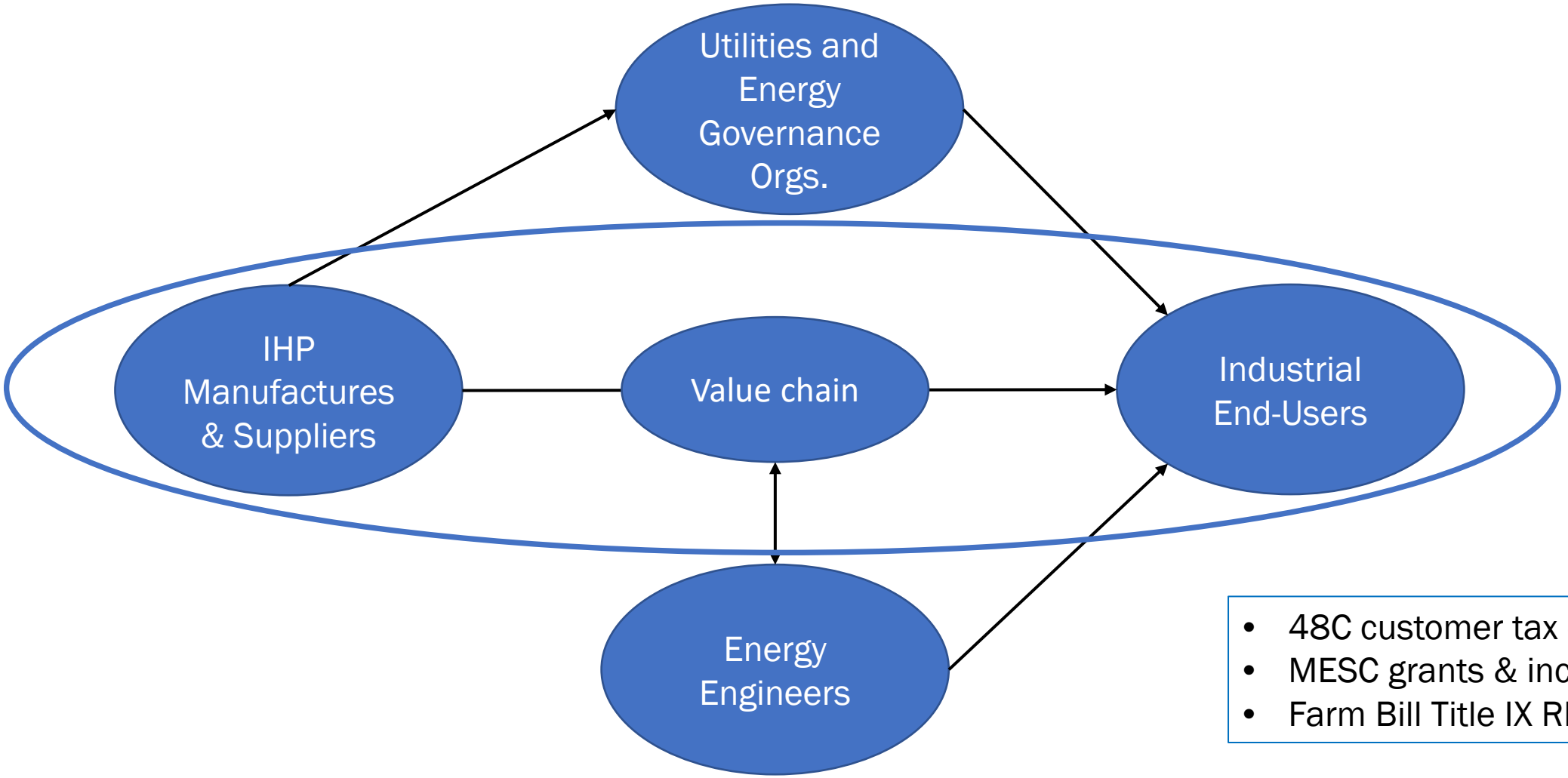
- On-shoring of IEA knowledge base
- National trainings
- Regional TAPs
- IAC involvement



IHP Demonstration Incentives



IHP Implementation Incentives



- 48C customer tax credits
- MESC grants & incentives
- Farm Bill Title IX REAP

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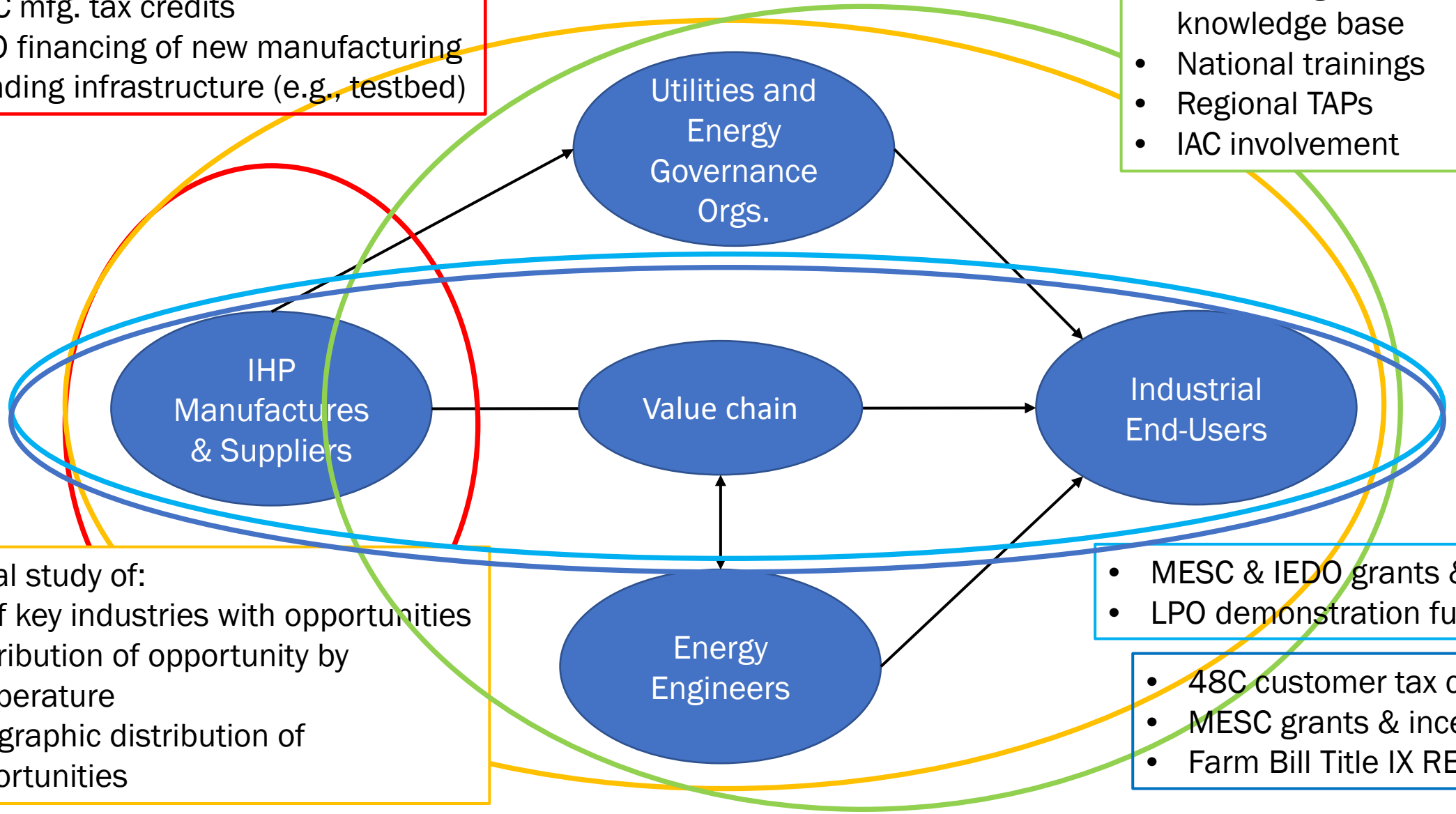

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- MESC & IEDO grants & incentives
- LPO demonstration fund

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Relevant Funding:

- BIL 40523 IAC Expansions
- BIL 40521 IAC Impl. Grants
- BIL 40534 State Manufacturing Leadership
- IRA 50161 Advanced Industrial Facilities Deployment

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Relevant Funding:

- BIL 40555 Rebate Program
- IRA 50143 Manufacturing Conversion Grants (+OCED)
- DPA (IRA)
- 48c + 45x Tax Credits

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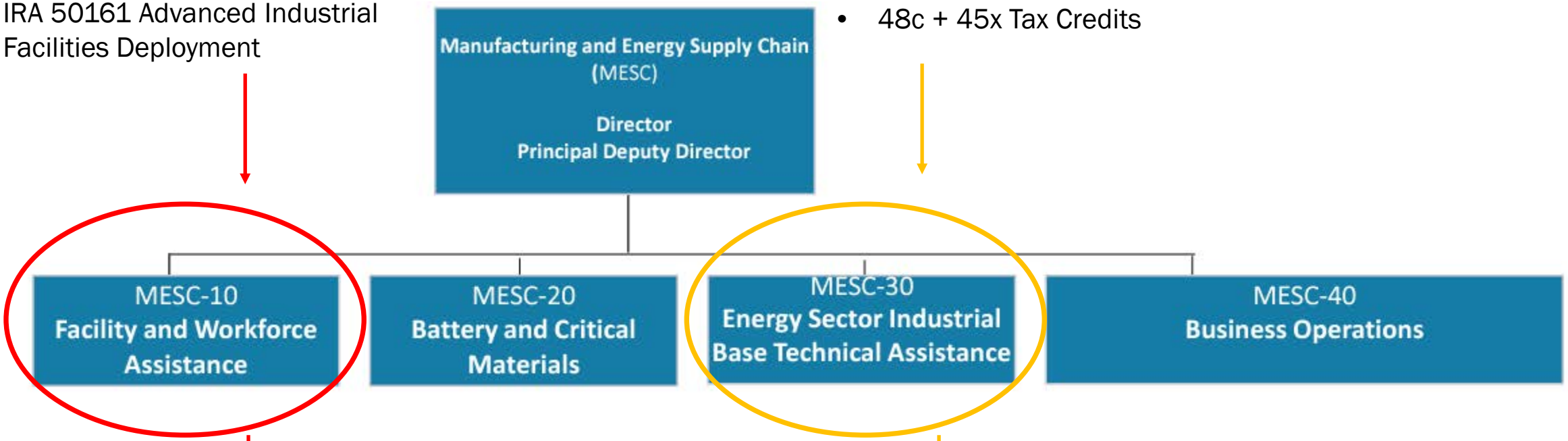


IHP Connected Programs:

- State leadership grants and programs
- ($3.2m) IAC expansions

IHP Connected Programs:

- ($250m) DPA awards for IHP manufacturing*
- ($10b) 48 C for manufacturers & end-users

Source: https://usea.org/sites/default/files/event-/Dr.%20Zach%20Valdez.pdf

Overview of 48C Round 1 (2023)

What is the Qualifying Advanced Energy Project 48C Credit?

- Competitively-awarded Investment Tax Credit (ITC) established in 2009 and functions very similar to FOA
- Expanded by IRA with **$10B** for (1) clean energy manufacturing & recycling, (2) critical materials, and (3) industrial GHG emissions reduction projects
- Projects receive 30% ITC (or 6% if prevailing wage and apprenticeship requirements not met)
- DOE will accept a first round of applications in 2023 to allocate up to $4B, with additional competitive application rounds in future years
- Approximately 40% of credits ($1.6B) will be allocated to projects in coal communities (if sufficient meritorious applications are received)

Legend

- Scope defined by ARRA in 2009
- Scope added by IRA

Clean Energy Manufacturing and Recycling

- Re-equip, expand, or establish Industrial or manufacturing facility for production **or recycling of** clean energy and energy efficiency technologies

Critical Materials Processing, Refining, and Recycling

- Re-equip, expand, or establish an industrial facility to process, refine, or recycle critical materials (50 USGS minerals + DOE critical materials)

Industrial GHG Emissions Reductions

- Re-equips industrial or manufacturing facility to reduce greenhouse gas emissions by at least 20%

Timeline and Review

- **Notice Released:** May 31
- **Concept Papers Due:** July 31
- **Full Applications Due:** Fall 2023

DOE will evaluate proposals against technical review criteria reflecting four major priority measures, and pass recommendations to Treasury:

1. Commercial Viability
2. Greenhouse Gas Emissions Impacts
3. Strengthening U.S. Supply Chains and Domestic Manufacturing for a Net-Zero Economy
4. Workforce and Community Engagement

With merit review scores plus program policy factors DOE will rank all meritorious projects into a final list for up to $4 billion in allocations for IRS

Allocation Decisions: No later than March 31, 2024

BIL, IRA Industrial Demonstrations Program $

BIL 40521 IAC Implementation Grants (i.e., TAPs expansion) $

Industrial Efficiency & Decarbonization Office

Energy- and Emissions-Intensive Industries	Cross-Sector Technologies	Technical Assistance & Workforce

<u>IHP Connected Programs:</u>

- ($104m) Industrial Efficiency & Decarbonization FOA (ongoing)
- ($156m) FY23 Multi-topic FOA (Industrial Heat Shot)

<u>IHP Connected Programs:</u>

- ($23m) TAPs program (awarded)
- ($70m) ASU EPIXC Institute

Source: https://www.energy.gov/sites/default/files/styles/full_article_width/public/2022-10/IEDO.png?itok=KXBMa0JJ

Highlighted Barriers

Supply Side:

- Workforce gaps
- Intellectual property constraints on IHP components
- Large manufacturers not operating domestically at scale
- Codes and regulatory constraints
- Perceived risk from suppliers, implementers w/out demonstrations/market assessment

Demand Side:

- Limited domestic IHP product availability
- Lack of demonstrated energy/GHG and **cost** savings
- Lack of knowledge of opportunity
- Limited current vendor support for international product
- Need engineering to support implementation and integration at end-user facilities
- Resource adequacy - supply of electricity
- Economic constraints for end-users, large capex investment
- Fuel switching

Ongoing ACEEE Work to Help Overcome Barriers

Supply Side:

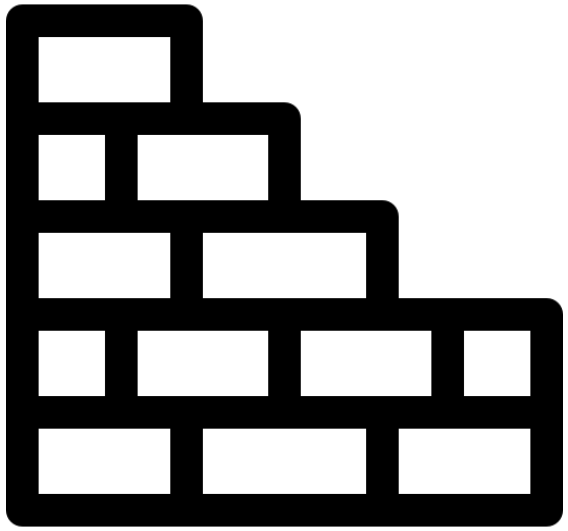
- ACEEE and partners are engaging with DOE, White House, Treasury, and other possible sources of federal funding to:
  - **outline the most significant barriers IHP manufacturers face in increasing domestic production, and possible enablers**
  - connect players with funding opportunities (FOAs) as we gain understanding
- Identifying contacts with IHP suppliers for further collaboration, NEMA
- ACEEE response to RFI on DPA co-funding for heat pumps

Demand Side:

- ACEEE is engaging with utility sponsors, creating IHP pilot projects for end-users in their service territories
- ACEEE is engaging with the Renewable Thermal Collaborative and their network of end-users

*Pilots give proof of concept & build knowledge base in the marketplace for both suppliers and end-users

Where we are



Where we want to go

*Combination of policy action & connection of key supply chain actors

Use of DOE's IACs and TAPs program for implementation assistance and maintenance

Alleviating codes constraints for IHP components and refrigerants

Creation of a national industrial heat pump test facility

Co-funding opportunities for demonstrations

Utility programming in support of IHP implementation

National trainings on opportunities for engineers, others

IHP Alliance

- Assistance with utility program design
- How to leverage state policy
- Utility based pilot projects

*in addition to advocating, communicating policy action

Utilities and Energy Governance Orgs.

- Suppliers Group
- Evaluation of needs, barriers

IHP Manufactures & Suppliers

- Buyers Group
- Evaluation of needs, barriers
- ACEEE training(s) on IHP use

Industrial End-Users

Value chain

- Connection to implementers and integrators (Cascade, FlexTech, Armstrong etc.)
- Connection to technical assistance measures (IACs, TAPs)

Energy Engineers

- Thermal analysis; what are thermal needs of each system? Re-engineering of thermal systems in retrofitting
  - Armstrong International

Next Steps

Understanding of barriers, coalition, alignment on consistent messaging

- ACEEE, NEMA, RTC IHP Alliance
- IHP Workshops at ACEEE Summer Study & EER
- Collaboration with TAPs, EPIXC Institute

Communicating priorities, identifying best pathways for mitigating barriers

- Convening of stakeholders from across IHP value chain
- Public event for stakeholders to commit to accelerating US IHP market

Affecting action, demonstrations, funding

- Congressional briefing/hearing On IHPs
- Advancing installed IHP capacity and pilots, designated demonstration site for key applications

Key Outcomes

Upcoming Events and Resources

- ACEEE IHP report: https://www.aceee.org/research-report/ie2201
- ACEEE IHP website landing page: https://www.aceee.org/industrial-heat-pumps
- RTC industrial electrification report: https://www.renewablethermal.org/electrifying-us-industry/
- RTC suite of three Heat Pump Decision Support Tools: https://www.renewablethermal.org/heat-pump-decision-support-tools/
- Australian Alliance for Energy Productivity's online heat pump estimator: http://www.heatpumpestimator.com/
- LBNL Electrification of U.S. Manufacturing With Industrial Heat Pumps report: https://eta-publications.lbl.gov/sites/default/files/us_industrial_heat_pump-final.pdf
- Next IHP workshop at ACEEE's Energy Efficiency as a Resource Conference in October https://www.aceee.org/energy-efficiency-resource