Threads in the Global Energy Transition

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LEAPS
The Laboratory for Energy And Power Solutions

ASU Driving Innovation to Impact

*ASU is a comprehensive public research university, measured not by whom it excludes but by **whom it includes and how they succeed**; advancing research and discovery of **public value**; and assuming fundamental responsibility for the economic, social, cultural, and overall health of the communities it serves. **Focus on use-inspired research and principled innovation***

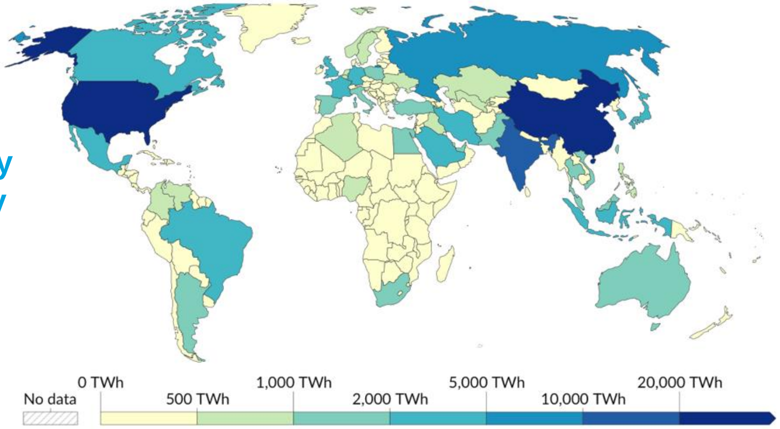
- Largest US university: 181,000 students including 73,000 online and 32,000 engineering students; 5,500 faculty + 5,300 research staff
- Over $880M/yr in research to deployment; 1,550 patents and $1.3B in investment capital over last 20 years
- Commitment to sustainability with world's 1st School of Sustainability
- $6B in utilities infrastructure, own and operate
- 50 MW solar generation, 20 MW combustion turbine, 25 MW combined heat and power (CHP); largest thermal loop in AZ
- Many leading international centers and networks
- Public-private partnerships and networks with utilities, developers, federal and state entities, non-governmental, and non-profits

- **Breadth:** $100M/yr and 1,500 pp in energy Research, Development, Technology Evaluation, Technical Transfer, Pilot Deployment, Policy
- **Reach**: 100+ countries; YouthMappers, DreamBuilder, others

Our Motivations (energy)

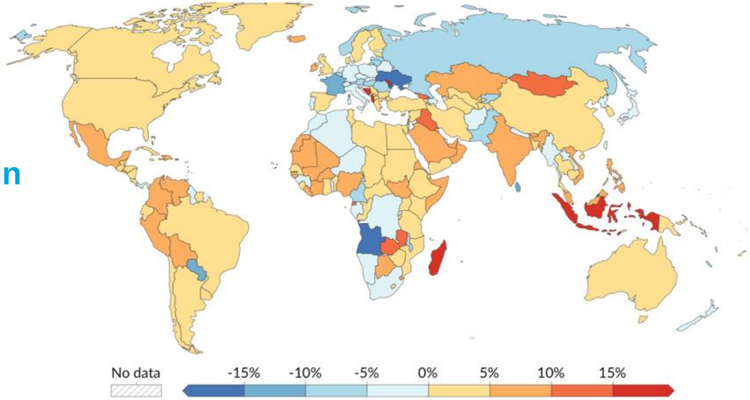
- Rapid load growth
- Universal energy access
- Climate change
- Global security and stability
- Thriving societies
- Resilience and self-reliance

Primary Energy Use



These trends underrepresent the inflection point the world is hastening through, which amplifies uncertainty of potential futures, and we have limited knowledge on how to meet all carbon, social, and economic goals

Change in Primary Energy Use



Data source: U.S. Energy Information Administration (2023); Energy Institute - Statistical Review of World Energy (2023)

Our Work (Our Services)

Education and research have a key role in universities, but humanity needs more to thrive

Solutions Brokering
Stakeholder engagement; co-creating needs and solutions; unlocking transformative collaborations

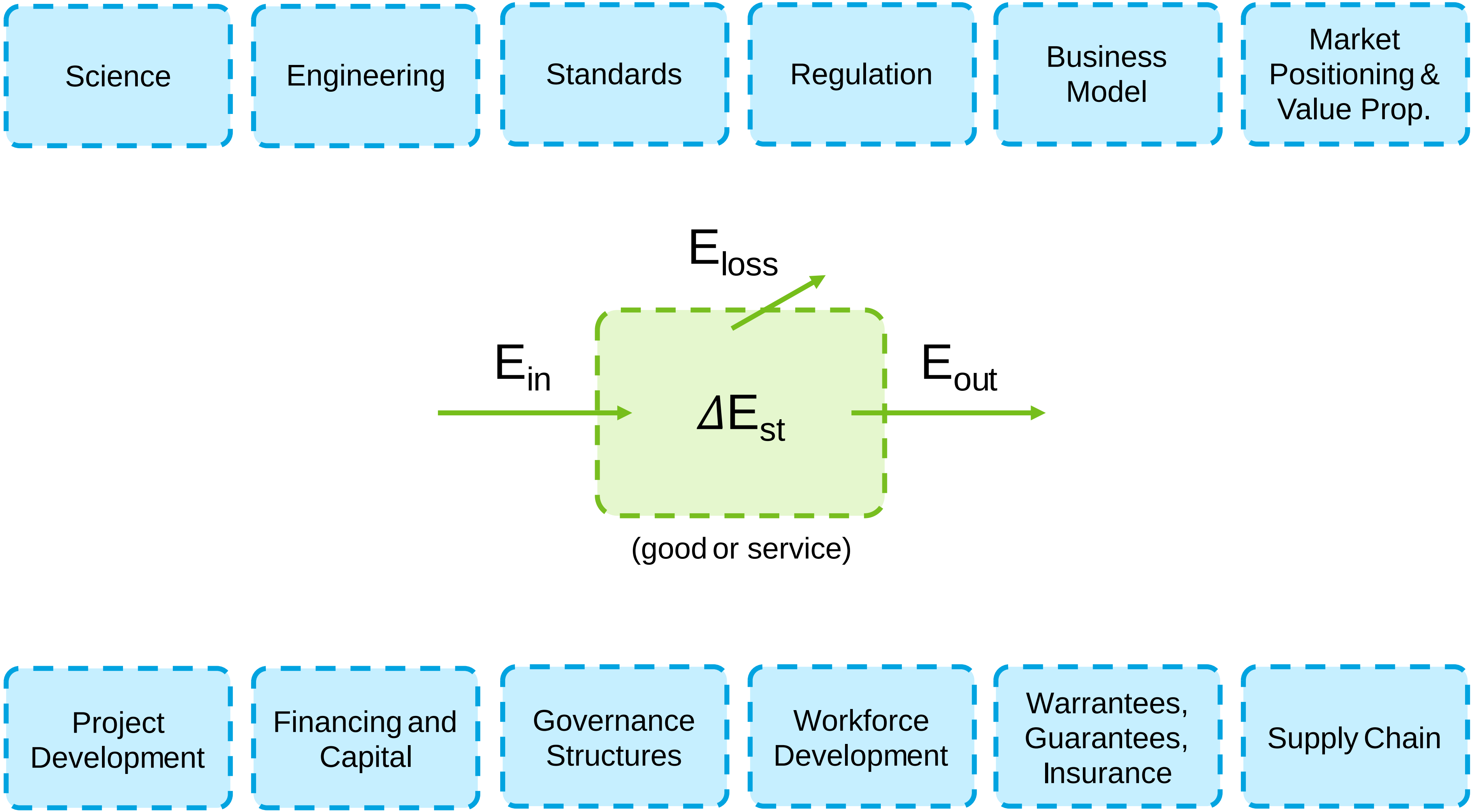
Research and Development
Advancing basic science and applied research to generate inventions and innovations

Master Planning
Defining long-term strategy with immediate actions that build momentum

Demonstration and Evaluation
Testing new technology and completing commercial pilots for on-grid and off-grid systems

Project Development
Partnering from idea to implementation for assessment, design, tender, review, financial close, and construction

Training and Capacity Building
Educating and empowering the workforce; extension services for communities



Science
Engineering
Standards
Regulation
Business Model
Market Positioning & Value Prop.
E_{loss}
E_{in}
ΔE_{st}
E_{out}
(good or service)
Project Development
Financing and Capital
Governance Structures
Workforce Development
Warrantees, Guarantees, Insurance
Supply Chain

Planning for a Net Zero Future in Arizona

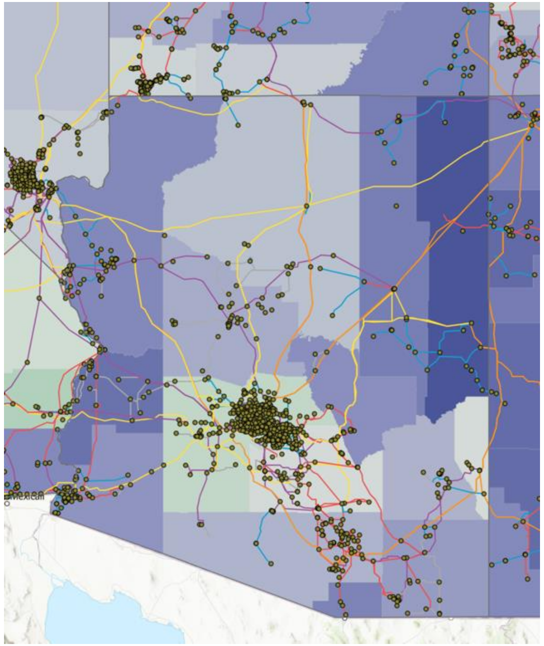
Supporting Arizona's economy while decarbonizing with faster, cheaper, and no-carbon energy sources

Results:

- 4-year effort, 30% complete
- 5 working groups: electrification, transportation, buildings, industry, natural and working lands
- 20+ stakeholder engagement events
- 100+ measures evaluated in Net zero plans by 2050, with ambitious but attainable milestones
- Prioritized low-income and disadvantaged opportunities for cleaner air
- Cost-benefit analysis to prioritize public and private investments

Arizona and Southwest energy infrastructure (lines = transmission) (dots = substations)

LIDAC areas (shaded = income)



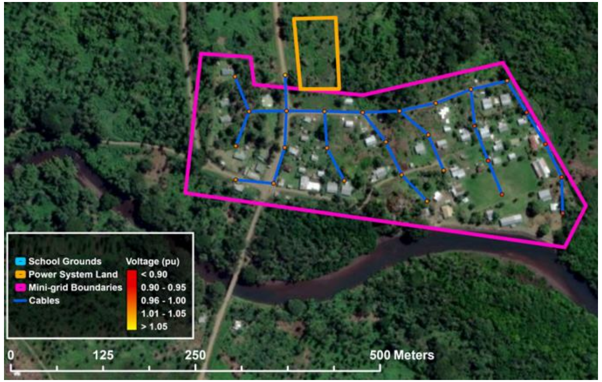
EPA

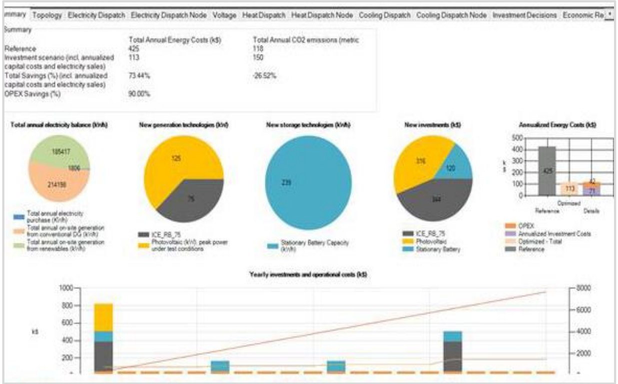
Arizona State University

Accelerating Microgrid and DER assessment to tender

Single process combines analysis of generation, distribution, loads, costs, revenues, financing, tariff analysis, etc.

Up to 80% reduction in design time… and improving.





By the Numbers

- $2 M to develop and demonstrate
- 200+ site designs completed
- 250+ more sites requested
- $134 M implementation funds
- 50 MW capacity planned
- 30,000 people to benefit
- 12 publications, reports, talks

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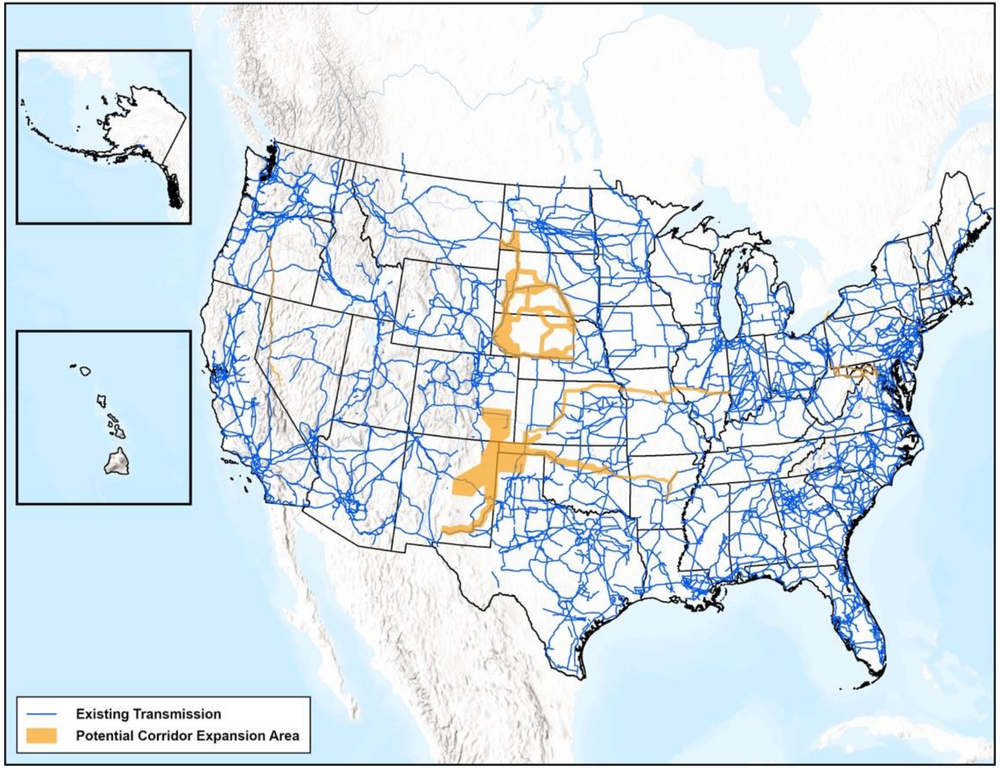
XENDEE

Rapid front-end engineering design for transmission planning



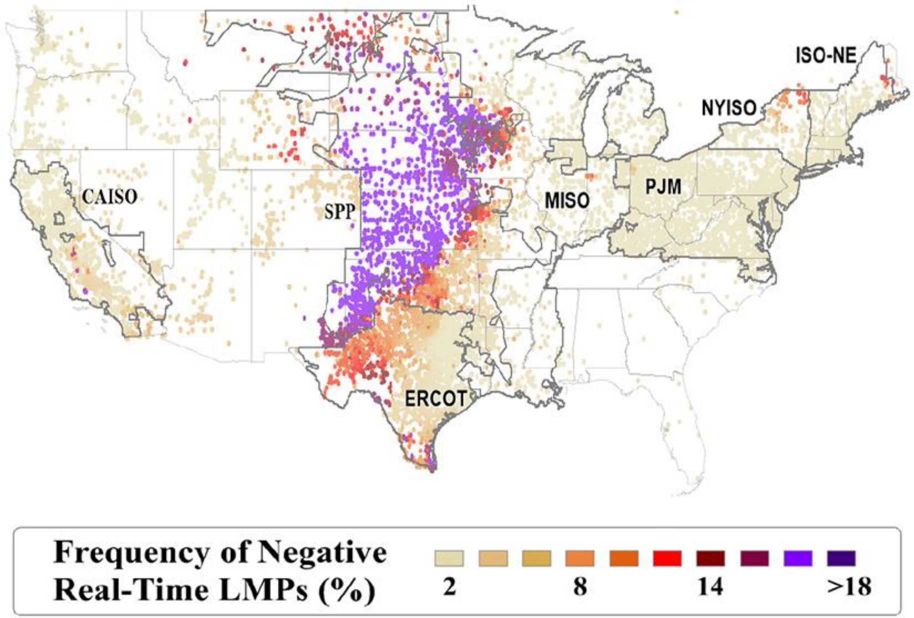
Electricity demand is growing faster than what the sector can (likely) handle

Climate and weather are placing increasing stress on the grid

Need innovation across the sector

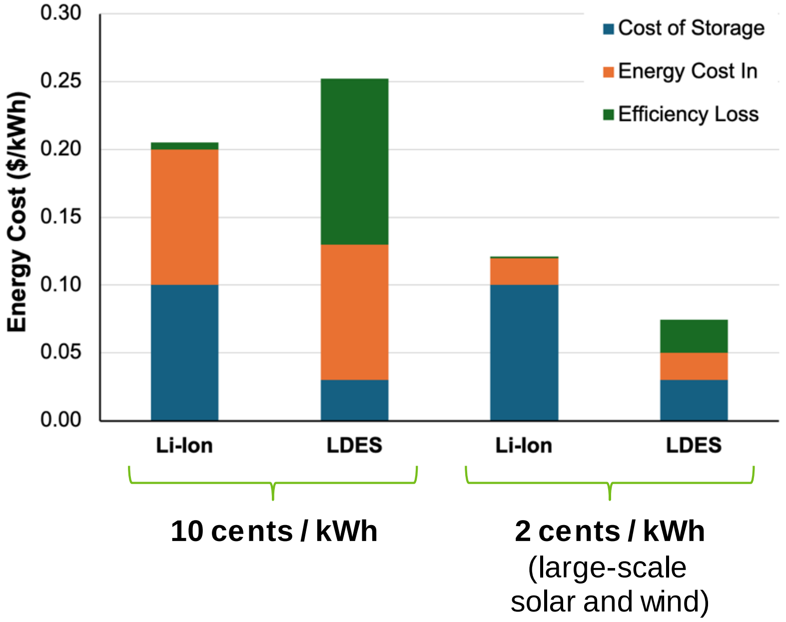
Need more of everything - generation, transmission, distribution, retail services, distributed resources

Long Duration Energy Storage for Renewables and Low Cost



Frequency of negative real-time LMPs in 2021 | ABB Power Grids Velocity Suite

The low efficiency of long duration energy storage (LDES) is less relevant when storage is inexpensive and input energy is cheap/free



Assuming 95% efficiency Li-Ion, 45% efficiency LDES

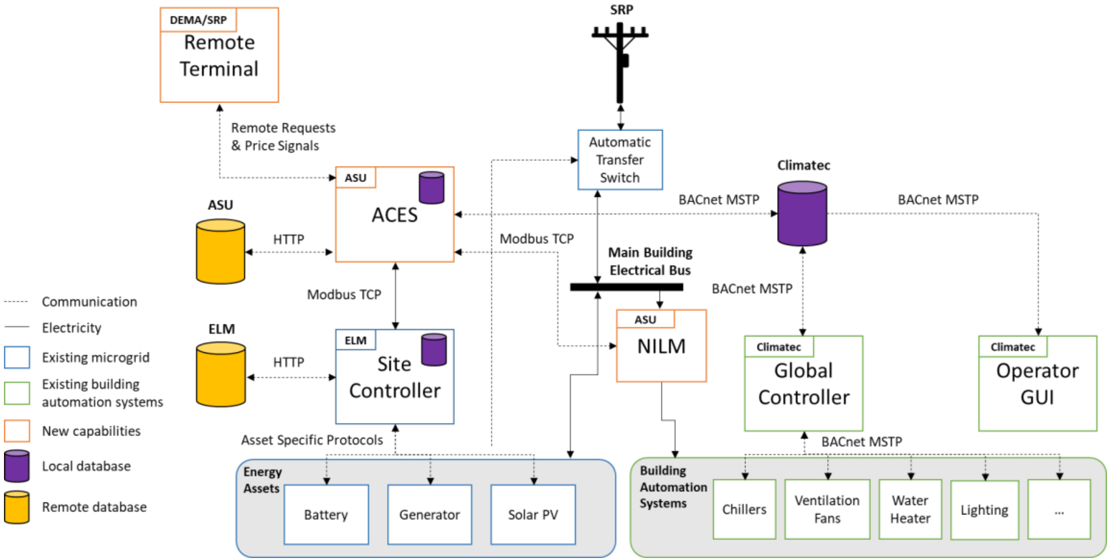
SWSIE

Microgrids and Virtual Power Plants for Critical Services

Creating **"stacked value"** by coupling building automation systems and distribution energy resources, and introducing learning algorithms to adapt controls and circumstances change

Results:

- Military base demonstration
- 350 kW system
- IEEE 2030.7 tests successful
- **10-20% reduction in utility bills**
- **25% improvement in resilience**
- **No *new* capital equipment installed**, just the supervisory controller



ESTCP · Arizona State University · CLIMATEC · ELM · SRP · Arizona Department of Emergency and Military Affairs

Monetizing the Public Value of Microgrids

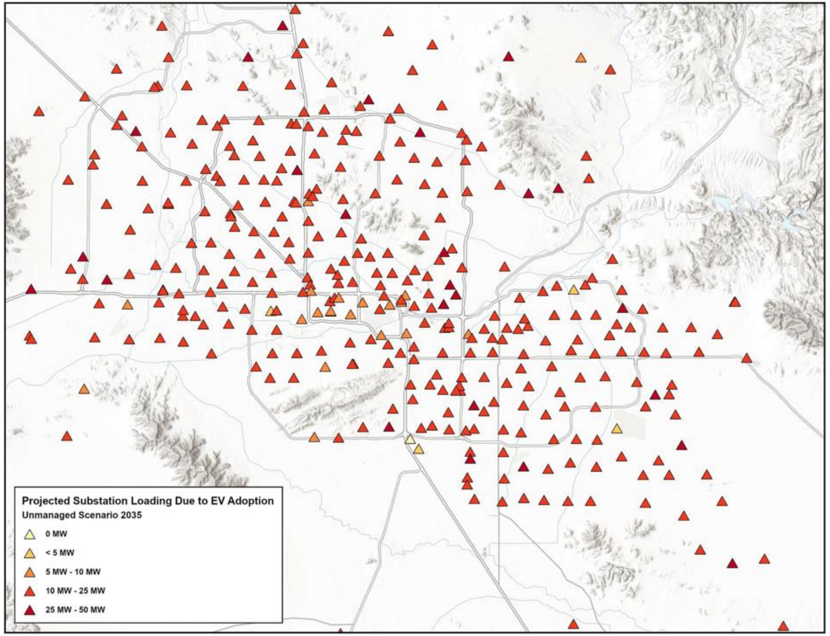
Evaluating the **"public value"** of microgrids and distributed resources to support creation of policy and business models with additional revenue streams for owners/customers

Department of the Navy ONR Science & Technology | United States Marine Corps | MCAS Miramar | California Public Utilities Commission | ASU Arizona State University

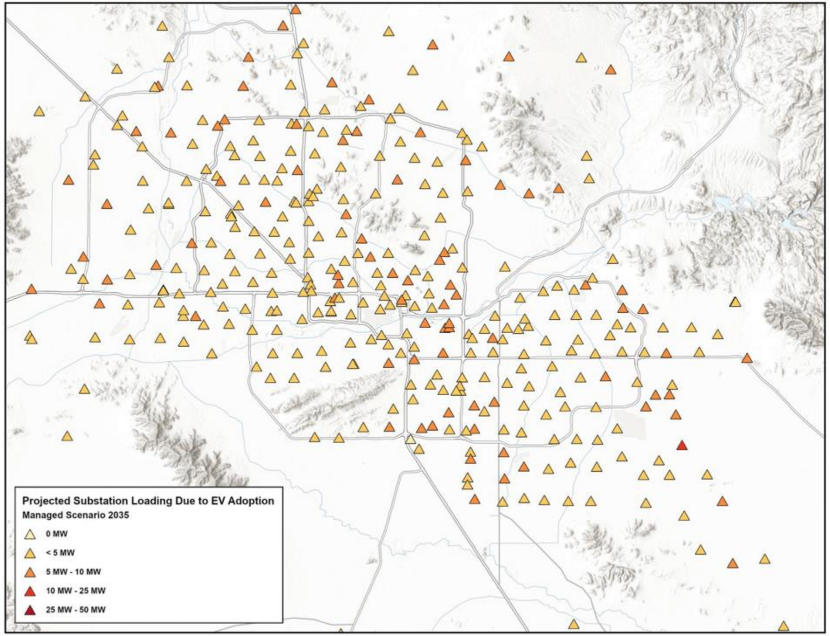
Using managed EV charging to defer infrastructure upgrades

Reducing substation and overall system loading through managed charging, **deferring capital upgrades**

Unmanaged Charging

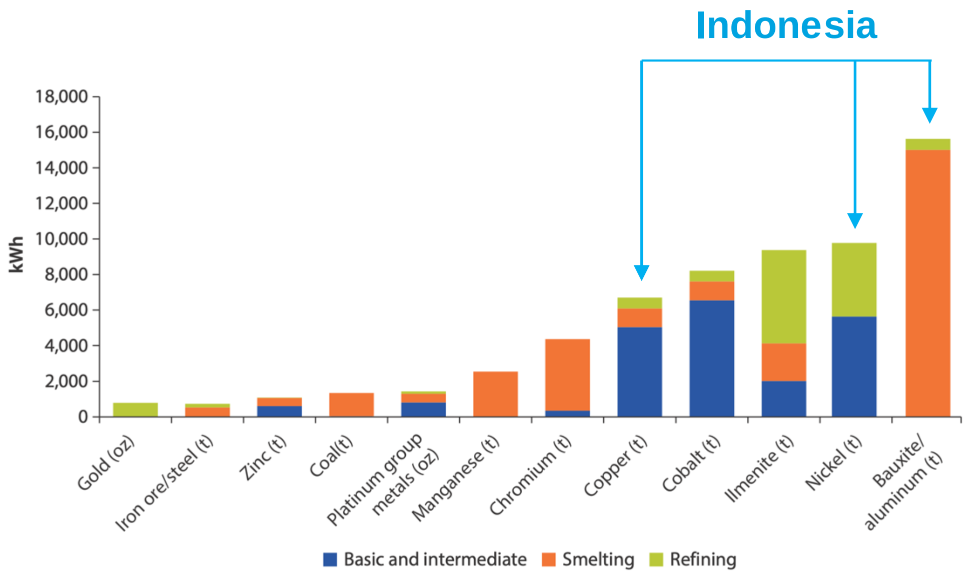


Managed Charging (50% of total)



Decarbonizing Minerals Processing

Energy needed for mineral extraction and processing



Source: USGS 2011, figure from *The Power of the Mine* by The World Bank

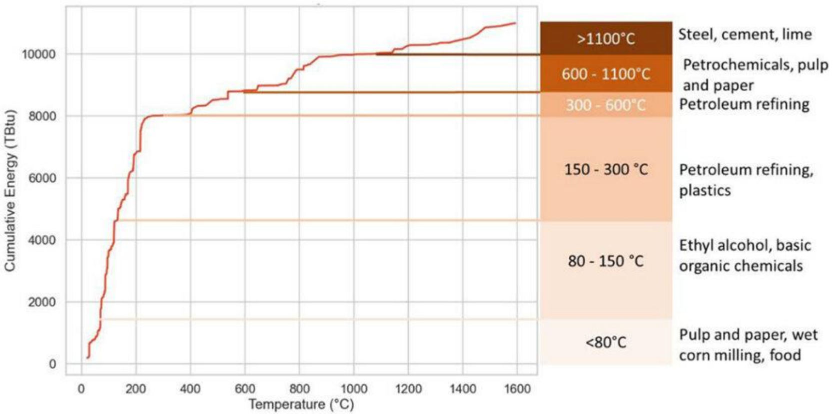
Decarbonizing process heat

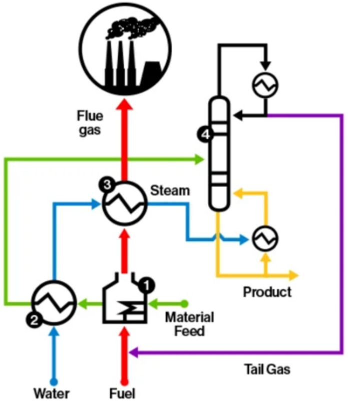
(smelting, manufacturing, and more)

Source: Shutterstock

Electrified Processes for Industry without Carbon

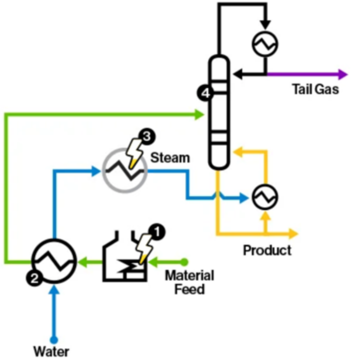
ASU's EPIXC (https://epixc.org) is a catalyst for overcoming key barriers to the implementation of electric heating in manufacturing processes and aims to reduce manufacturing carbon emissions by advancing electric heating technologies, at a systems level, by reducing the levelized cost of electric heat.





Traditional process

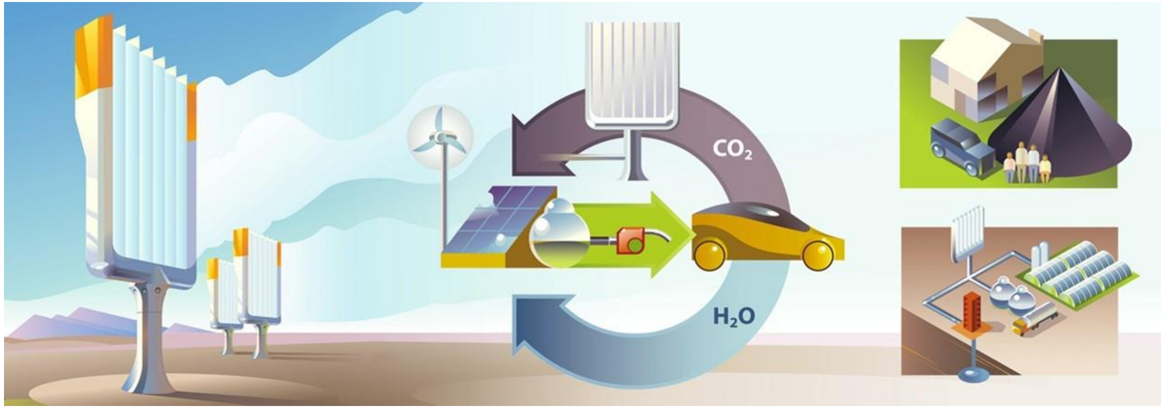
1. Fired furnace reactor
2. Feed effluent heat exchanger
3. Heat recovery
4. Separator



EPIXC process

1. Electrified reactor
2. Feed effluent heat exchanger
3. Electric boiler
4. Separator

Capturing the carbon we cannot mitigate



Carbon Collect Ltd
MechanicalTree™

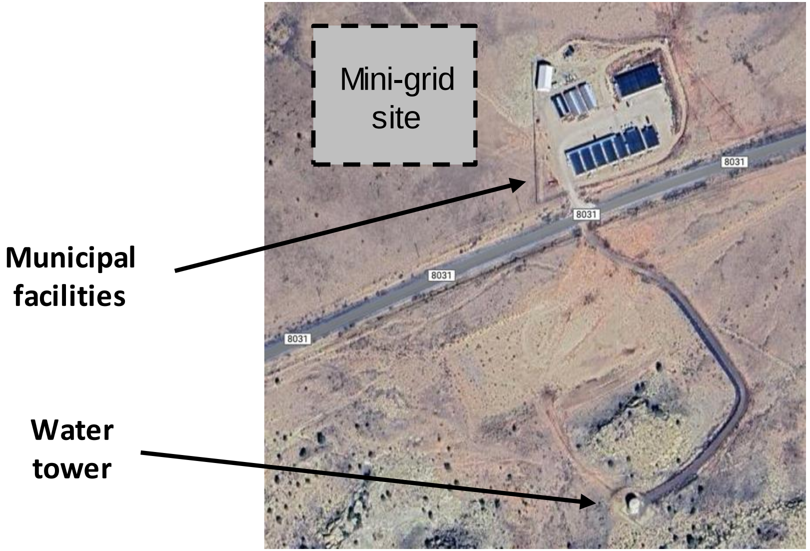
Passive capture from wind
Tonnage scale, 150 disks

Supporting a Just Energy Transition for Tribes

Coal plants are often in small, disadvantaged communities that loose significant revenue when the plant shuts down. Traditional methods of powering indigenous people's remote critical infrastructure with diesel generation is costly, intermittent, complicated, and dirty.

Results (1 of 7 projects with Hopi):

- Municipal services for 6,300 people
- 45% annual cost savings ($716,800 / year)
- 1,250 kW solar + 2,200 kWh / 550 kW battery + 130 kW diesel (replacing 650 kW diesel)
- Stakeholder engagement to understand all community needs and goals
- Mini-grid design for costing and power engineering
- Procurement and construction of solar-battery mini-grid
- Workforce development for managers, installers, technicians, and operators



Arizona State University | HOPI UTILITIES CORPORATION | BOXPOWER | XENDEE

Workforce Development Programs for the New Energy Economy

Provide training for managers, engineers, operators, and technicians in advanced energy technologies and cybersecurity, with options for certifications and CEUs. 1000 pp/yr

Microgrid Development Process:

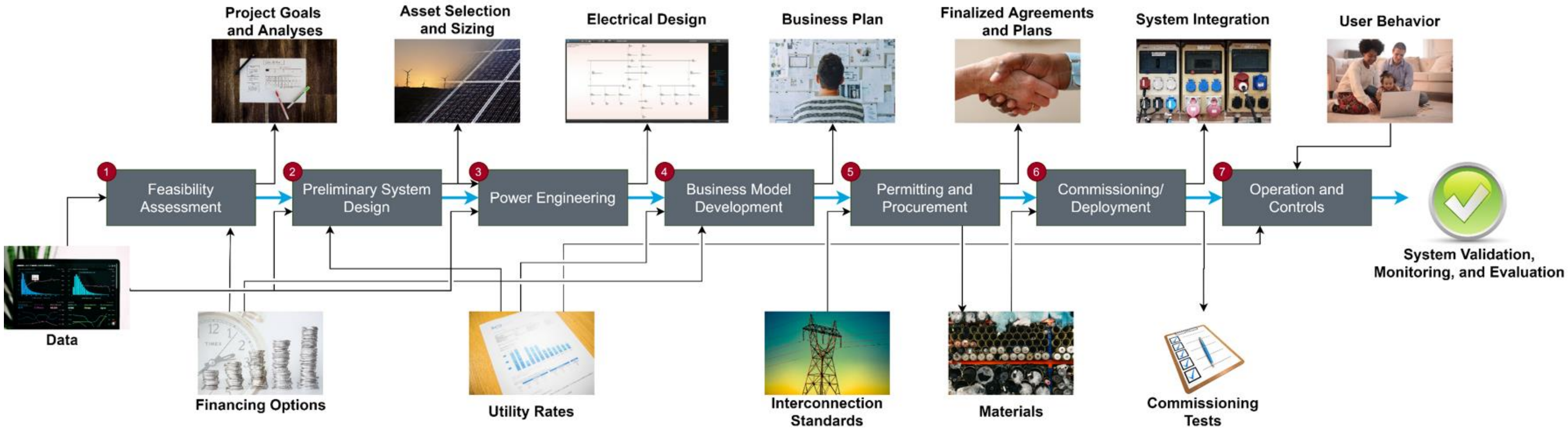
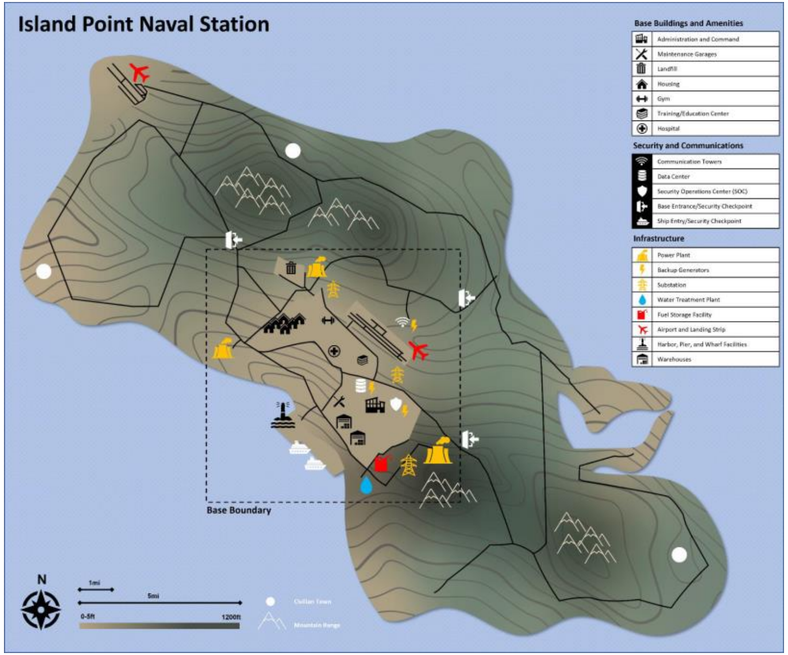
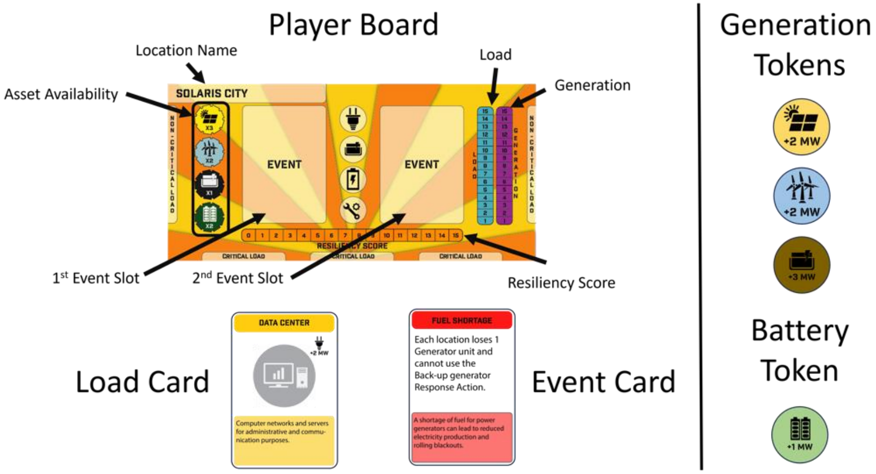


Table top exercises

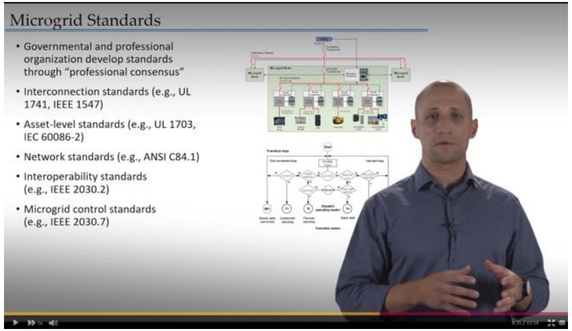
Interactive game-based training





Hand-on training and simulation

Virtual real-time or self-paced

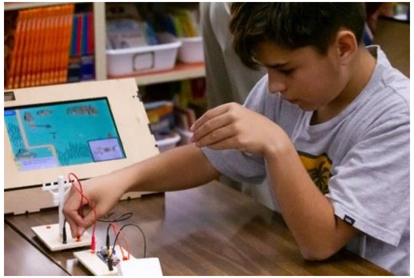


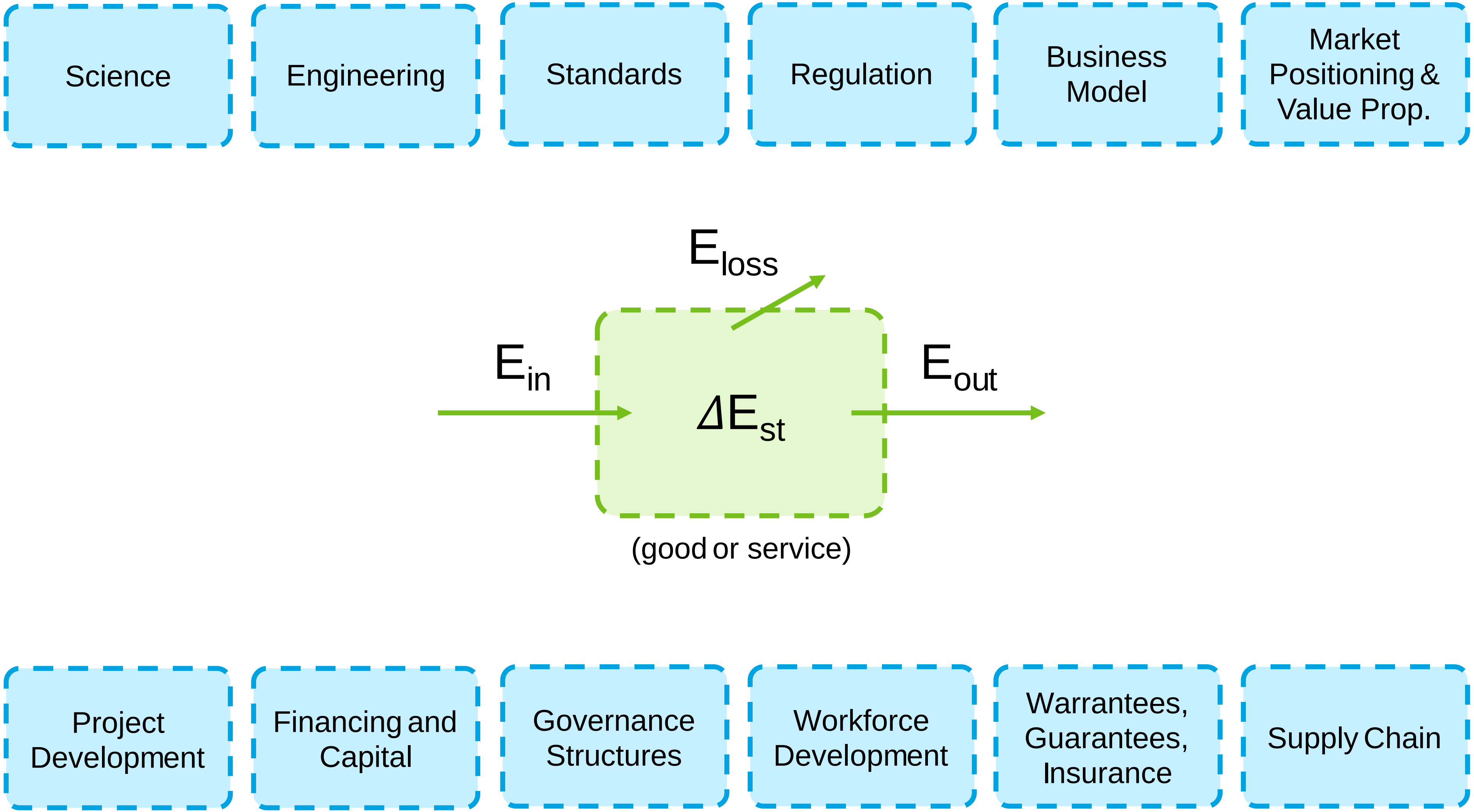
The hardware shown in the image above is used for... (Select all that apply.)

- [ ] Bringing the output of several strings of solar panels together to be connected to an inverter
- [ ] Connecting multiple loads to a power source
- [ ] Protecting expensive transmission equipment from excessive current
- [ ] Integrating large systems with three or more inputs
- [ ] Small or remote connections

Cybersecurity

K-12 engagement

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