Organizational Structure

Storage Century Challenge
Organizational Structure

- RTIC
  - Energy Storage Subcommittee
    - **Executive Champions**
      Paul Dabbar (S4), Bruce Walker (OE), Lane Genatowski (AR)
    - **Executive Committee**
      Co-chairs: Alex Fitzsimmons, Michael Pesin
      - **Technology Development** [Storage | Power Elect.] (Eric Hsieh, OE)
      - **Technology Transition** (Marcos Gonzales, OTT)
      - **Policy and Valuation** (Alejandro Moreno, EERE)
      - **Domestic Manufacturing and Supply Chain** (Valri Lightner, EERE)
      - **Workforce Development** (Linda Horton, SC)

DOE

Policy and Valuation: Purpose and Rationale

Provide tools, analysis and recommendations that maximize the value of energy storage to the electric and transportation systems and drive U.S. leadership in storage innovation, manufacturing, and commercial use.

Why does policy and valuation matter to storage?

Energy storage has the potential to offer significant value to the U.S. economy as both an end-use product and a source of industrial competitiveness.

But there are substantial barriers that prevent the full realization of that value and could slow the growth of the sector that require new policies, regulations, and analytical understanding to overcome.

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Policy and Valuation: Getting Policies and Regulations Right

Policies are limited by incomplete understanding of:

- **What can storage do?** Technical capabilities and lifecycle costs
- **What is it worth?** The value of different services under different conditions
- **How to integrate, operate, and pay for it?** Planning, operation and compensation of storage in the power system

Who does this affect?

PUCs	ISO/RTOs	States	Utilities
Developers	Consumers	Manufacturers	DOE

What is the result? Rules and policies that limit the value, compensation, and deployment of storage

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Policy and Valuation: DOE Role

DOE has the analytical capabilities, data and computing resources, and institutional credibility to inform more effective and cost effective policy and regulatory decisions.

Caveat: DOE does not make policy, but offers policymakers the tools to most effectively meet their own policy and regulatory goals.

But -- in order to be effective, DOE policy and valuation support must be:

- **Targeted** at the most pressing policy barriers or regulatory challenges, and the specific information gaps that prevent them from being addressed
- **Systematic** in proactively working with decision-makers to identify and provide all the information needed to enable effective decisions, rather than ad hoc support for targets of easiest opportunity.
- **Coordinated** across relevant offices in DOE, to ensure the right areas of expertise are applied to a given question and avoid conflicting information on a given topic.
- **Informed and objective**, with support to decision-makers closely linked to the analysis informing it and avoiding any appearance of supporting one technology or office's mission over another's.

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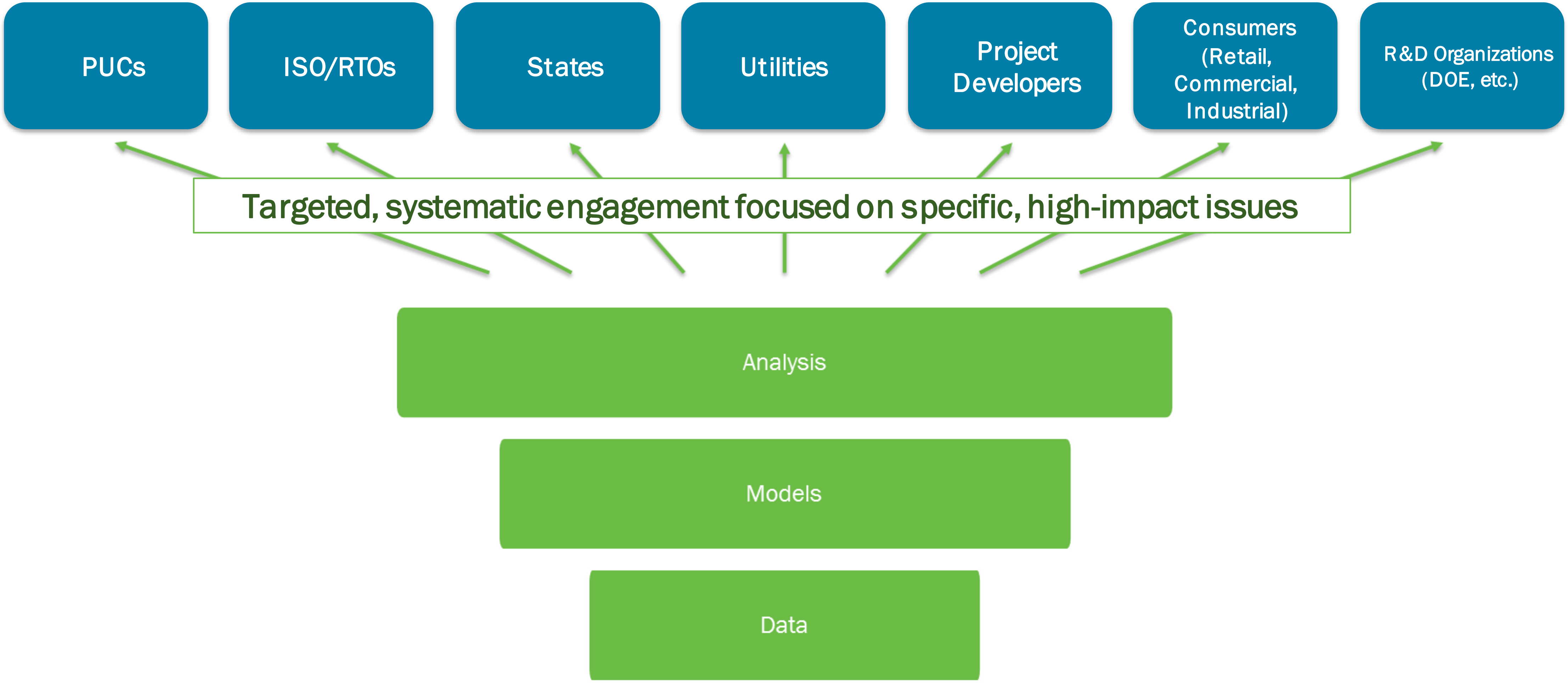
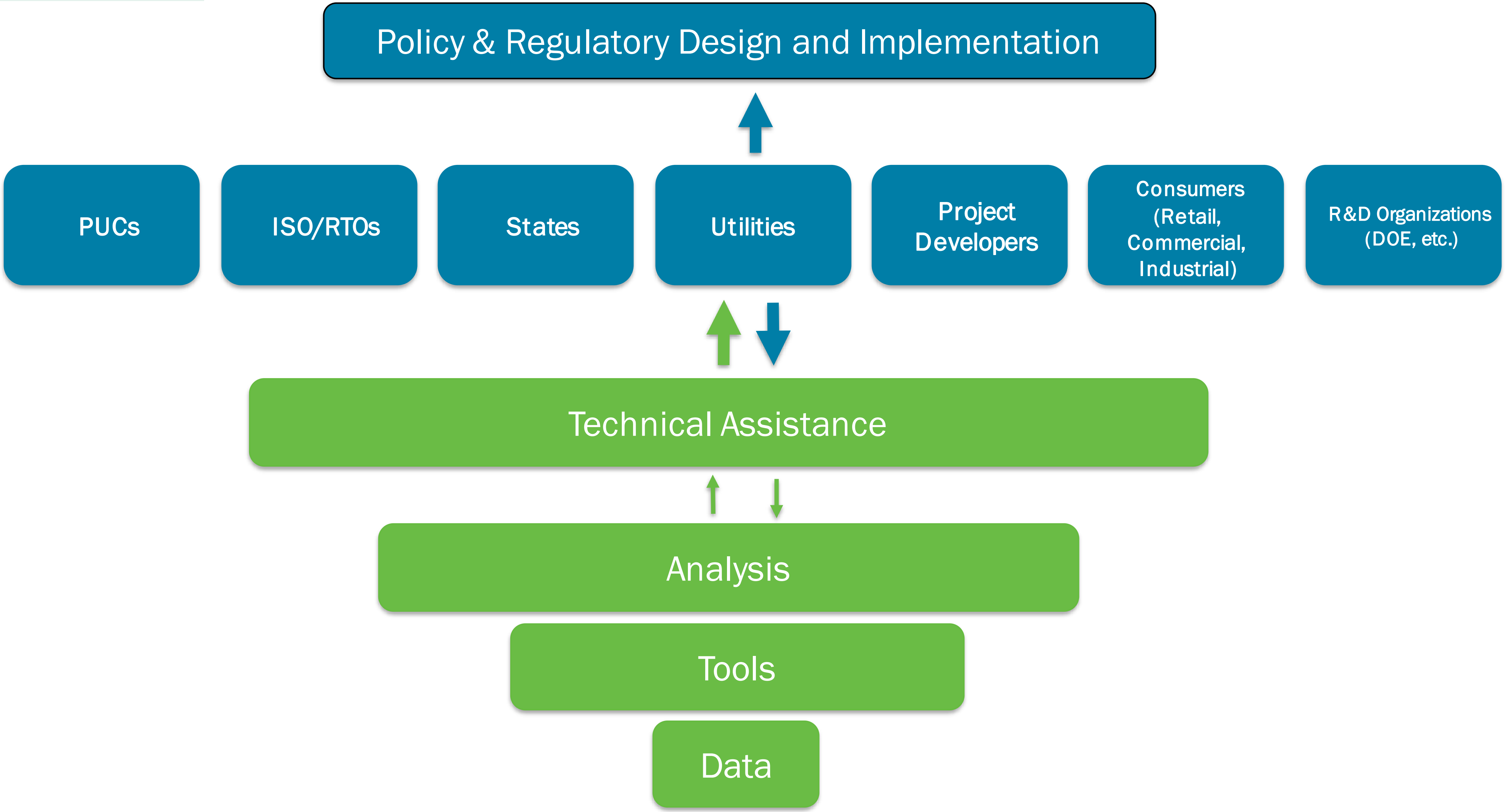
Policy and Valuation: DOE Role - Delivery

How can these products be delivered? Systematic <u>policy support and technical assistance</u> to critical organizations, supported by best-in-class <u>analysis</u> based on up-to-date <u>data</u> and improved <u>models</u>



Goal: Improve energy storage policy, regulations, and decision-making by providing coordinated technical assistance informed by cutting-edge data, tools, and analysis



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Policy and Valuation: Existing DOE Work (Examples)

Implementation – DOE has many efforts that can help address these challenges – some examples:

OE Storage Regulatory Engagements and TA

- Informational workshop and technical assistance to states evaluating energy storage deployments.
- TPTA Technical Assistance Program

OE Storage Analysis

- Analytic tools for utilities and regulatory agencies to facilitate planning and implementation of energy storage in transmission and distribution infrastructure.

GMLC Analysis and Institutional Support

- Institutional support framework for PUCs, ISOs/RTOs
- Framework for valuation of grid services, grid architecture
- Demonstration of storage contribution to black-start (Plum Island)

EIA

- Improved representation of storage in capacity expansion models
- Annual Energy Outlook

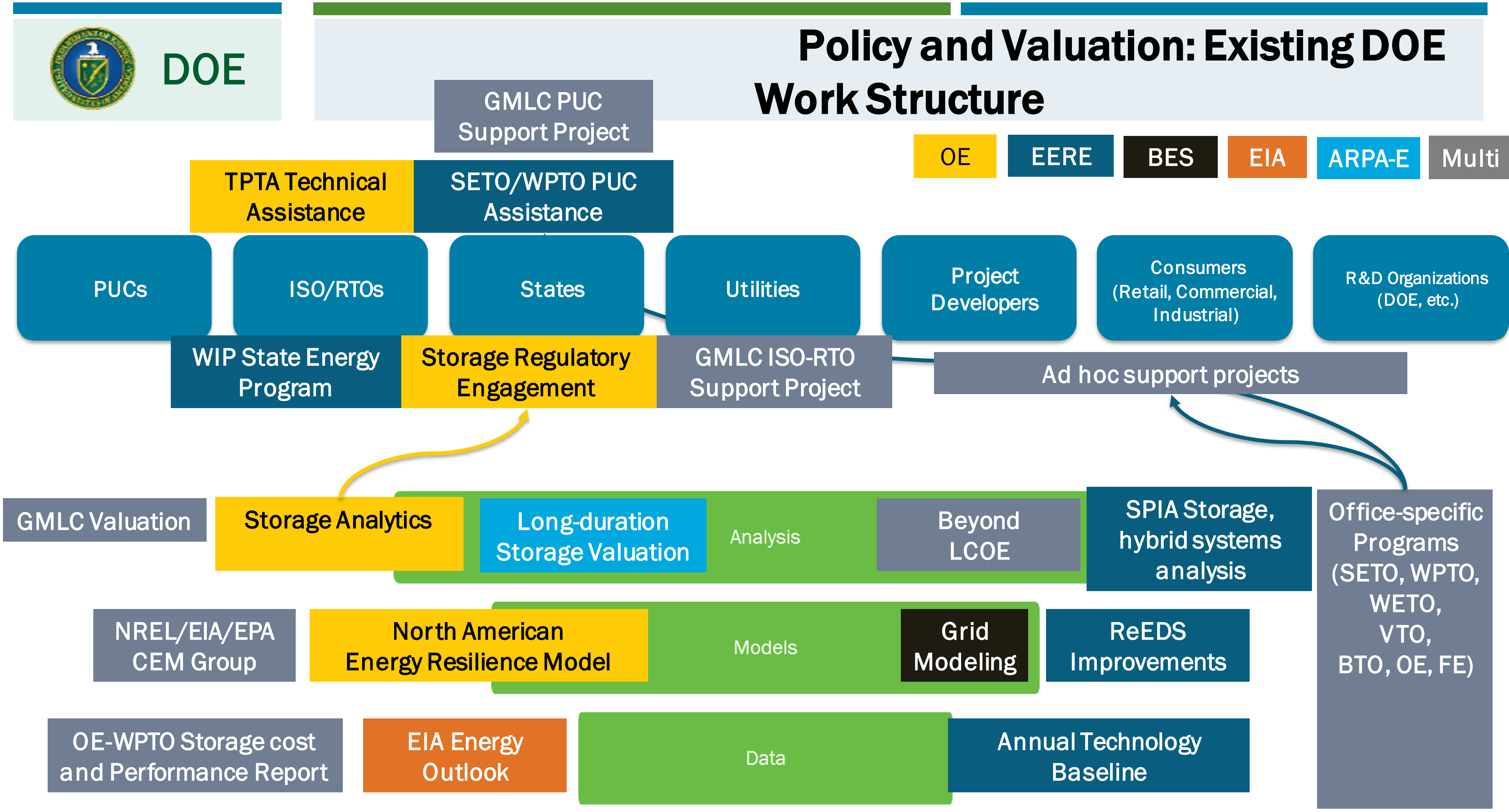
EERE Strategic Programs (SPIA) Analysis

- Improved representation of storage in capacity expansion models
- Evaluation of long duration storage, hybrid systems • Storage futures study • Annual Technology Baseline

Individual EERE Offices

- Solar: Solar + storage for resilience; Integration costs of BTM storage + PV; SHINES demo projects
- Hydro: Storage data (w OE); valuation guidelines/tool for PSH; storage in power models; hydro in micro-grids, hydro + batteries;
- Fuel Cells: H2@scale for grid storage; • Wind: grid services from grid and utility-scale wind + storage • OWIP: State Energy Program

Policy and Valuation: Existing DOE Work Structure



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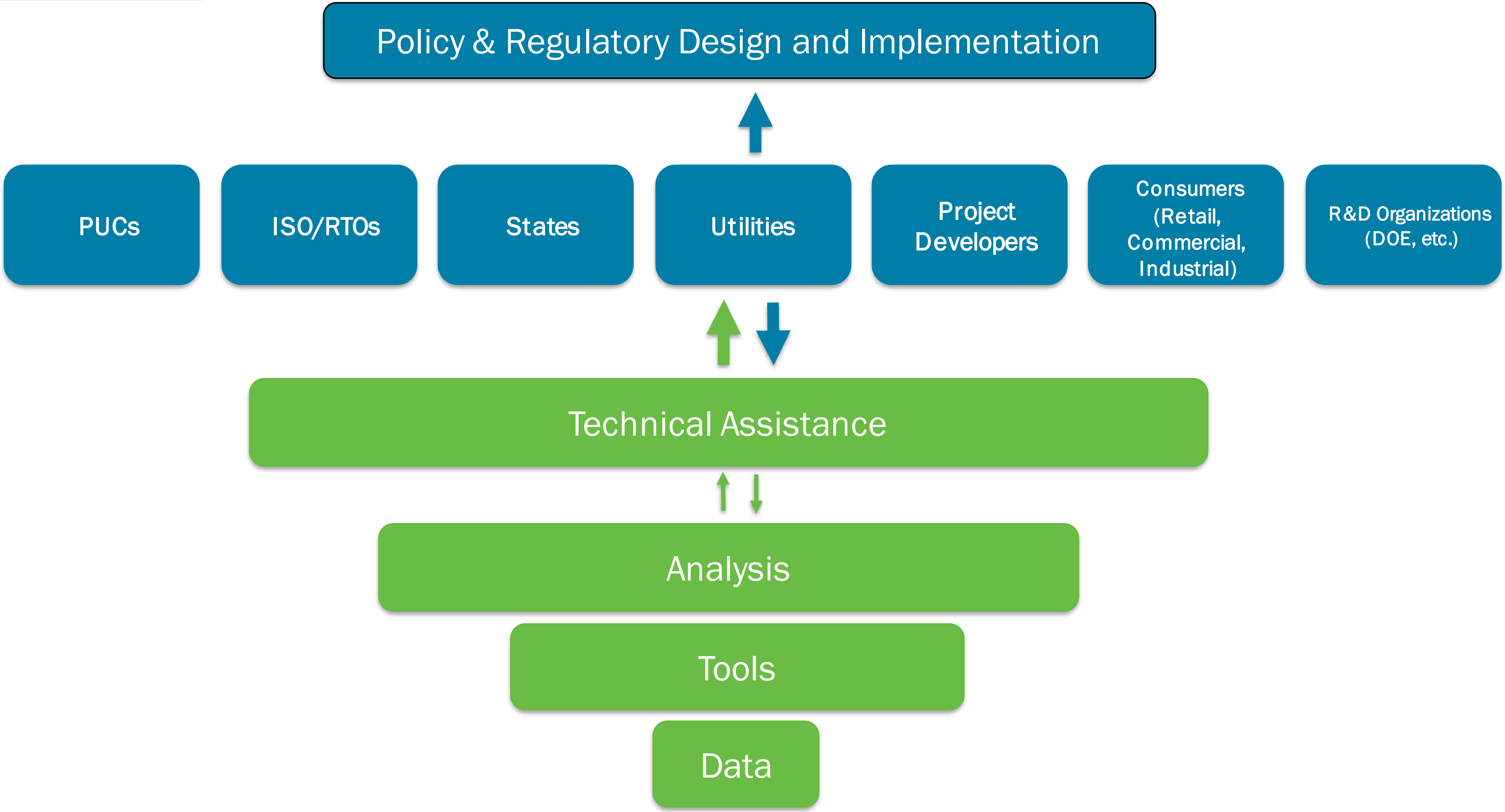

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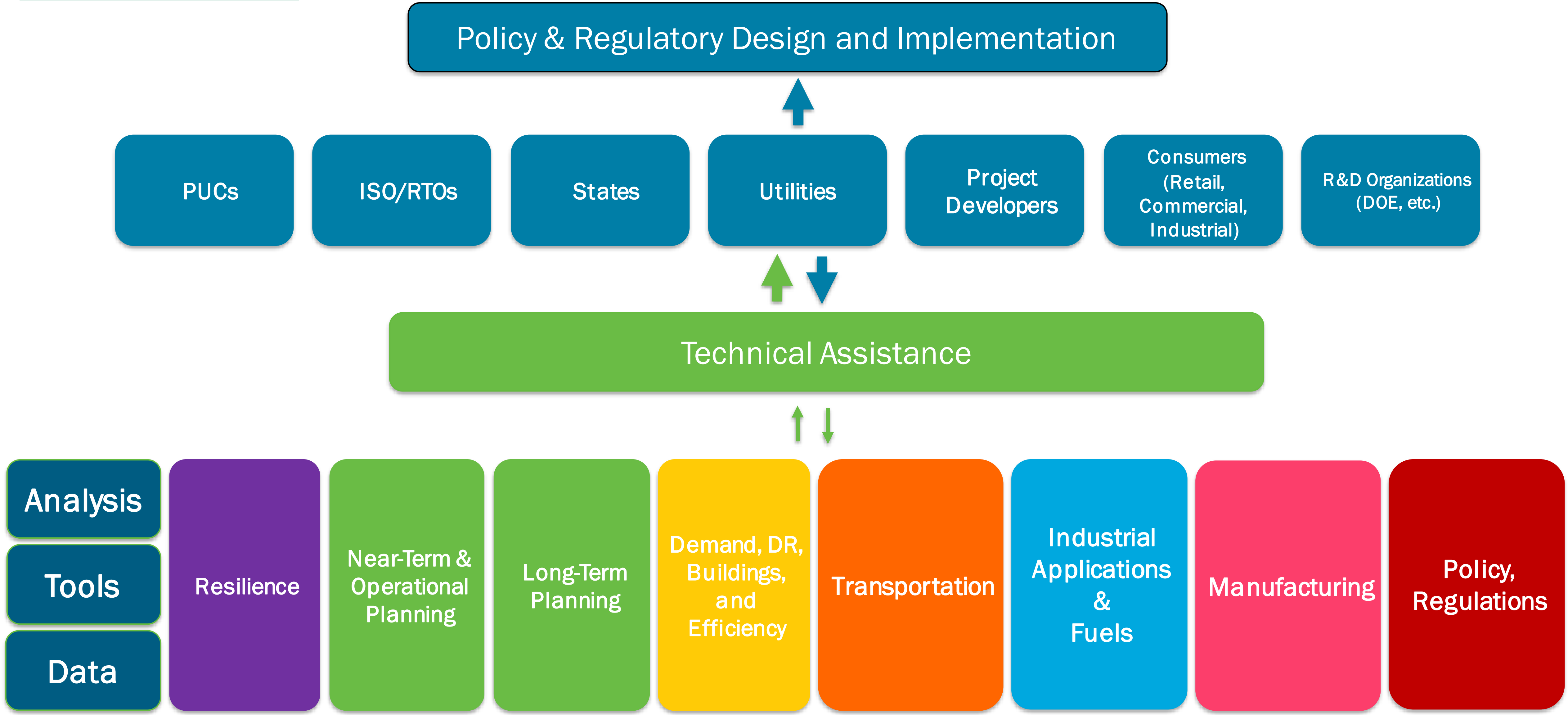

Resilience

Research Needs:

Analysis	Long-term	• How can storage improve the resilience of the overall energy system under a variety of future threat, grid mix, grid architecture scenarios?
	Near-term	• How is resilience valued by different customer types? • Can storage systems cost-effectively provide black-start, other resilience services given different system configurations and threat types?
Tools		• Infrastructure & Grid System Resilience Models (NAERM) • Microgrid & Facility Optimization Tools • Outage Cost Calculator • Resilience Value Methodology
Data		• Energy Storage Cost , Performance, Financing • Threat Probability (including cyber) • Outage Duration & Cost • Willingness-to-pay • System/facility characteristics and requirements

Gap: The value of bulk and distributed storage resources to power system resilience is poorly understood

Outcome: Limited understanding of resilience may lead to underrepresentation of storage in power system planning, insufficient compensation for storage systems, and regulations that do not encourage optimization of storage for system resilience

Stakeholder Impacts:

- **PUCs/ISOs:** Develop regulations, rules, market products that artificially limit storage's contribution to resilience
- **Utilities:** Storage is not included in IRPs, or is incorporated in ways (e.g. size, location, operations) that do not reflect its resilience value
- **Developers:** Lack of compensation for resilience value leads to under-deployment and limited resilience benefits
- **DOE & R&D Organizations:** Reduced investment in technologies and configurations that maximize resilience

Assessing energy storage's contribution to system resilience requires understanding each technology's technical characteristics, its ability provide resilience services, and the value of those services under a wide range of power system conditions, structures, and generation/load mixes.

Long-term Planning

Research Needs:

Analysis

Long-term

- How much, where, and at what duration will storage be needed in future grid scenarios?
- How will DER adoption impact bulk-side investment requirements?

Near-term

- Assess how the technical characteristics of long-duration storage technologies should be valued in long-term planning tools?
- Deployment and value of storage technologies in long-term planning processes using imperfect foresight and stochastic optimization

Tools

- Capacity & Transmission Expansion Models (ReEDS, PSS/E)
- Dispatch/ Production Cost Models (PLEXOS, PROMOD)
- DER Adoption Models (dGEN, DER-CAM)
- Demand & Flexibility models (dsgrid)

Data

- Future Storage Cost, Performance, and Financing Projections
- Market Rules, Policy, and Incentive Data
- Distribution & Transmission System Data
- Spatial &Temporal Demand Projections

Gap: The full variety of storage technologies are not adequately represented in long-term planning tools.

Outcome: Unable to assess if storage (especially long-duration storage) can enable reliable and cost-effective grid operation in future scenarios that may have higher penetrations of variable renewable electricity.

Stakeholder Impacts:

- **PUCs/ISOs:** Develop regulations, rules, market products that artificially limit storage's deployment
- **Utilities:** Do not invest in the right types or the right amount of storage
- **States:** Fail to meet policy objectives in a reliable, cost-effective way
- **DOE & R&D Organizations:** Unable to effectively prioritize storage R&D investments that can provide the most future impact

Understanding how much, what types, and the locational value of energy storage in future scenarios requires the full variety of behind-the-meter and utility-scale storage technologies to be included in long-term planning tools.

Demand, DR, Buildings, and Energy Efficiency

Research Needs:

Analysis	Long-term	• How can changes in long-term energy demand projections impact the amount of storage needed and its value?
	Near-term	• How can grid interactive buildings compliment or compete with storage? • How will changing patterns of human behavior impact the energy demand and the ability for demand sides resource to provide flexibility to the grid?
Tools		• Demand Profile and Flexibility Models • Building Models (EnergyPlus, Scout) • Stock Turnover • Cost-effectiveness methodology
Data		• Spatial &Temporal Demand Projections • Consumer Behavior • Technology Performance Characteristics • Cost and Avoided Cost Data

Gap: Storage is often not assessed relative to other technologies that can provide flexibility or under scenarios with varying demand.

Outcome: Unable to determine when and where storage can provide the most value, or if it is the most cost-effective solution for a given facility, portfolio of facilities, or for grid relative to other alternatives.

Stakeholder Impacts:

- **PUCs/ISOs:** Develop regulations, rules, market products that artificially limit either storage or demand side flexibility resources to provide services and be appropriately compensated
- **Utilities:** Do not invest in the most cost-effective flexibility solutions, overcharge consumers
- **States:** Fail to meet policy objectives in a reliable, cost-effective way
- **Consumers:** Unable to effectively prioritize storage relative to other technology alternatives

It is imperative to understand what factors drive energy demand changes and consumer behavior patterns related to demand side flexibility in order accurately estimate how much storage the grid may need and whether it is cost competitive with other flexibility alternatives.

Technical Assistance

ISO/RTOs Technical Assistance	Utility Technical Assistance	Public Utility Commission Technical Assistance	State Legislatures Technical Assistance	State Energy Offices Technical Assistance	FERC Technical Assistance	Congressional Technical Assistance	Local Community Technical Assistance	DOD Technical Assistance

Universally Applicable Technical Assistance

	Demand, DR, Buildings, EE	Operational Planning	Long-term Planning	Resilience	Transportation	Industrial & Other Fuels	Manufacturing	Policy
Analysis – Long-term	How can changes in long-term energy demand projections impact storage?	Can storage defer or eliminate new T&D investments ?	How much storage will be needed under evolving grid conditions?	Can storage improve the resilience of the overall energy system?	Can EVs (V2G) provide aggregated storage services to the grid?	How would increased H2 production impact the price and demand of other fuels?	What industrial policies could increase domestic storage manufacturing?	Should storage be embedded in the grid and have its costs socialized?
Analysis – Near-term	How can grid interactive buildings compliment or compete with storage?	How can storage optimize dispatch and system stability?	How can storage optimize dispatch and system stability?	How can storage cost-effectively minimize outages at critical facilities?	Can storage mitigate the potential impacts of EV charging on a given distribution system?	Can storage improve the efficiency and reduce the cost of industrial processes?	What are the bottlenecks of lithium-ion supply chain?	What could be the impact of storage ITC?
Tools	Demand Profiles & Flexibility Models Building Models Stock Turnover Cost-effectiveness Methodology	**Distribution:** Distribution Feeder Models; Distribution Power Flow **Bulk:** Plant Optimization; Dispatch Models Behind-the-meter and utility-scale storage valuation methodologies	**Distribution:** DER Adoption **Bulk:** Capacity & Transmission Expansion Behind-the-meter and utility-scale storage valuation methodologies	Infrastructure & Grid Resilience Models Microgrid Optimization Tools Outage Cost Calculator Resilience Value Methodology	Transportation Systems Models Chagrining/Fuel Infrastructure Models Vehicle Adoption Models Mobility Flow Value Methodologies	Cross-sectoral equilibrium models Integrated Industrial-Storage Models Value of New Fuels (H_2, NH_3, etc.) Methodologies Industrial Storage Application Methodologies	Supply ChainTools Material Flow Tools Process Efficiency & Competitiveness Methodologies	Rate Impact Tools Rate Impact Methodologies
Data	Consumer Behavior Spatial & Temporal Demand Tech Performance Cost & Avoided Cost	Current Spatial & Temporal Demand Current BTM & Utility Scale Tech Cost, Performance, and Finance	Future Spatial & Temporal Demand Future BTM & Utility Scale Tech Cost, Performance, and finance	Microgrid Data Willingness-to-Pay Threat Probability Outage Cost & Duration	Technology Penetration Infrastructure Spatial & Temporal Demand Vehicle & Subcomponent Cost	Production Cost Characteristics of Novel Fuels Industrial Process Demands (Thermal & Electrical) Industrial Processes & Fuels Costs	Competitiveness Critical Minerals Process Efficiency Cost	Safety & Codes Federal Policy Industrial Policy Cyber Policy Market Rules Procurement Polices Taxes & Incentives

DOE

Extras

Near-term and Operational Planning

Research Needs:

Analysis

Long-term

- Can storage defer or eliminate new T&D investments?
- How can storage optimize dispatch and system stability?

Near-term

- How do different technical characteristics and systems configurations change the dispatch and operational profiles of storage technologies?

Tools

- Dispatch/ Production Cost Models (PLEXOS, PROMOD)
- Power Flow & System Stability Models (Open DSS, PSLF, PSS/E)
- Distribution Systems Models (SMART-DS)

Data

- Storage Performance Characteristics
- Current Storage Technology Cost
- Distribution & Transmission System Data
- Spatial & Temporal Electricity Demand

Gap: The value of bulk and distributed storage resources to power system resilience is poorly understood

Outcome: Limited understanding of resilience may lead to underrepresentation of storage in power system planning, insufficient compensation for storage systems, and regulations that do not encourage optimization of storage for system resilience

Stakeholder Impacts:

- **PUCs/ISOs:** Develop regulations, rules, market products that artificially limit storage's contribution to resilience
- **Utilities:** Storage is not included in IRPs, or is incorporated in ways (e.g. size, location, operations) that do not reflect its resilience value
- **Developers:** Lack of compensation for resilience value leads to under-deployment and limited resilience benefits
- **DOE & R&D Organizations:** Reduced investment in technologies and configurations that maximize resilience

Storage technologies' dynamic performance characteristics need to be incorporated into near-term operational planning tools so developers and planners can assess behind-the-meter and utility-scale storage's ability to improve dispatch and power flow while minimizing system costs.

Transportation

Research Needs:

Analysis

Long-term
- Can EV and/or fuel cell vehicles (V2G) provide aggregated storage services to the grid?
- Can transportation storage assets increase grid resilience?

Near-term
- Can storage mitigate the potential impacts of EV charging on a given distribution system?
- What is the cost relationship between power sector storage and transportation storage?

Tools
- Transportation System Models (TEMPO)
- Chagrining/Fueling Infrastructure Models (EVI-Pro)
- Vehicle Adoption Models (MA3T, ADOPT)
- Mobility Flow Model
- Value to Grid Methodology

Data
- Technology Penetration
- Charging/Fueling Infrastructure Characteristics
- Spatial and Temporal Charging/Fueling Demand
- Vehicle and Subcomponent Performance
- Vehicle and Subcomponent Cost

Gap: Lack ability to quantify the potential amount and value of services that transportation storage assets (EVs/fuel cell vehicles) can provide to the grid

Outcome: Fail to remove initial obstacles for V2G interactions and consumers/utilities are unable to utilize EVs or fuel cell vehicles as a storage resource for the grid thereby increasing system and consumer costs

Stakeholder Impacts:

- **Manufactures:** Do not resolve warranty issues that prevent consumers from using EVs or fuel cell to provide grid services
- **Utilities:** Vehicle-to-grid potential is not included in IRPs, forcing the procurement of otherwise unnecessary capacity
- **PUCs:** Unable to assess what benefits and costs of different V2G mechanisms
- **Consumers:** Inability to be compensated for potential services to the grid, reduces the value of EVs and fuel cell vehicles, and decreases vehicle deployment

Developing methodologies and tools that can quantify the potential value that transportation-related storage assets (EVs, fuel cell vehicles, etc.) provide the grid is crucial if we want to maximize the value of existing storage assets and diversify the types of storage available to grid.

Industrial & Other Fuels

Research Needs:

Analysis	Long-term	• How would increased H_2 or other fuel production impact the price and demand of other types of energy? • How could legacy infrastructure be used to support the deployment of hydrogen or other types of emerging fuels?
	Near-term	• Can storage improve the efficiency and reduce the cost of industrial processes? • Framework for comparing the performance characteristics and tradeoffs between renewable fuel pathways
Tools		• Cross-Sectoral (Supply, Demand, Price) Equilibrium Models • Integrated Industrial Storage Models (H_2 production) • Value of new fuels (H_2, NH_3, etc.) Methodologies • Industrial Storage application Methodologies
Data		• Production cost and characteristics of novel fuels to store energy • Cost of industrial processes & fuel • Industrial Process Temporal Energy Demands (electric and thermal)

Gap: Ability to quantify the benefits coupling different energy storage technologies with industrial processes or the value and services that novel energy mediums/fuels can provide.

Outcome: Unable to assess if storage can be cost-effectively paired with industrial processes, miss opportunity to support energy mediums/fuels that can provide a wide range of services across multiple sectors.

Stakeholder Impacts:

- **Consumers:** Miss opportunity to invest in systems that can make their businesses more efficient, profitable, and resilient
- **States:** Fail to meet policy objectives in a reliable, cost-effective way
- **DOE & R&D Organizations:** Unable to effectively prioritize storage R&D investments that can provide the most future impact

Need to assess how storage can increase industrial efficiency/productivity and if new energy medium/fuels can cost-effectively provide a wider array of services across multiple sectors.

Manufacturing

Research Needs:

Analysis

Long-term

- How can the U.S. increase it storage manufacturing competitiveness?
- What factors make different economies competitive storage manufacturers?

Near-term

- What are supply chain bottlenecks of each storage technology?
- What are the key drivers of manufacturing cost?

Tools

- Supply Chain Analysis Tools
- Material Flow Tools
- Process Efficiency & Competitiveness Methodologies

Data

- Competitiveness Statistics
- Critical Mineral Supply Chain Data
- Process Efficiency
- Manufacturing Costs

Gap: Challenging to assess what factors enable economies to be competitive manufacturers of energy storage as well as how supply chain constraints might limit storage deployment in the future.

Outcome: U.S. misses an opportunity to become a leader in energy storage manufacturing, especially for the next generation of storage technologies.

Stakeholder Impacts:

- **Developers:** Have to purchase products and subcomponents that are manufactured abroad, opening themselves up to unnecessary risk
- **Customers:** May pay premium if energy storage technologies are more costly than they otherwise could be due to supply chain bottlenecks
- **Federal Government/ States:** Lose opportunity to create new jobs and catalyze economic activity up and down the energy storage supply chain

Understanding how much, what types, and the locational value of energy storage in future scenarios requires the full variety of behind-the-meter and utility-scale storage technologies to be included in long-term planning tools.

Policy, Regulations, and Markets

Research Needs:

Analysis	Long-term	• How will market changes and the creation new products impact storage's value and operation? • How will markets evolve in scenarios with high penetrations of zero-marginal cost generators?
	Near-term	• How will market rules impact how storage technologies are operatized and compensated? • How could new incentives (ITC) impact the deployment of storage technologies?
Tools		• Rate Impact Tools • Policy and Rate Impact Methodologies
Data		• Safety & Codes • Market Rules • Taxes & Incentives • Procurement Policies • Cyber Policy • Industrial Policy

Gap: Limited ability to comprehensively understand how policies, regulations, and market rules interact to the value, operation, and deployment of energy storage technologies.

Outcome: Ineffective policies limit the optimal operation of storage technologies, minimize value, and decrease deployment.

Stakeholder Impacts:

- **ISOs/RTOs:** Develop regulations, rules, market products that artificially limit storage's contribution to energy, capacity, and essential reliability service markets
- **Utilities:** Less likely to include storage in future planning because of uncertainty caused by market rules, regulations, codes and standards
- **Developers:** Less likely to build storage because they are unable to receive adequate compensation or deploy storage in an optimal fashion

Understanding the impact of regulations, market rules, and other policies is critical to identifying the types of services storage technologies will be compensated for providing, the potential for future energy storage deployment under different scenarios, and ways to enhance existing rules to minimize costs, and increase the reliability and resilience of the grid