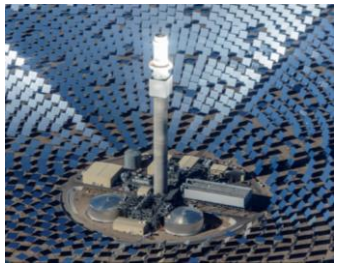
The Value of Long-Duration Energy Storage (LDES): Policy and Perception




PRESENTED BY

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SAND2021-7261 PE

Overview

- **Problem Statement**
- **Policy Overview**
- **Perceptions** – LDES Survey Results
- **Summary**

Problem Statement

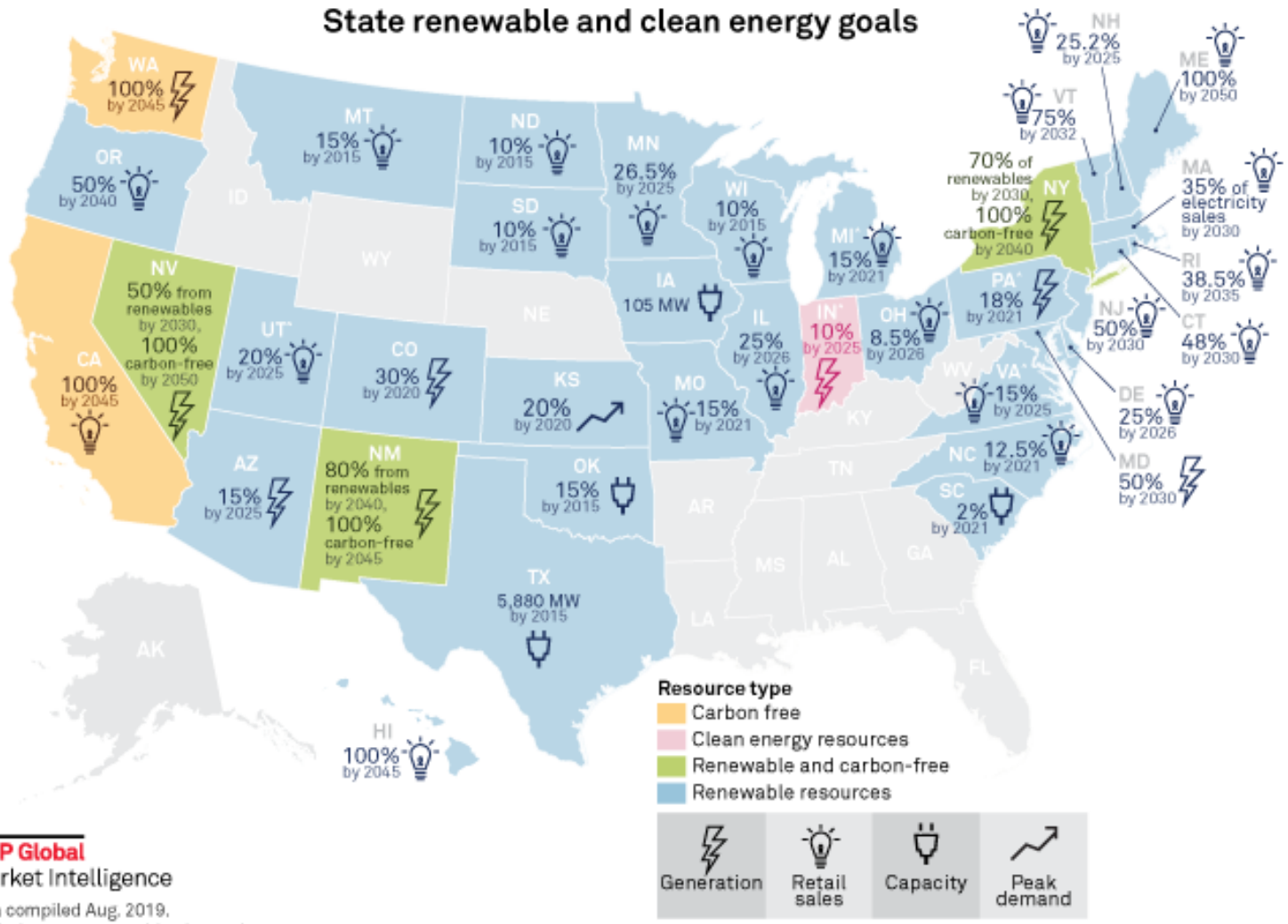
Long-duration energy storage (LDES) is not currently valued (or needed) in existing energy markets…

but it will be.

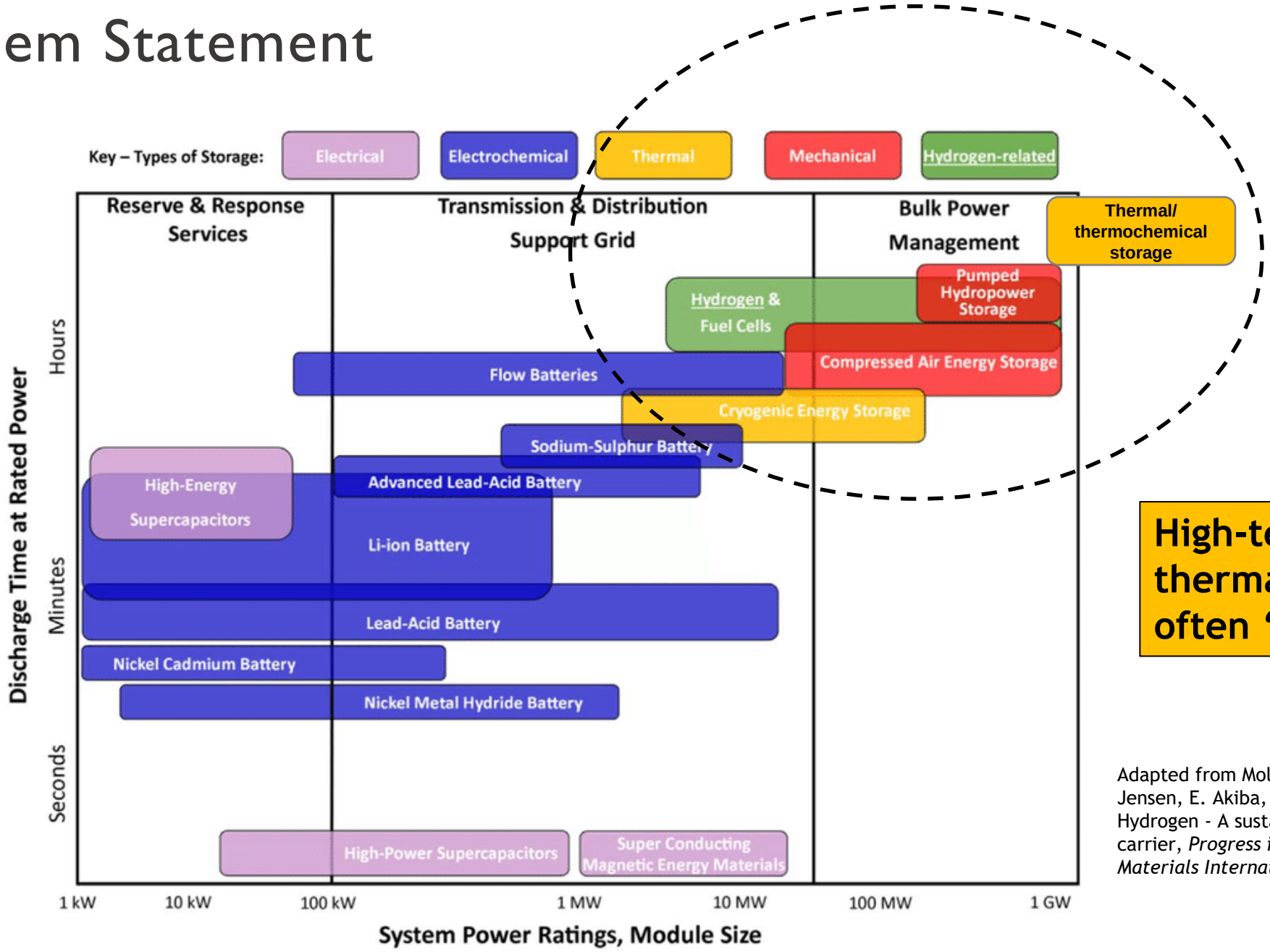
Problem Statement

New large-capacity, long-duration energy storage solutions are needed to ensure grid performance* with increasing intermittent renewables and threats that batteries alone cannot economically address

*Stability, reliability, and resilience



Problem Statement



High-temperature thermal storage often "left out"

Adapted from Moller, K.T., T.R. Jensen, E. Akiba, and H.W. Li, 2017, Hydrogen - A sustainable energy carrier, *Progress in Natural Science-Materials International*, **27**(1), p. 34-40

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Polls

- How do you feel about the following statement? "Regulatory policies will play an important role in enabling the deployment and viability of long-duration energy storage technologies."
  - 1) Strongly disagree
  - 2) Disagree
  - 3) Neutral
  - 4) Agree
  - 5) Strongly agree
- What is your current knowledge about regulatory policies that may impact energy storage technologies?
  - 1) No knowledge
  - 2) Very little knowledge
  - 3) Some knowledge
  - 4) Good amount of knowledge
  - 5) Significant amount of knowledge

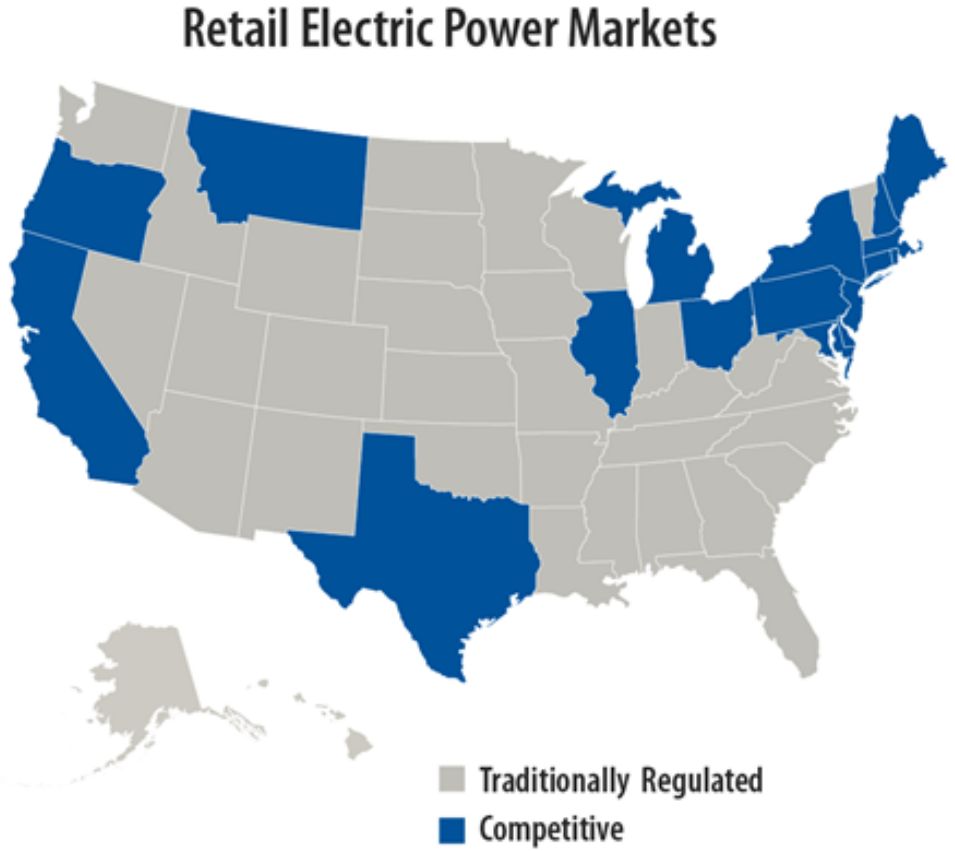
Electricity Markets in the United States

Regulated Market

- "Vertically integrated" utility **owns or controls** generation, transmission, and distribution
- **Regulated by states** (public utility commissions)
- Cost recovery via rates charged to customers
- **LDES needs to solve grid problem and be reliable, low-risk**

Deregulated (Restructured) Market

- Prohibited from owning generation and transmission
- Responsible for interstate transmission, distribution, O&M
- Interstate transmission governed by **Federal Energy Regulation Commission (FERC)** and RTOs and ISOs*
- Market is **competitive**
- **LDES needs to make money**



https://www.epa.gov/repowertoolbox/understanding-electricity-market-frameworks-policies

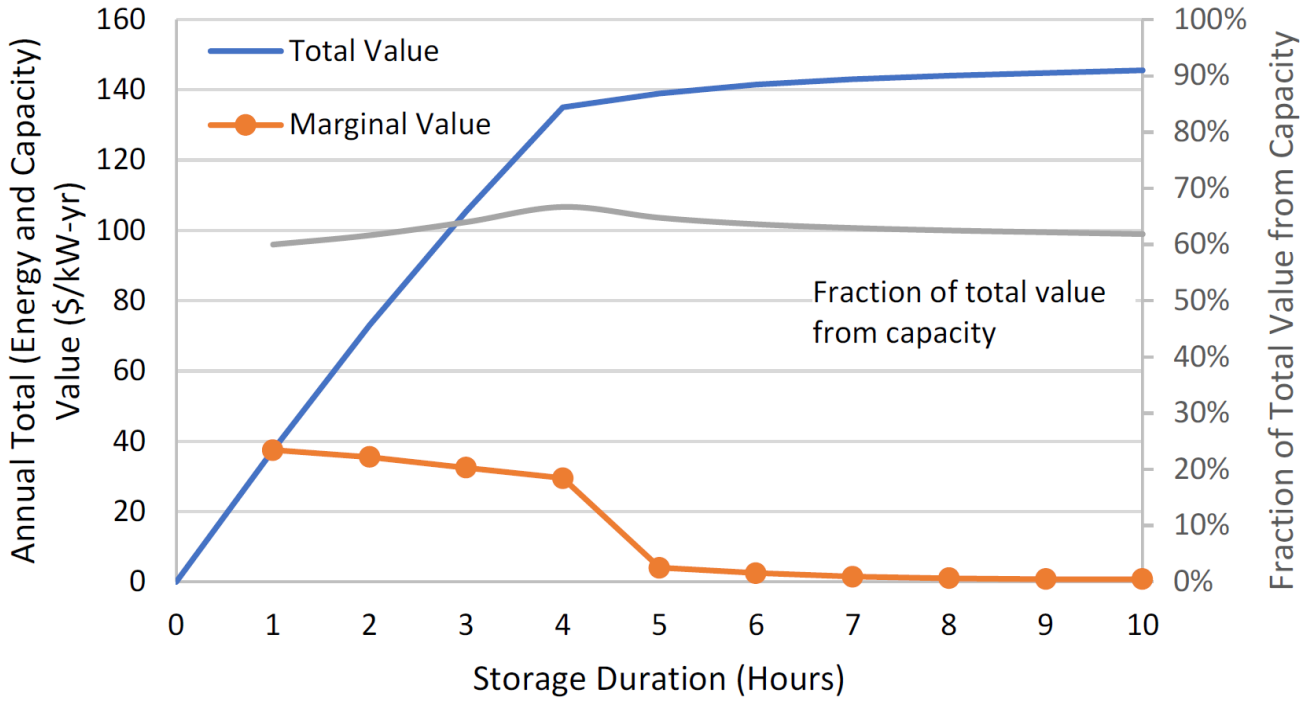
*RTO = Regional transmission operator, ISO = Independent system operator

"LDES Needs to Solve a Grid Problem"

- In 2018, **FERC Order 841** required RTOs and ISOs to establish market rules, including **energy storage durations** to receive full capacity or resource adequacy credit in wholesale electricity markets
  - Nearly all regions adopted 4 hour-or-less energy storage requirement*
  - **Currently little need or value beyond 4 hours**
  - But need will increase
    - **Strategen (2020) found that 45 – 55 GW* of LDES needed for California after 2030**

*80 GW total generation in CA

*Denholm et al. (2021), NREL/TP-6A20-77480



Energy storage value as a function of duration assuming **4-hr duration requirement**, $90/kW-yr **capacity payment**, and 2019 market for **energy time shifting.**

"LDES Needs to Make Money"

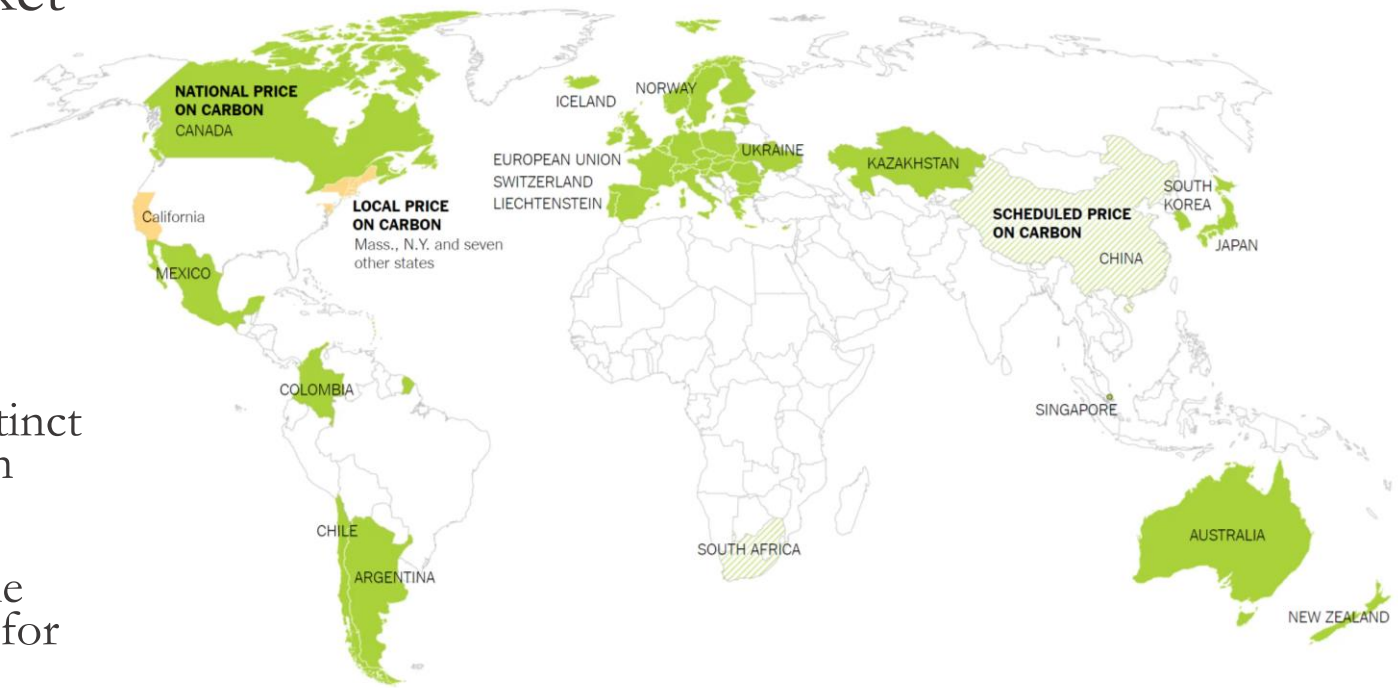
- **Enable Value Stacking Policies**
  - Energy market (MWh) – Time shifting
  - Capacity market (MW) – Resource adequacy
  - Transmission asset (mitigate thermal overload and defer upgrades)
  - Ancillary services (short-term grid stability)
- **Resiliency policy** (insurance) for natural disasters and other threats
  - Utilize LDES for long-term resiliency *and* other value streams
    - Energy, capacity, ancillary, transmission

Hurricane Maria knocked out power in Puerto Rico **for nearly a year**

https://www.nrdc.org/experts/rob-moore/disaster-aid-part-bi-partisan-budget-bill

International Policies

- European Union Electricity Market Design Directive (recast)
  - **Pros**
    - Aims to reduce barriers to energy storage
    - Encompasses both reconversion to electricity or conversion to another energy carrier
    - Energy storage recognized as a distinct asset class, separate from generation
  - **Cons**
    - Germany and France impose double taxation on energy storage systems for charging (consumer) and then discharging (generator)
- Carbon Pricing (Tax)
  - ~40 countries impose carbon pricing
  - Makes non-carbon LDES more competitive



https://menloservice.sandia.gov/https://www.nytimes.com/interactive/2019/04/02/climate/pricing-carbon-emissions.html

"LDES Needs to be Reliable and Low Risk"

- U.S. Federal Policies and Programs
  - 2020 BEST Act
    - Requires DOE to establish cross-cutting energy storage R&D to reduce cost and extend duration of energy storage systems
  - DOE Long Duration Storage Shot (Earthshot)
  - DOE ARPA-E DAYS and SETO CSP programs
- State Policies and Programs
  - California:
    - Governor Newsom recently proposed US$350 million of support for "**pre-commercial long-duration storage projects**"
    - California Energy Commission (2020 GFO-19-308) - Assessing Long-duration Energy Storage Deployment Scenarios to Meet California's Energy Goals
    - Eight community choice aggregators (CCAs) launched a joint request for offers to procure up to 500 MW of long-duration storage

https://www.publicpower.org/periodical/article/long-term-storage-gets-closer-look-with-growth-renewables-decarbonization-push

Policy – Equity and Justice

- **Justice40 Initiative**
  - 40 percent of the overall benefits from Federal investments in climate and clean energy to disadvantaged communities

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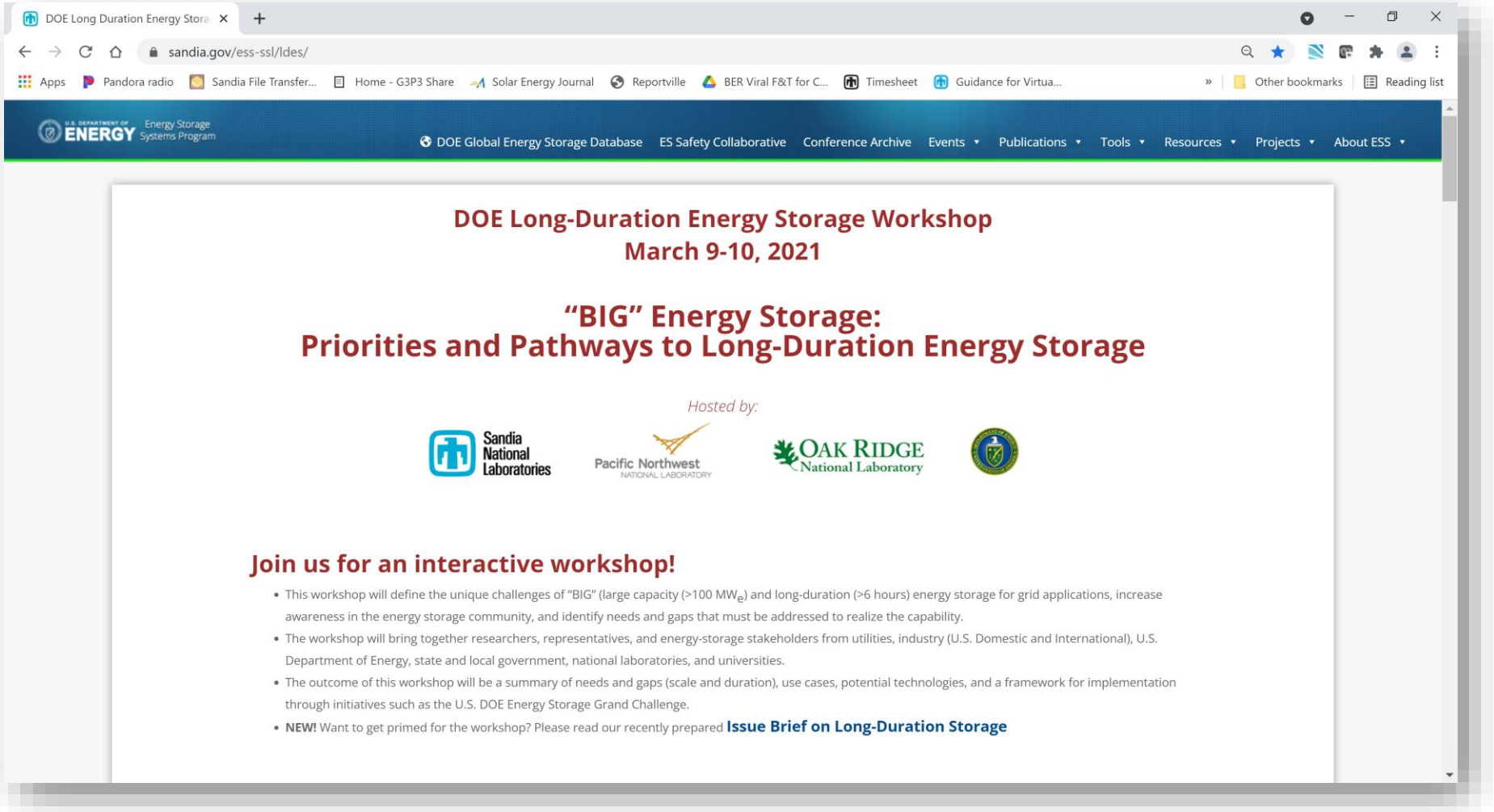
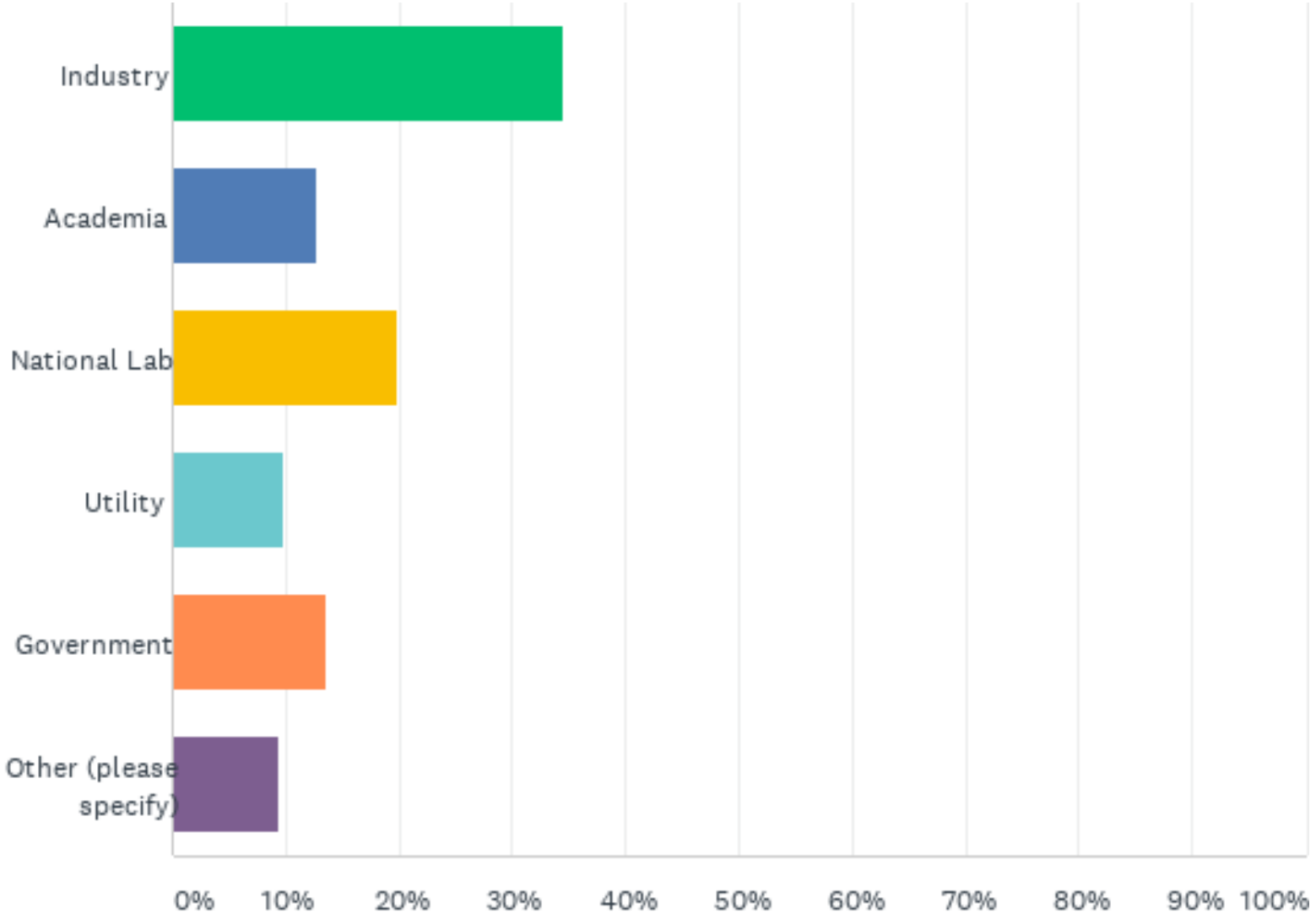
Long Duration Energy Storage Workshop Survey

- 464 survey respondents



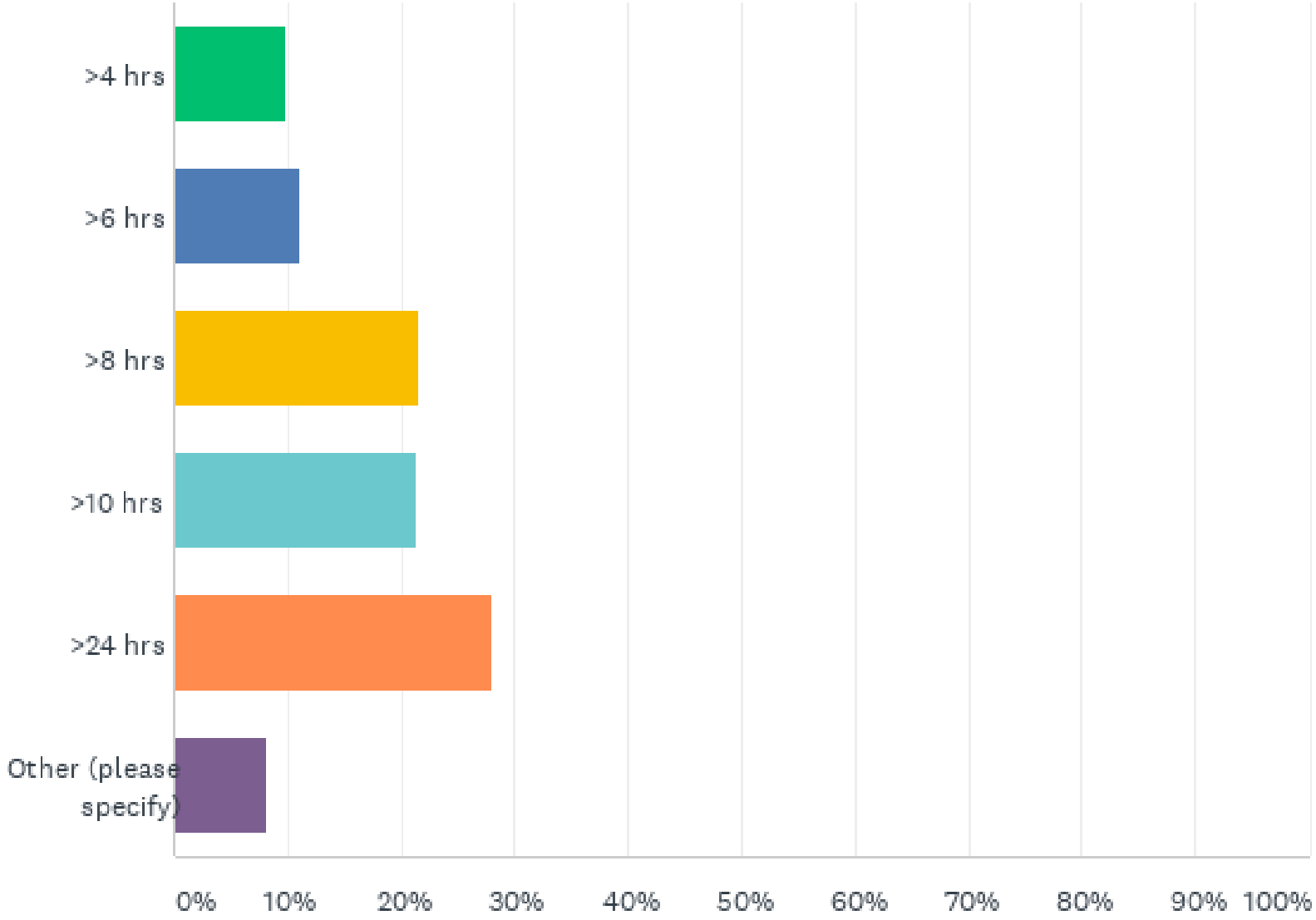
Q1: What best describes where you work?

Answered: 464 Skipped: 0



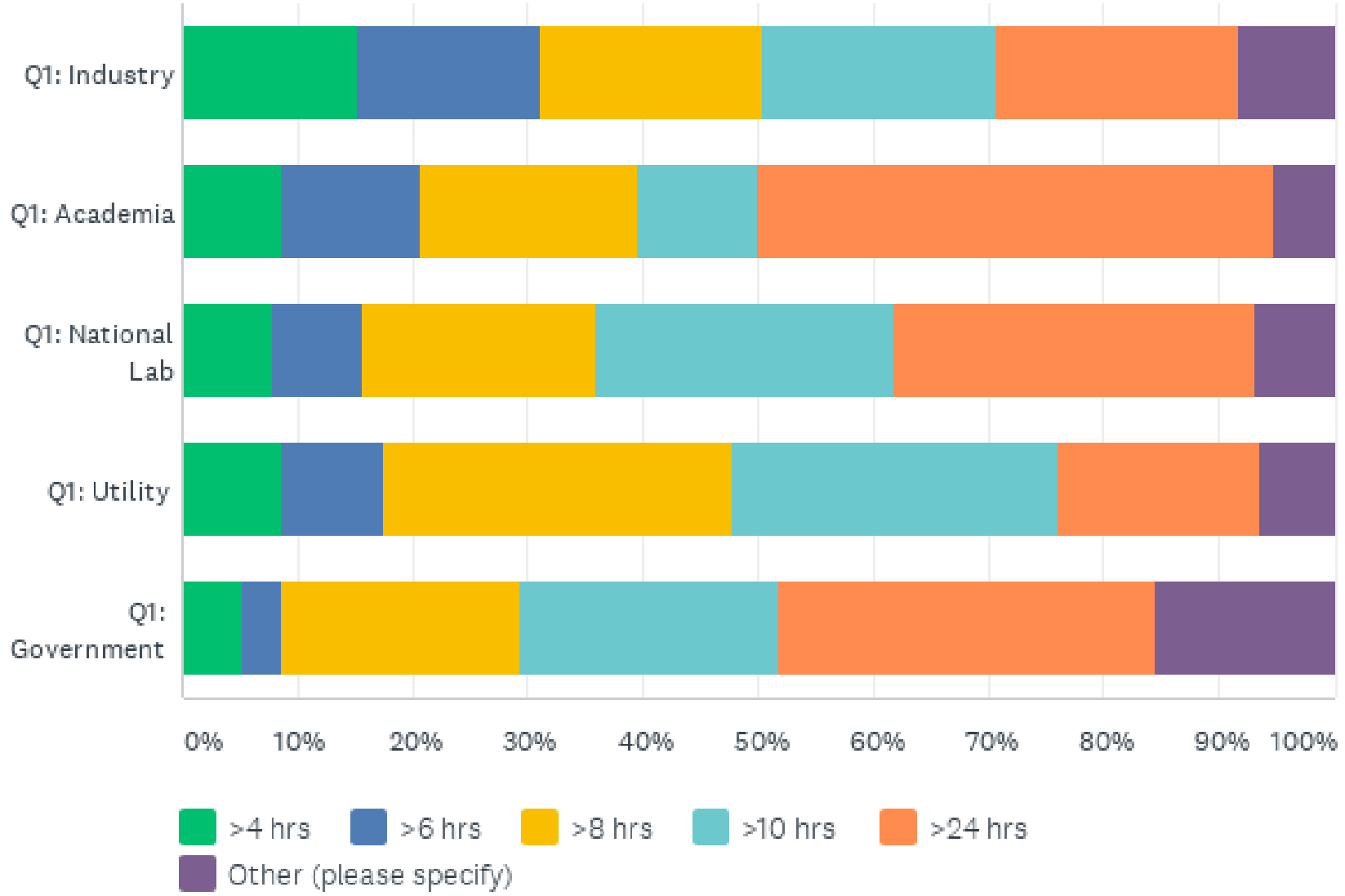
Q2: How do you define long-duration storage?

Answered: 449 Skipped: 15



Q2: How do you define long-duration storage?

Answered: 408 Skipped: 13



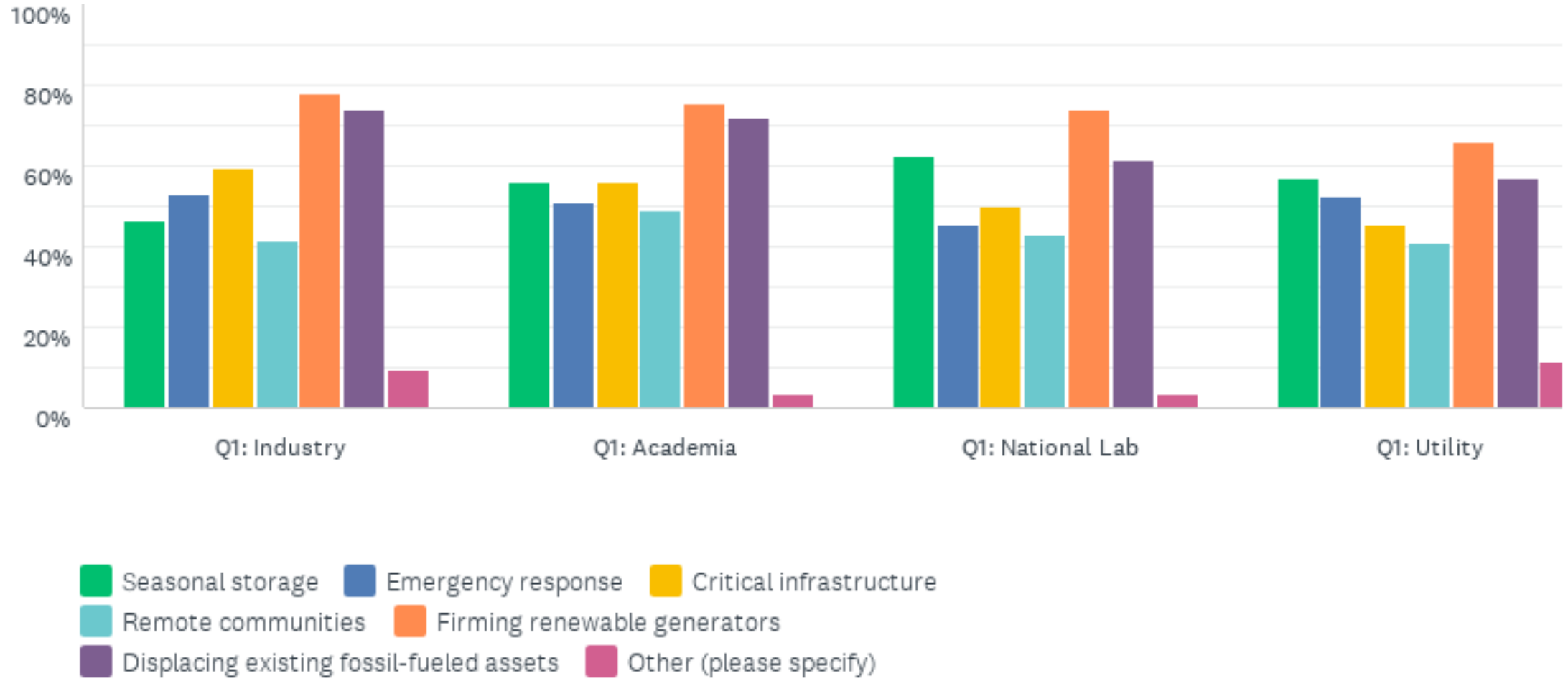
Q2: How do you define long-duration storage?

Answered: 408 Skipped: 13

	>4 HRS	>6 HRS	>8 HRS	>10 HRS	>24 HRS	OTHER (PLEASE SPECIFY)	TOTAL
Q1: Industry (A)	15.29% 24 E	15.92% 25 E	19.11% 30	20.38% 32	21.02% 33 B	8.28% 13 Responses	38.48% 157
Q1: Academia (B)	8.62% 5	12.07% 7	18.97% 11	10.34% 6 CD	44.83% 26 AD	6.90% 4 Responses	14.46% 59
Q1: National Lab (C)	7.87% 7	7.87% 7	20.22% 18	25.84% 23 B	31.46% 28	6.74% 6 Responses	21.81% 89
Q1: Utility (D)	8.70% 4	8.70% 4	30.43% 14	28.26% 13 B	17.39% 8 B	6.52% 3 Responses	11.27% 46
Q1: Government (E)	5.17% 3 A	3.45% 2 A	20.69% 12	22.41% 13	32.76% 19	15.52% 9 Responses	14.22% 58
Total Respondents	43	45	85	87	114	35	408

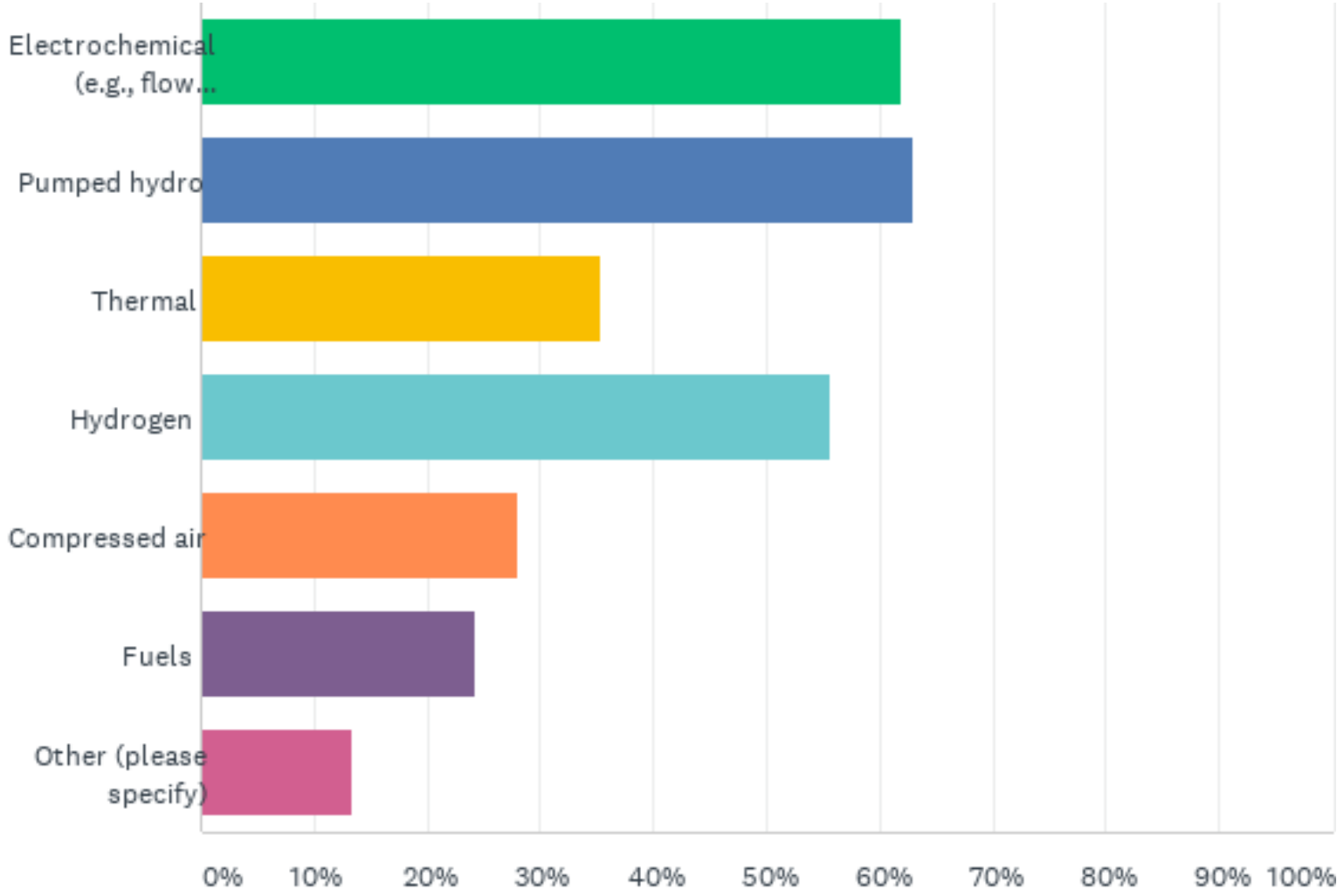
Q3: What use case(s) for long duration energy storage are you interested in?

Answered: 401 Skipped: 20



Q5: What technologies do you think are best suited to provide long duration energy storage?

Answered: 417 Skipped: 47



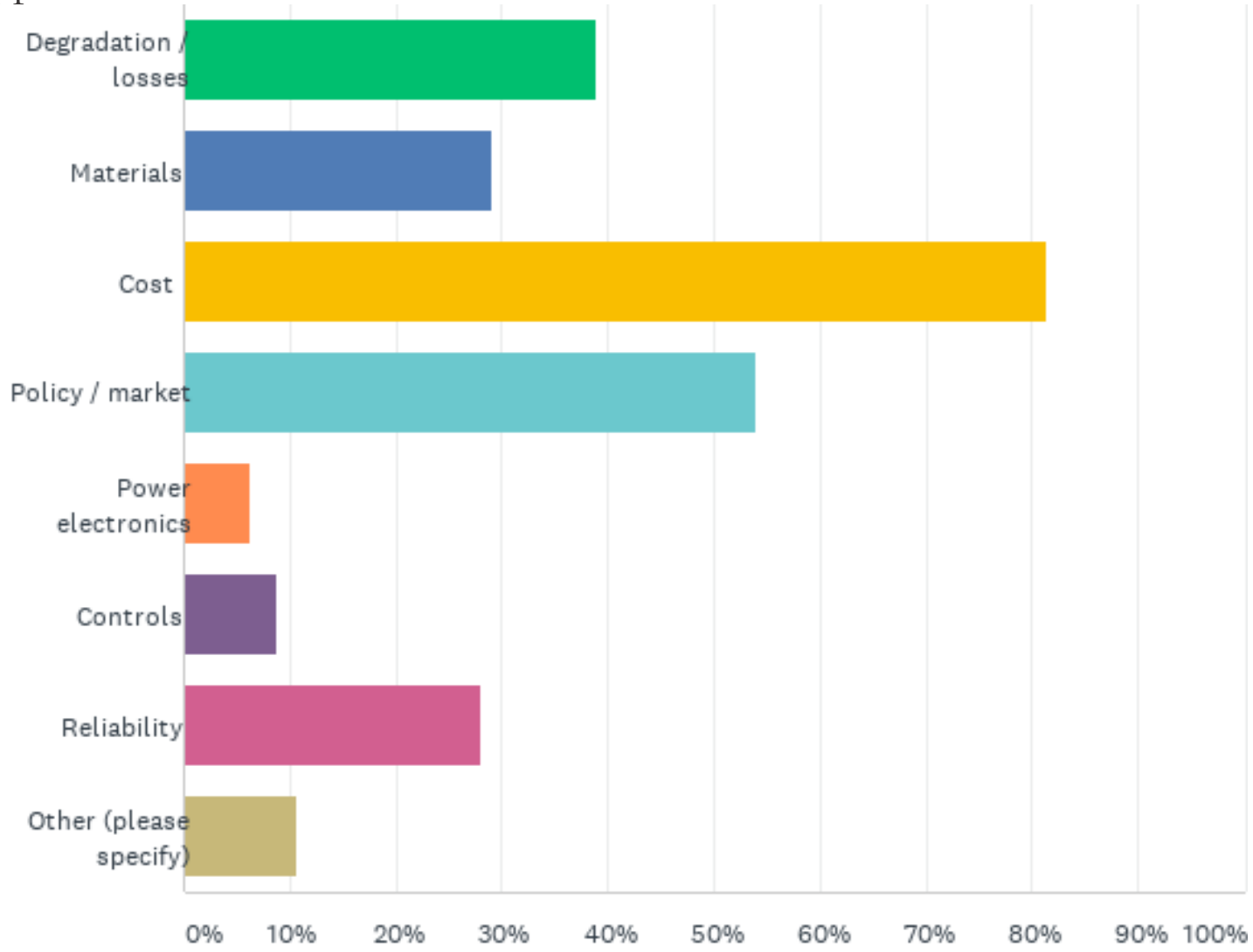
Q5: What technologies do you think are best suited to provide long duration energy storage?

Answered: 380 Skipped: 41

	ELECTROCHEMICAL (E.G., FLOW BATTERIES)	PUMPED HYDRO	THERMAL	HYDROGEN	COMPRESSED AIR	FUELS	OTHER (PLEASE SPECIFY)	TOTAL
Q1: Industry (A)	59.46% 88	63.51% 94	39.86% 59 D	51.35% 76	27.70% 41 D	22.30% 33	12.84% 19 Responses	107.89% 410
Q1: Academia (B)	73.21% 41	55.36% 31	21.43% 12	50.00% 28	16.07% 9 D	19.64% 11	12.50% 7 Responses	36.58% 139
Q1: National Lab (C)	60.71% 51	58.33% 49	39.29% 33	61.90% 52	17.86% 15 D	28.57% 24	8.33% 7 Responses	60.79% 231
Q1: Utility (D)	70.73% 29	70.73% 29	21.95% 9 A	56.10% 23	53.66% 22 ABC	21.95% 9	4.88% 2 Responses	32.37% 123
Q1: Government (E)	64.71% 33	70.59% 36	45.10% 23	56.86% 29	33.33% 17	27.45% 14	19.61% 10 Responses	42.63% 162
Total Respondents	242	239	136	208	104	91	45	380

Q6: What are the biggest challenges facing long duration storage?

Answered: 424 Skipped: 40



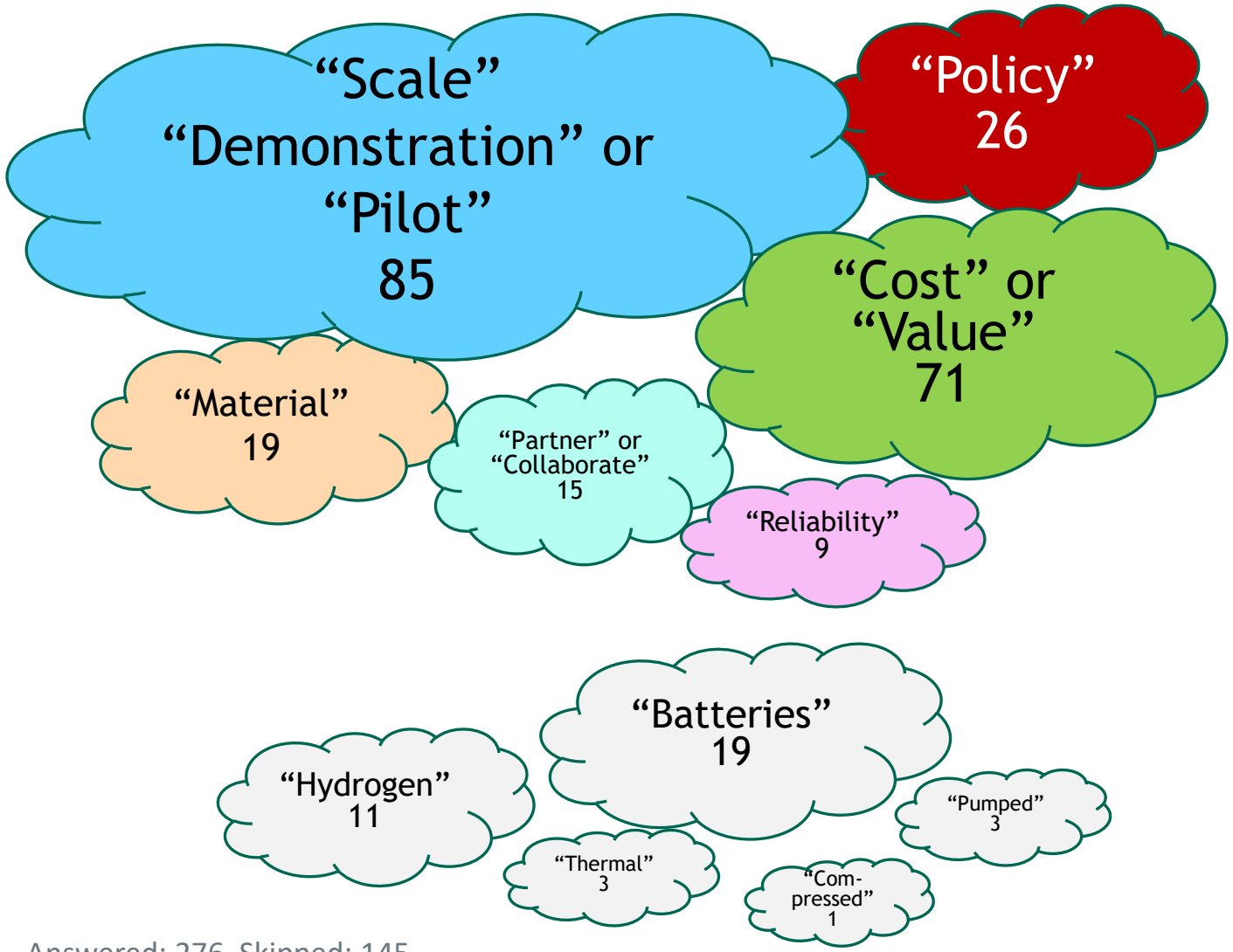
Q6: What are the biggest challenges facing long duration storage?

Answered: 424 Skipped: 40

	DEGRADATION / LOSSES	MATERIALS	COST	POLICY / MARKET	POWER ELECTRONICS	CONTROLS	RELIABILITY	OTHER (PLEASE SPECIFY)	TOTAL
Q1: Industry (A)	28.00% 42 C	24.67% 37	76.00% 114	64.00% 96 BCD	4.67% 7	7.33% 11 D	20.67% 31	12.67% 19 Responses	92.49% 357
Q1: Academia (B)	50.00% 28	39.29% 22	91.07% 51	44.64% 25 A	12.50% 7	14.29% 8	30.36% 17	8.93% 5 Responses	42.23% 163
Q1: National Lab (C)	48.81% 41 A	34.52% 29	82.14% 69	51.19% 43 A	7.14% 6	7.14% 6 D	38.10% 32	9.52% 8 Responses	60.62% 234
Q1: Utility (D)	41.86% 18	25.58% 11	83.72% 36	44.19% 19 A	11.63% 5	20.93% 9 ACE	34.88% 15	4.65% 2 Responses	29.79% 115
Q1: Government (E)	45.28% 24	24.53% 13	84.91% 45	47.17% 25	3.77% 2	5.66% 3 D	30.19% 16	5.66% 3 Responses	33.94% 131
Total Respondents	153	112	315	208	27	37	111	37	386

Q7: How can DOE and the national labs best address the challenges of long duration energy storage?

- Fund **demonstration** projects at **scale**; bridge valley of death to commercialization
- Assess **costs** and **value** of LDES in different use cases
  - Perform technoeconomic analyses for future carbon-free scenarios and architectures for individual utilities and regions
- Ensure **policy** enables LDES
- Foster **collaborations** between universities, national labs, and industry
- Improve LDES **technologies** to increase reliability/bankability and reduce costs



Answered: 276 Skipped: 145

Summary

Summary – LDES and Relevant Policies

- **Policies for monetization and multiple value streams**
  - Energy market (time shifting, MWh)
  - Capacity market (meeting loads, MW)
  - Transmission asset (prevent thermal overloads)
  - Resilience/insurance (recovering from natural disasters)
  - Elimination of double taxation (consumption and generation)
  - Carbon tax (cost avoidance)
- **Technology demonstrations to lower risk of adoption**
  - Federal assistance for technology development (e.g., DOE Storage Shot, CSP program, ARPA-E Days)
  - State mandates for storage deployment (e.g., California)
- **Equity and justice**
  - Ensure disadvantaged communities benefit from policies

Summary –LDES Perceptions

- **LDES Perceptions**
  - **Different sectors** define duration, technologies, and challenges differently
  - Key **technologies** include pumped hydro, electrochemical, hydrogen, and thermal storage
  - Key **challenges** include cost, policy/market, degradation/losses, reliability/materials
  - **Government** should focus on **larger-scale demonstrations**, **cost reductions**, and **policies that enable LDES**

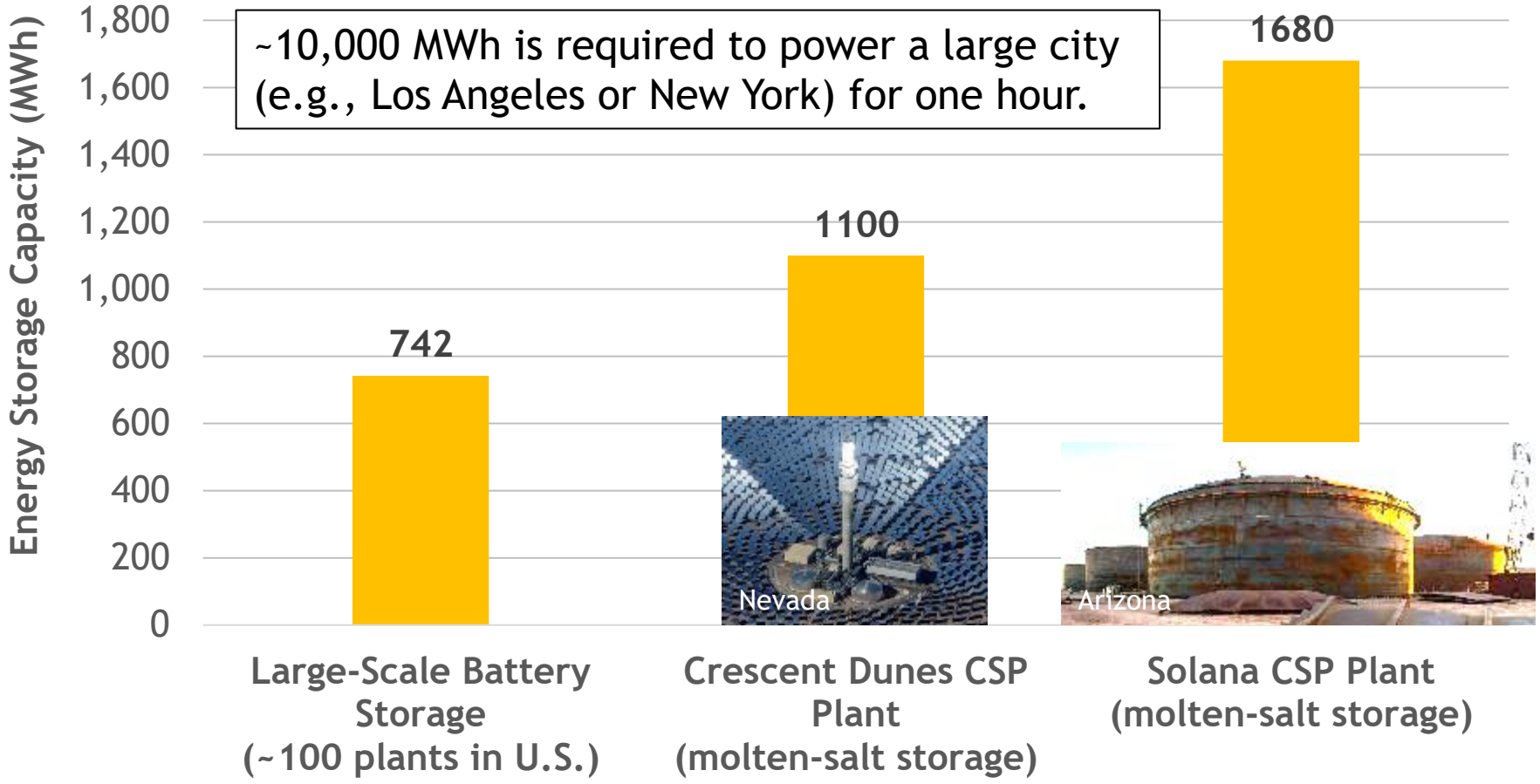
Questions?

Cliff Ho, (505) 844-2384, ckho@sandia.gov

Backup Slides

Growing Need for Large-Scale Energy Storage

Battery data from U.S. Energy Information Administration (June 5, 2018)
CSP data from https://solarpaces.nrel.gov/projects



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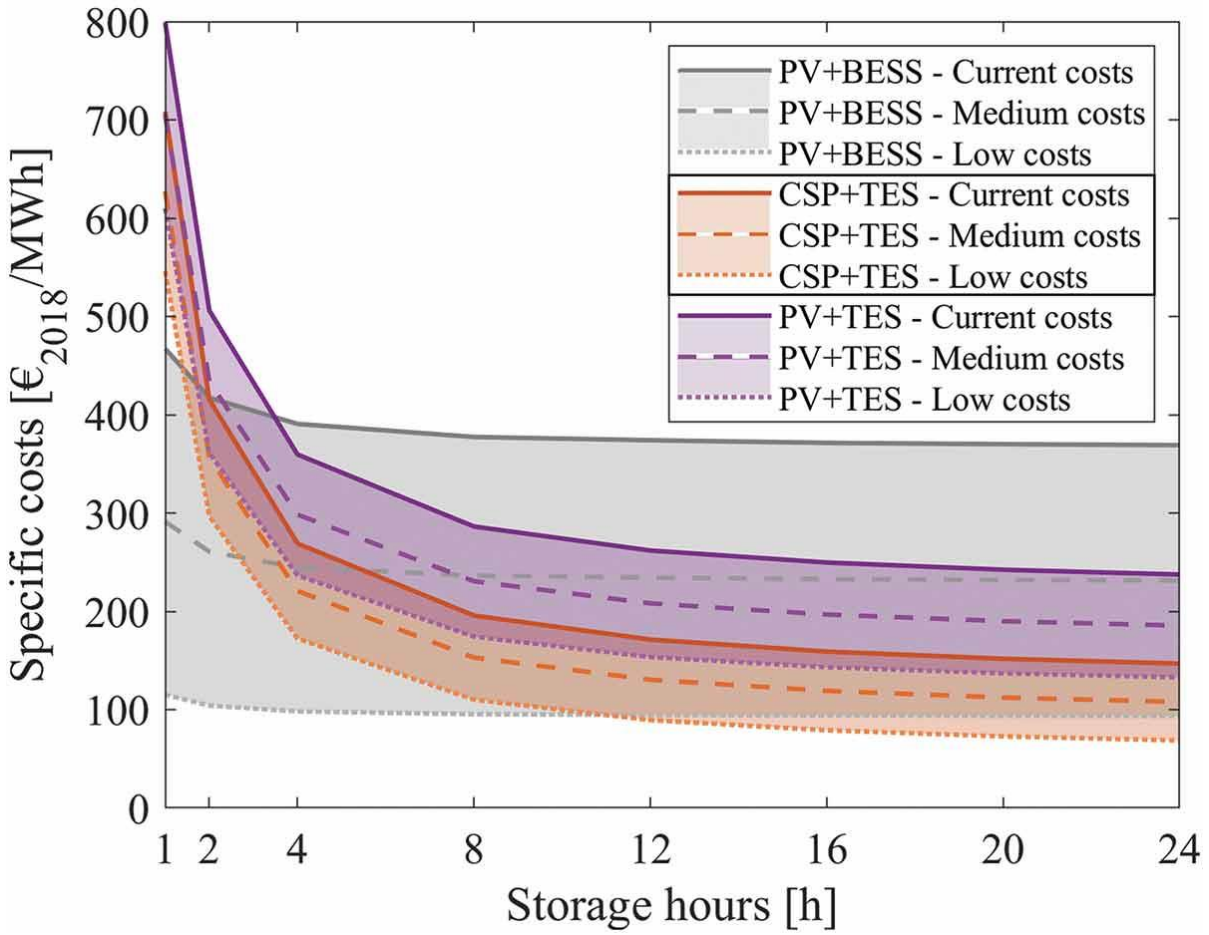
"LDES Needs to be Cost Competitive"

- E.g., CSP vs. PV + batteries
  - LCOS for long-duration thermal storage is competitive with PV + batteries after ~4 – 10 hrs



F. Schöniger, R. Thonig, G. Resch & J. Lilliestam (2021) Energy Sources, Part B: Economics, Planning, and Policy, 16:1, 55-74, DOI: 10.1080/15567249.2020.1843565

BESS = Battery Energy Storage System

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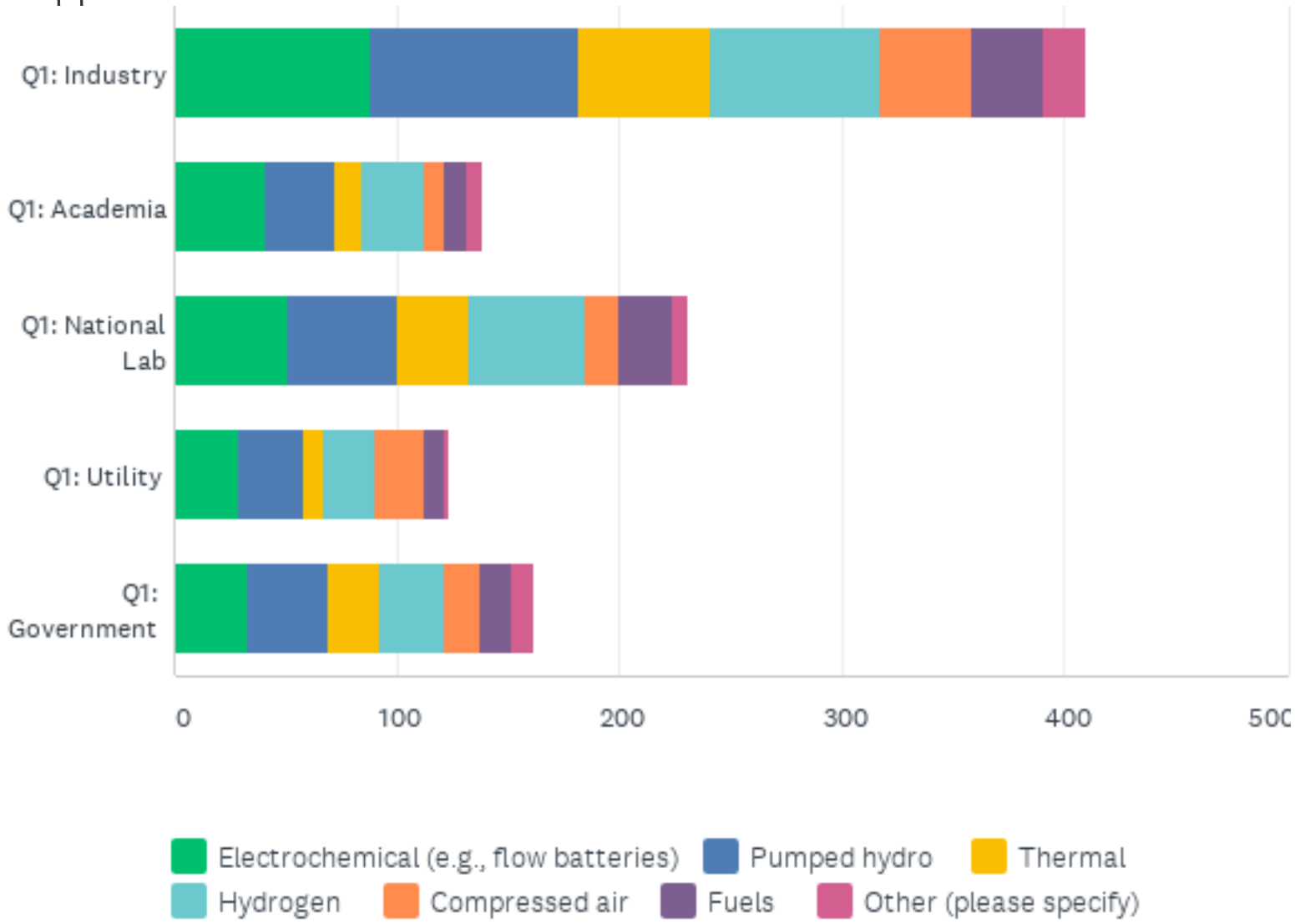

Advantages and Disadvantages of Deregulated Markets

Advantages of Electricity Deregulation

1. **More energy companies to choose from**
2. **Competition may lead to lower energy prices**
3. **Customers can support green companies; technological progress may be fostered**

Disadvantages of Electricity Deregulation

1. **Wholesale prices fluctuate**
2. **Lack of energy supply security; crucial services not ensured or controlled by governments**
3. **Rural and disadvantaged customers may suffer from energy shortages**
4. **Environmental problems**

Texas multi-day power outage affected 5M customers

Price of electricity rose over 7000% from $0.12/kWh to $9.00/kWh (NPR)

Adapted from https://environmental-conscience.com/electricity-deregulation-pros-cons/

www.texastribune.org/2021/02/15/rolling-blackouts-texas/

www.texastribune.org/2021/02/16/texas-power-outage-ercot/