DEFINING STRATEGY AND DELIVERING MARKETS WITH OPEN-SOURCE MODELING

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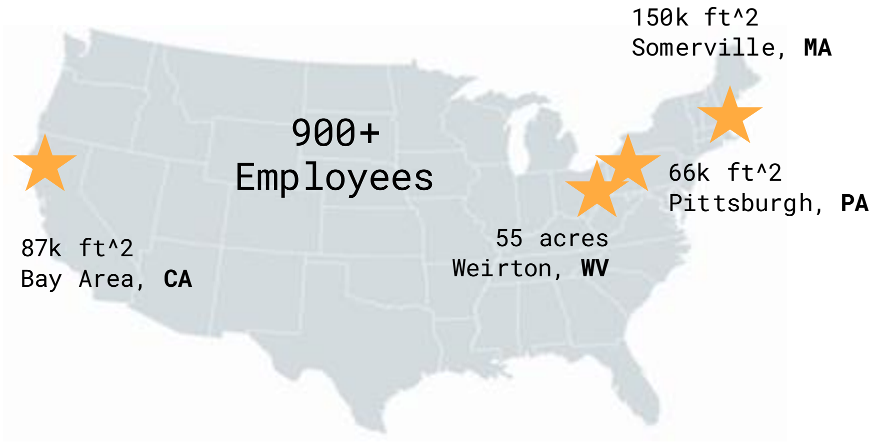
Gurobi Energy Innovation Summit

Form energy

Energy Storage
For A Better World

Form Energy Intro

Form Energy Overview



LED BY ENERGY STORAGE VETERANS

Decades of cumulative experience in energy storage with 100's of MW of storage deployed

OUR INVESTORS: LONG-TERM AND IMPACT-FOCUSED

$1.2B+ in venture capital from top investors including: T. Rowe Price, GE Vernova, Breakthrough Energy Ventures (BEV), TPG Rise Climate, Coatue, GIC, NGP, ArcelorMittal, Temasek, Energy Impact Partners, Prelude Ventures, MIT's The Engine Ventures, Capricorn's Technology Impact Fund, Eni Next, Macquarie Capital, Canada Pension Plan Investment Board, and other long-term, impact oriented investors

Form Factory 1: U.S. Based Commercial-Scale Manufacturing

Transforming Weirton Steel Land for Battery Manufacturing in West Virginia

- **Production Capacity**: 500 MW / 50 GWh annually by ‘28
- **Total Local Investment:** $760 million
- **Selection Process:** year-long, 500 sites
- **Construction Start:** 2023
- **Production Start:** 2024
- **Jobs:** Minimum 750 full-time jobs
- **Weirton Benefits:** Local manufacturing know-how, strong natural infrastructure

Form Factory 1 site, June 2023

Form Factory 1, July 2024 (first ~500k sqft)

Over 14 GWh of contracted multi-day storage projects

GREAT RIVER ENERGY

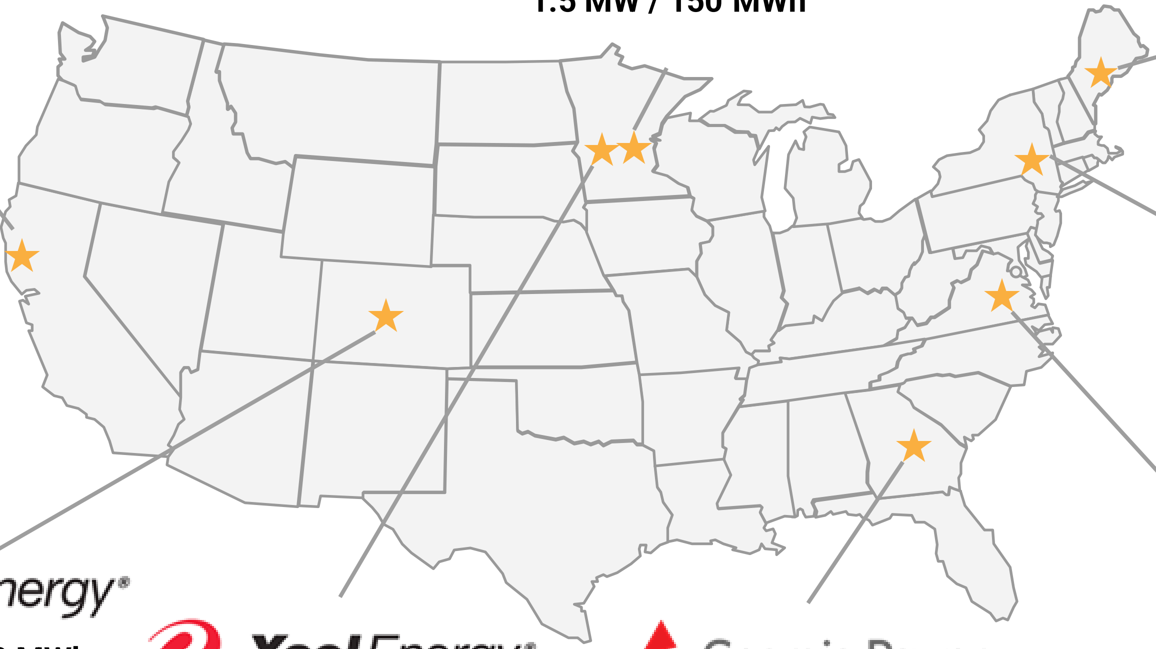
Broke ground Summer 2024

1.5 MW / 150 MWh

85 MW / 8500 MWh

STATE OF CALIFORNIA ENERGY COMMISSION

5 MW / 500 MWh



NEW YORK STATE | NYSERDA

10 MW / 1,000 MWh

CO regulatory approval ✓

Xcel Energy

10 MW / 1,000 MWh

Xcel Energy

10 MW / 1,000 MWh

MN regulatory approval ✓

Georgia Power

15 MW / 1,500 MWh

Dominion Energy

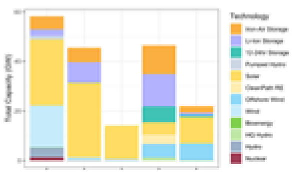
5 MW / 500 MWh

VA regulatory approval ✓

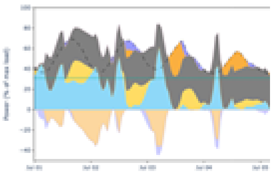
Our Technology: Iron Air

Formware™ provides accurate, full portfolio modeling of weather-driven grids

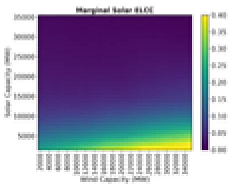
Proprietary power system model for zero-carbon capacity planning



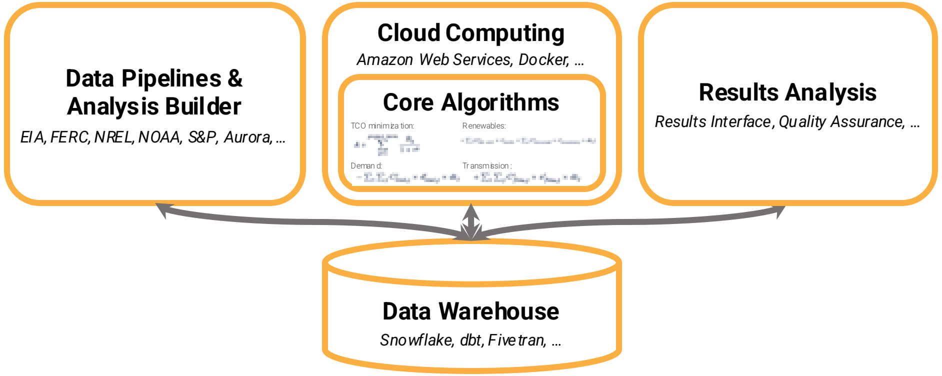
1 Capacity Expansion
What assets should I build?



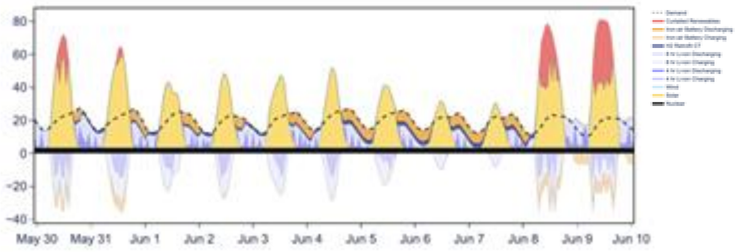
2 Economic Dispatch
How should I operate it?



3 Reliability & Adequacy
How reliable is it?



Software purpose-built for weather-driven grids

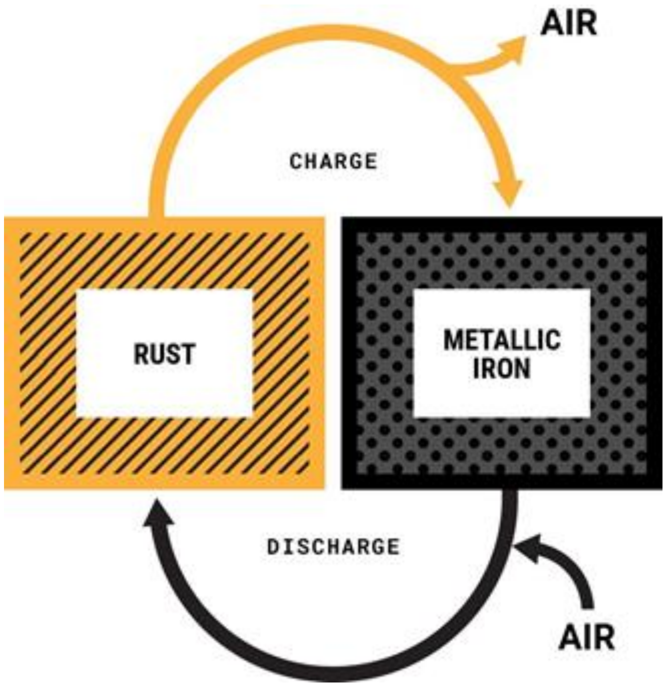


- **Hourly temporal granularity**
  ~80x more time steps than traditional grid planning models
- **Multi-scenario co-optimization**
  ~43x more weather years vs. industry standard
- **Resource adequacy & effective capacity**
  1 integrated model for investment, dispatch & reliability analysis
- **Use in peer-validated studies[1]**
  Published studies include: E3, Nature Energy, National Grid, Enel, UMN

Notes: (1) Full peer-validated studies can be accessed by clicking on listed hyperlinks.

Rechargeable iron-air is the best technology for multi-day storage

Form's 100-Hour Reversible Rust Battery



COST
Lowest cost rechargeable battery chemistry.
Chemistry entitlement <€1.00/kWh

SAFETY
No thermal runaway (unlike li-ion)
Non-flammable aqueous electrolyte

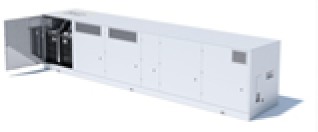
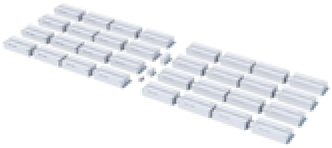
SCALE
Iron is the most globally abundant metal
Easily scalable to meet TW demand for storage

DURABILITY
Iron electrode durability proven through decades of life and 1000's of cycles (Fe-Ni)

What makes up a Form Energy system

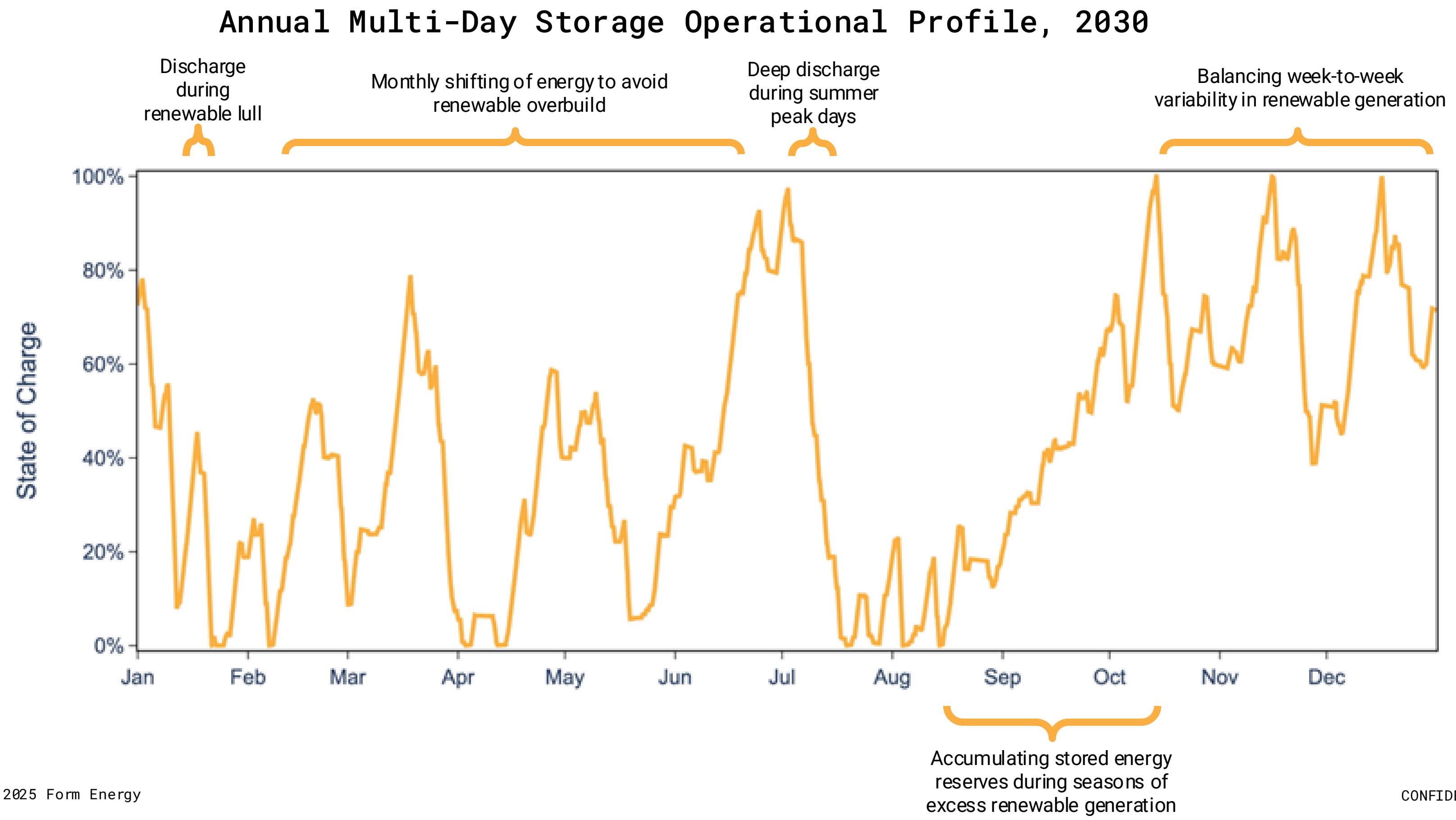
Modular design enables easy scaling to GWh systems




Cell	Battery Module	Enclosure	Power Block	System
~0.15 kW / 15 kWh	**~4.5 kW / 450 kWh**	**~45 kW / 4,500 kWh**	**~2.9 MW / 290 MWh**	**10+ MW / 1000+ MWh**
~1.37m x 0.94m x 70mm	~1.8m x 1m x 2.5m	~9.5' x 8' x 40'	<2 acres	5+ acres
Electrodes + electrolyte	30 cells	10 modules	64 enclosures	Many power blocks
Smallest electrochemical functional unit	Smallest building block of DC power	Product building block with integrated auxiliary systems	Smallest independent system and AC power building block	Commercial intent system

Multi-day storage shifts energy over weeks, months, and seasons



Modeling: Our Approach

Accurate modeling of multi-day storage requires the right inputs and methods

Input assumptions that affect the selection and value of multi-day storage

- Capital, operating costs, and performance specs for multi-day storage technologies
- Capacity accreditation for storage assets that is a function of duration
- Volatility in hourly time series data
  - *Annual electric demand*
  - *Renewable profiles*
  - *Gas and other fuel prices*
  - *Market prices*

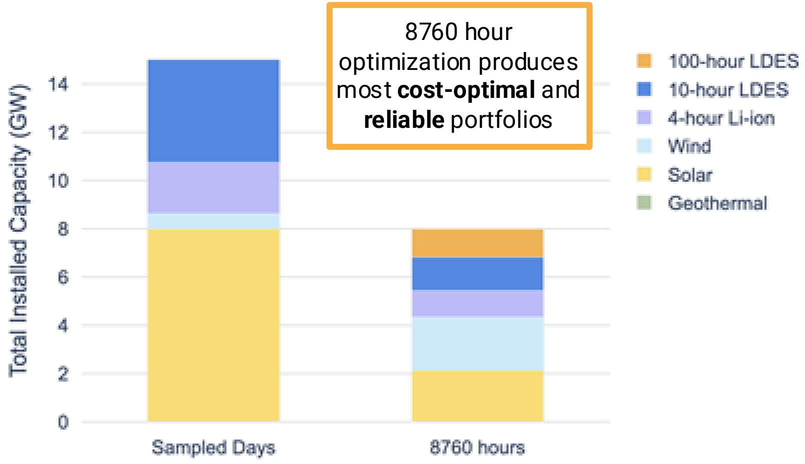
Best practices for capturing the reliability needs on today's electric grid

- Model 8760 hour grid operations in capacity expansion and production cost simulation
- Apply a dispatch method that enables MDS to arbitrage energy across months and seasons
- Use high fidelity, weather-correlated data that realistically captures hour-to-hour variation in load, renewable generation, etc.
- Simulate a diverse set of weather scenarios, including atypical grid stress events

Inputs + Methods lead to least-cost, reliable portfolios that manage real world weather volatility with firm, flexible resources

Model 8760 hour grid operations in planning and dispatch simulation

Case Study: 2040 Least-Cost portfolio optimization for Southwestern Utility



Annualized Portfolio Cost	$1.3 B/yr	$0.7 B/yr
Loss of Load in 8760 hr simulation	10 hours loss of load	0 hours loss of load

- Capacity expansion for an example Southwestern utility, modeling 2040 portfolio
- Resulting portfolios were dispatched over all 8760 hours of this weather year to assess loss of load
- 8760 hour optimization produces most optimal resource portfolio in terms of cost, reliability, and resource build
- Sampled days methods may not fully capture the value of long-duration energy storage (LDES)
- Renewable build requirements significantly decrease when LDES operations are accurately captured

The Potential for Multi-Day Storage in Germany

Study context

- The study was delivered by **Open Energy Transition**, a non-profit, open source-modelling organisation using **PyPSA**, Europe's leading open-source model
- Germany aims to reach **near 100% clean power by 2035**, but the role of **energy storage** is not well discussed yet
- Current models are not showing long duration storage due to low temporal scopes, emphasizing the need for **holistic view** with **annual perfect foresight** modelling
- Therefore, the aim of this study was to develop a comprehensive understanding of the system impact of **multi-day energy storage technologies for 2035**
- Our model considers **both electricity and heat,** presenting an integrated view of the energy system

Our Scenarios

Weather Years

A range of years, including strong dunkleflautes and low wind, were chosen to demonstrate the effects of weather patterns on renewable driven systems

Technology Costs

Cost scenarios were used to give clarity on what price iron-air becomes significantly valuable to the system:

- Baseline: €23.50/kWh
- Mid: €20.00/kWh
- Low €15.25/kWh

System Stressors

To understand the fundamental dynamics impacting the electricity system, we assessed scenarios including:

- a full gas phase out
- delayed transmission infrastructure deployment
- high gas prices

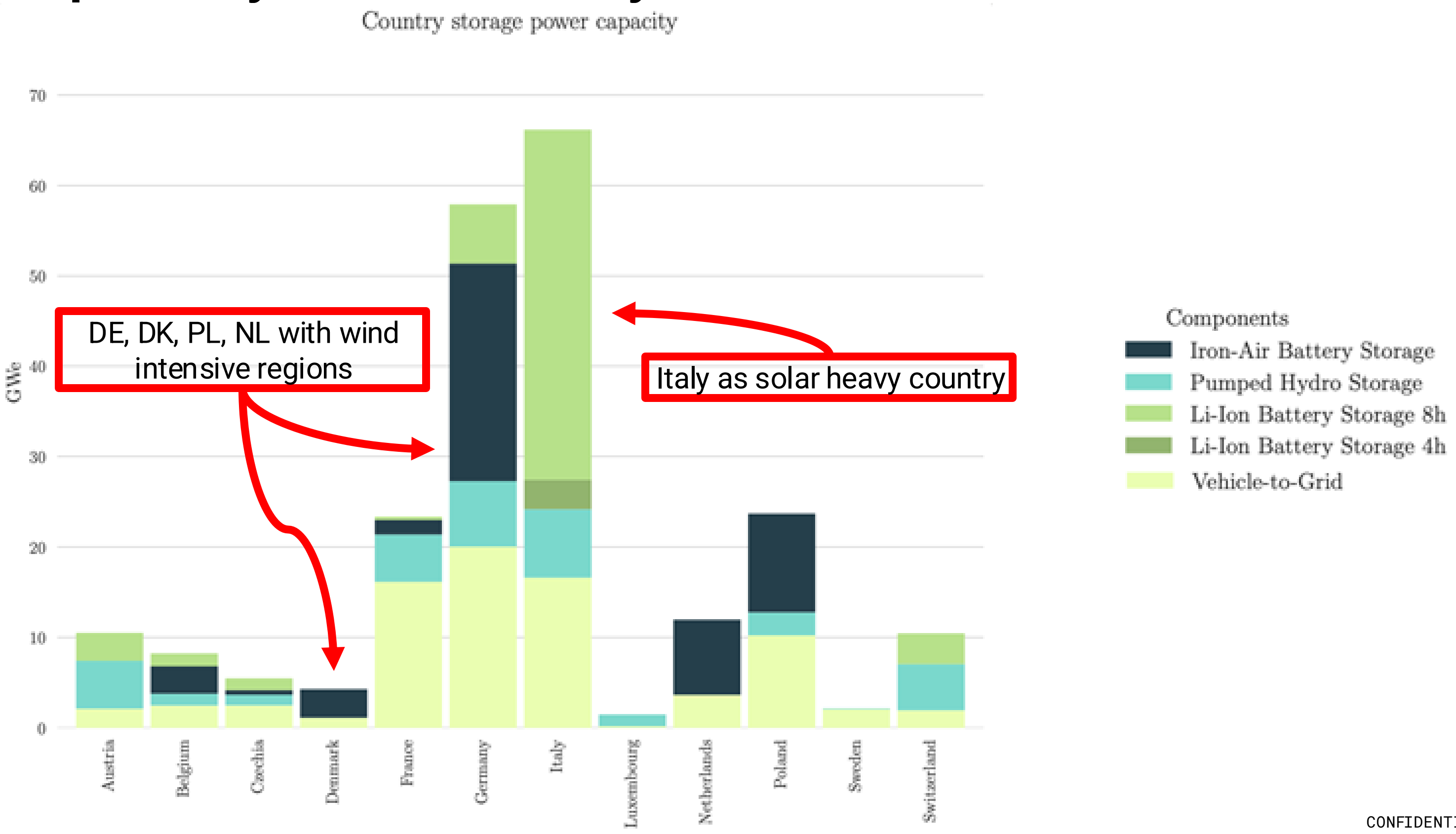
Up to 70 GW of MDS is deployed across our modelled regions, with up to 31 GW in Germany

Comparison of installed Iron-Air capacities (GW) in Germany

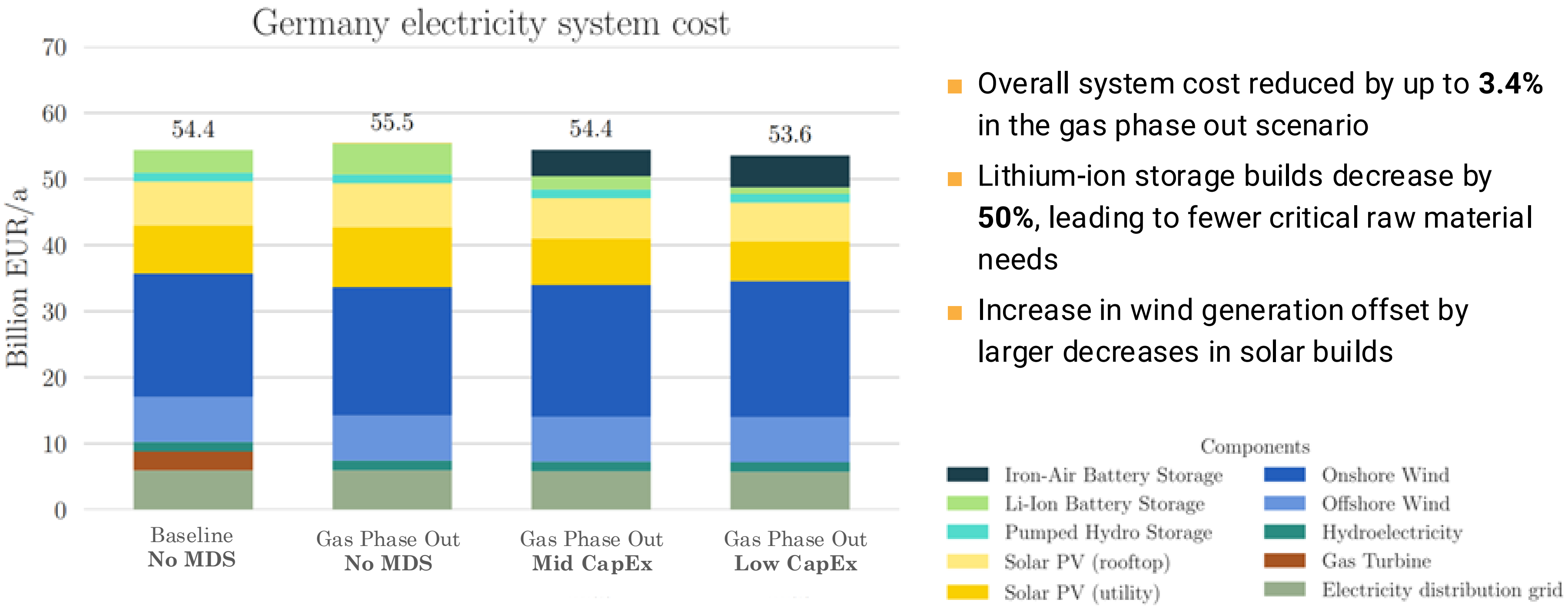
	Baseline (€2,350/kW)	**Mid CapEx** (€2,000/kW)	**Low CapEx** (€1,525/kW)
2013 (representative)	8.0	14.3	24.1
2012 (stressful)	2.7	8.6	20.0
1996 (stressful)	7.5	n.a.	n.a.
2010 (stressful)	12.4	21.3	31.0
Gas Phase Out	n.a.	19.4	30.6
Delayed Infrastructure	n.a.	14.5	25.0
High Gas Price	n.a.	14.2	24.1

Multi-Day Storage (MDS) forms part of a diverse storage portfolio, especially in wind heavy countries

Low CapEx

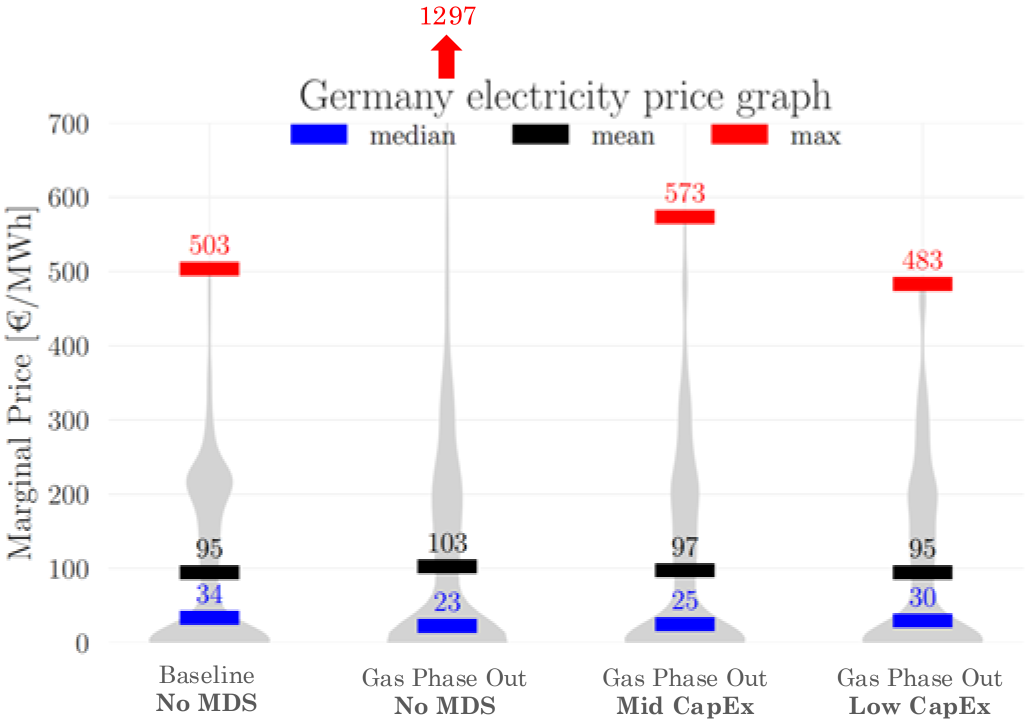


MDS decreases system cost by reducing the volume of resources needed to meet demand



- Overall system cost reduced by up to **3.4%** in the gas phase out scenario
- Lithium-ion storage builds decrease by **50%**, leading to fewer critical raw material needs
- Increase in wind generation offset by larger decreases in solar builds

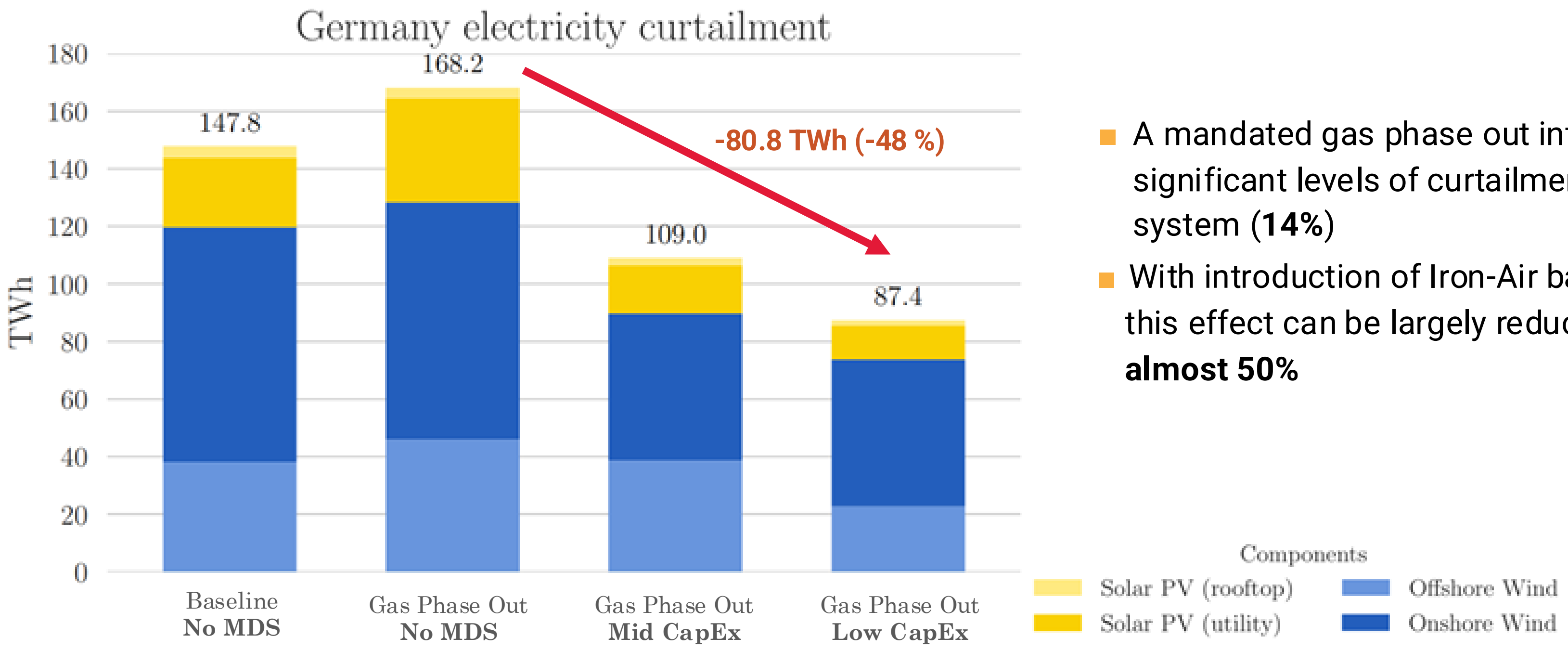
MDS reduces the average price of electricity through flattening high price hours and lowering the price spread



- Up to **7.8%** reduction in **average** marginal price
- Up to **62.7%** reduction in **extreme** marginal price
- Up to **30.4%** increase in **median** marginal price (fewer frequencies of low electricity prices)

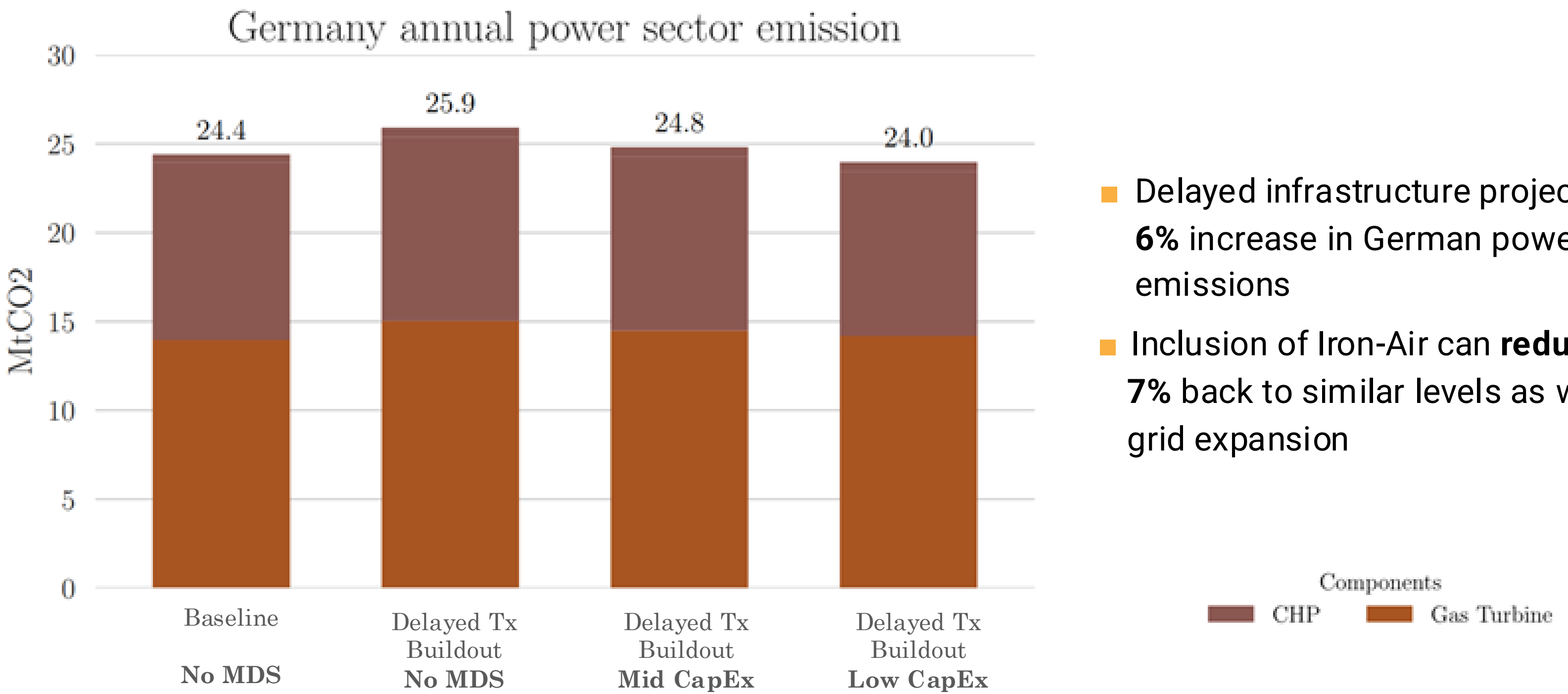
Note: Marginal prices shown are load weighted electricity prices.

MDS reduces curtailment by up to c.50% in Germany, reducing the average price of electricity



- A mandated gas phase out introduces significant levels of curtailment into the system (**14%**)
- With introduction of Iron-Air batteries, this effect can be largely reduced by **almost 50%**

MDS enables carbon emission targets as indicated by annual power sector emissions



- Delayed infrastructure projects lead to a **6%** increase in German power sector emissions
- Inclusion of Iron-Air can **reduce this by 7%** back to similar levels as with baseline grid expansion

Low-cost MDS have a great potential to reduce curtailment, flatten electricity prices and safeguard emission reductions while helping to achieve emission targets

Iron-Air batteries ...

- Flatten electricity prices by lowering peak prices and reducing the frequency of extreme low prices
- Significantly reduce curtailment, benefitting the systems
- Fill a gap during multi-day lulls, enabling economic gas retirements
- Enable a resilient pathway to a secure, low carbon system, even with reduced investments in gas generation and transmission delivery risks
- Provide a valuable hedge to extreme weather years and events