Adapted from EcoEnlightened Charitable Org. Inc.

How to design and build cost-competitive thermal storage (TES) in the **Age of Storage**

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A Basic Equation for Energy Storage

There will be a **tipping point** when carbon-intensive electricity generation becomes the more expensive option

Re < C is already true, but storage needed to solve intermittency problems

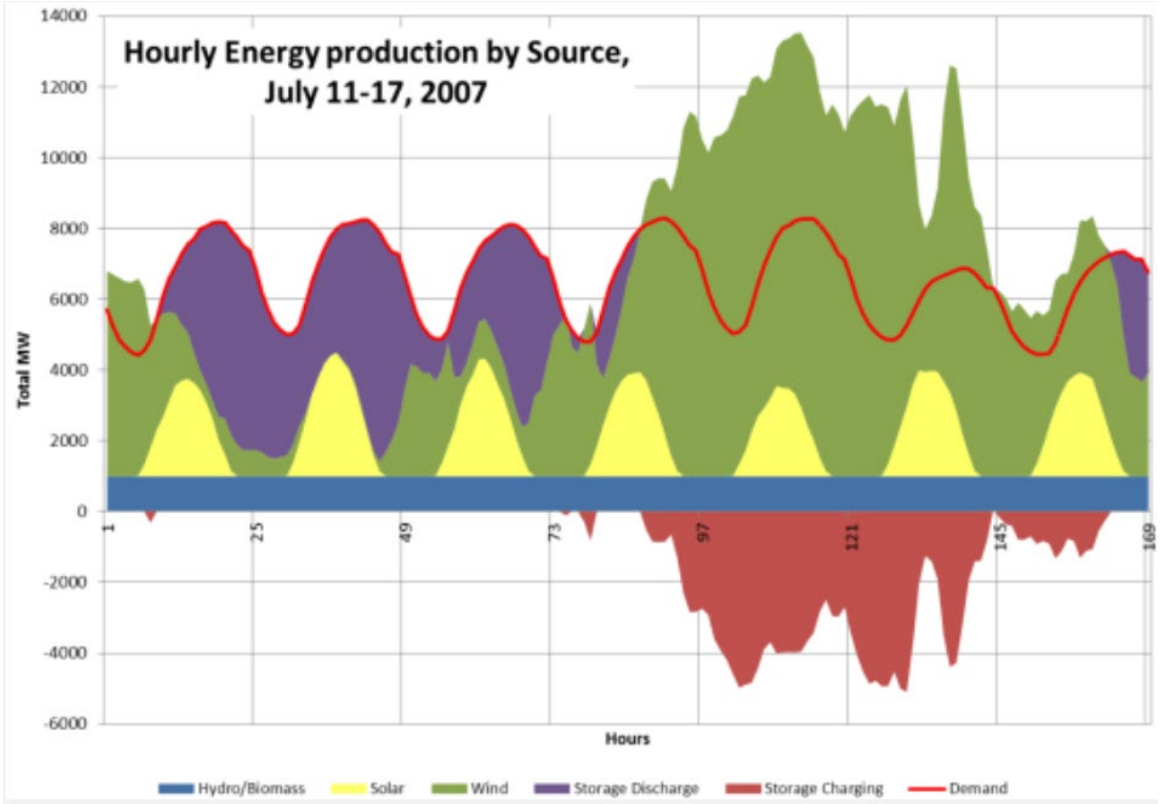
Renewable energy installations now limited by energy storage availability

$$Re + S < C$$

Renewable energy

Storage

Carbon intensive energy source



"Renewable Minnesota" IEER 2012

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Malta's Beginnings at X

Idea pitched to X in 2015

Malta spun out of X in 2018

At X, Malta Team advances concept, derisks design, validates cost model, develops business plan

Idea conceived ~2012

BEV signs on as Lead Investor

Breakthrough Energy VENTURES


QUARTZ

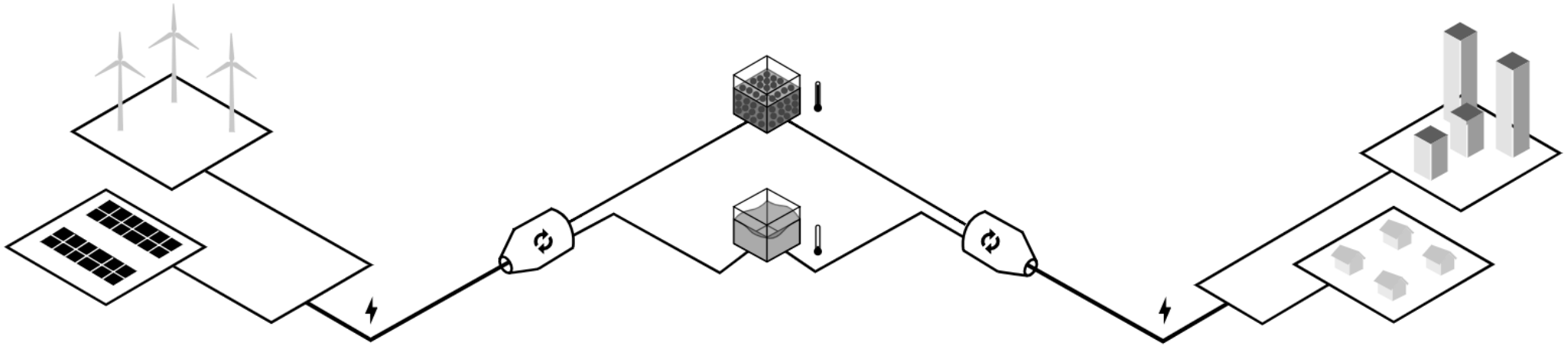
REVERSIBLE REFRIGERATOR

Bill Gates-led fund is investing in a startup to build a cheap battery using a "refrigerator on steroids"

By Akshat Rathi · December 21, 2018

Salty idea.

A Competitive Grid-Scale Energy Storage Solution



1. **COLLECTS**

   Renewable energy is gathered from wind or solar farms on the grid as electrical energy and sent to Malta's energy storage system.

2. **CONVERTS**

   The electricity drives a heat pump, which converts electrical energy into thermal energy by creating a temperature difference.

3. **STORES**

   The heat is then stored in molten salt, while the cold is stored in chilled liquid.

4. **RECONVERTS**

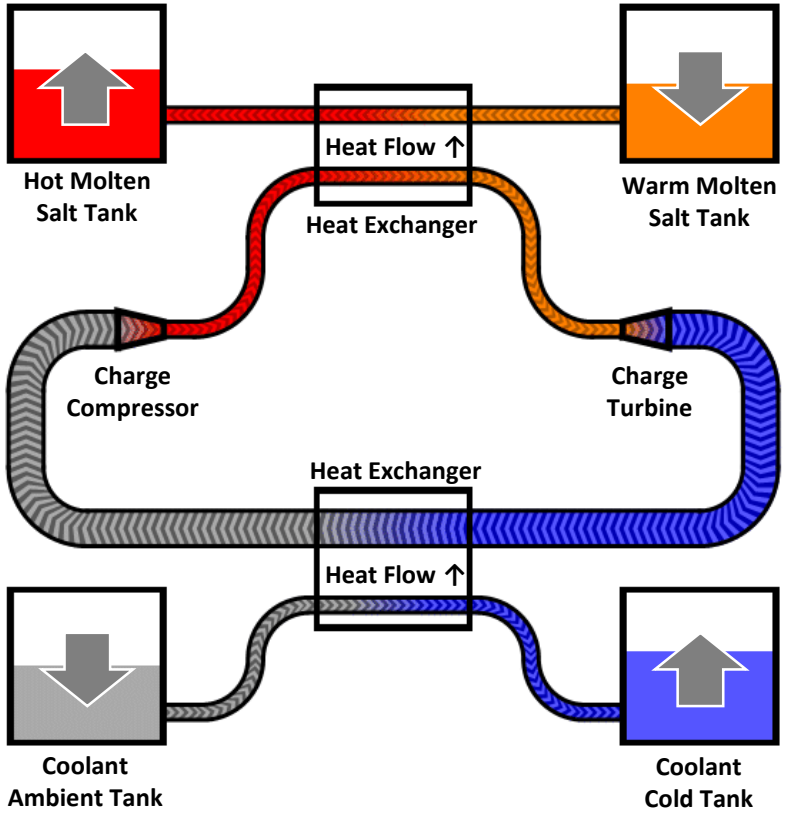
   The temperature difference is converted back to electrical energy by a heat engine.

5. **DISTRIBUTES**

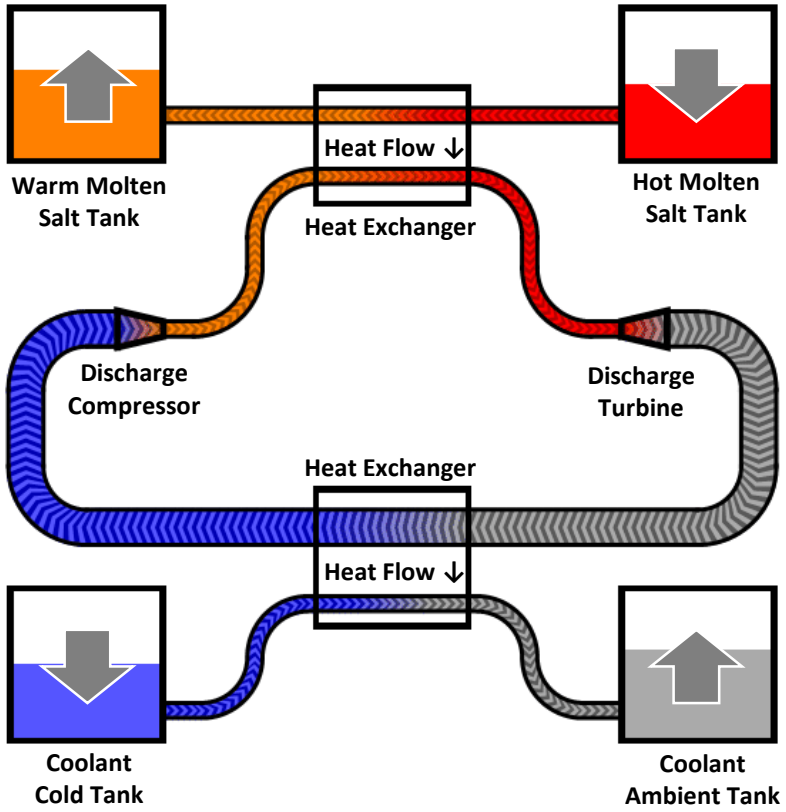
   Electricity is sent back to the grid when it is needed.

An Old Concept for a New Application

Charge Mode
(heat pump)



Discharge Mode
(heat engine)



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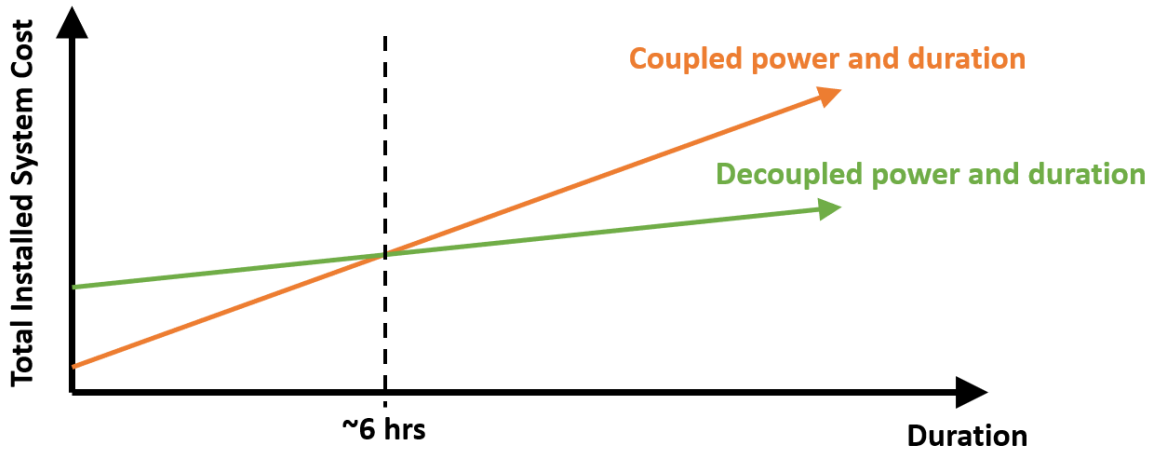
Malta has Transformational Potential

- Best in class cost profile
  - Costs competitive with future projections of li-ion batteries
  - 10+ hour duration base case
  - Duration can be increased from base case with minimal additional cost
  - ~30 yr plant design life
- Flexible deployment
  - Site agnostic
  - Variable nominal sizing



Technical soundness and existence of manufacturing ecosystem means that Malta is an implementation challenge not an R&D challenge

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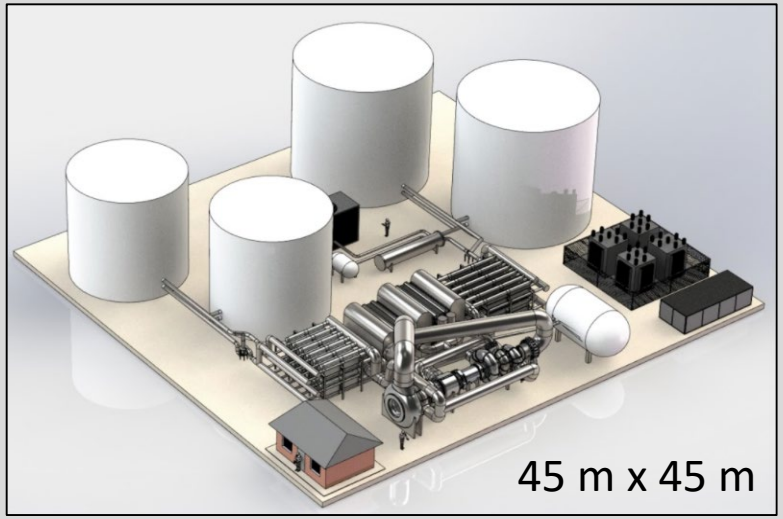
Sizes and Duration

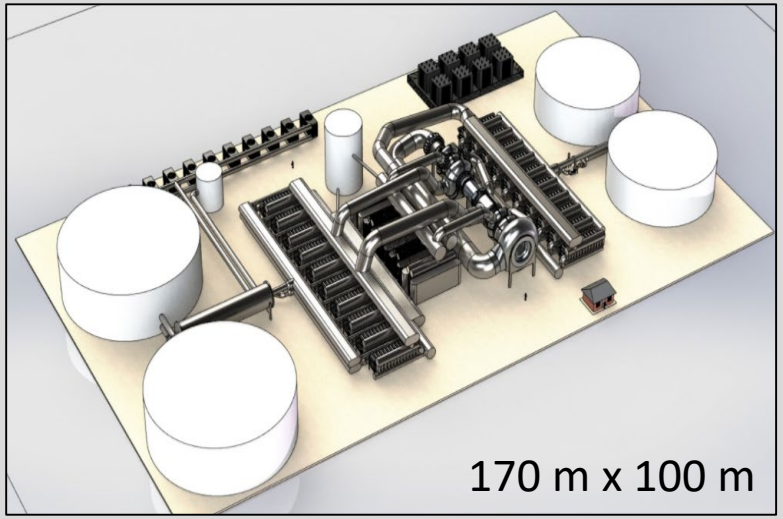
Nominal 10 MW

- Islands, Isolated, Weak Grids
- Critical Backup (e.g., data centers)
- Transmission & Distribution Deferral
- Renewable energy projects to firm power
- Microgrids, Military Bases



Nominal 100 MW

- Wholesale energy markets
- Vertically integrated utilities
- Storage mandates/incentives
- Renewable energy projects to firm power



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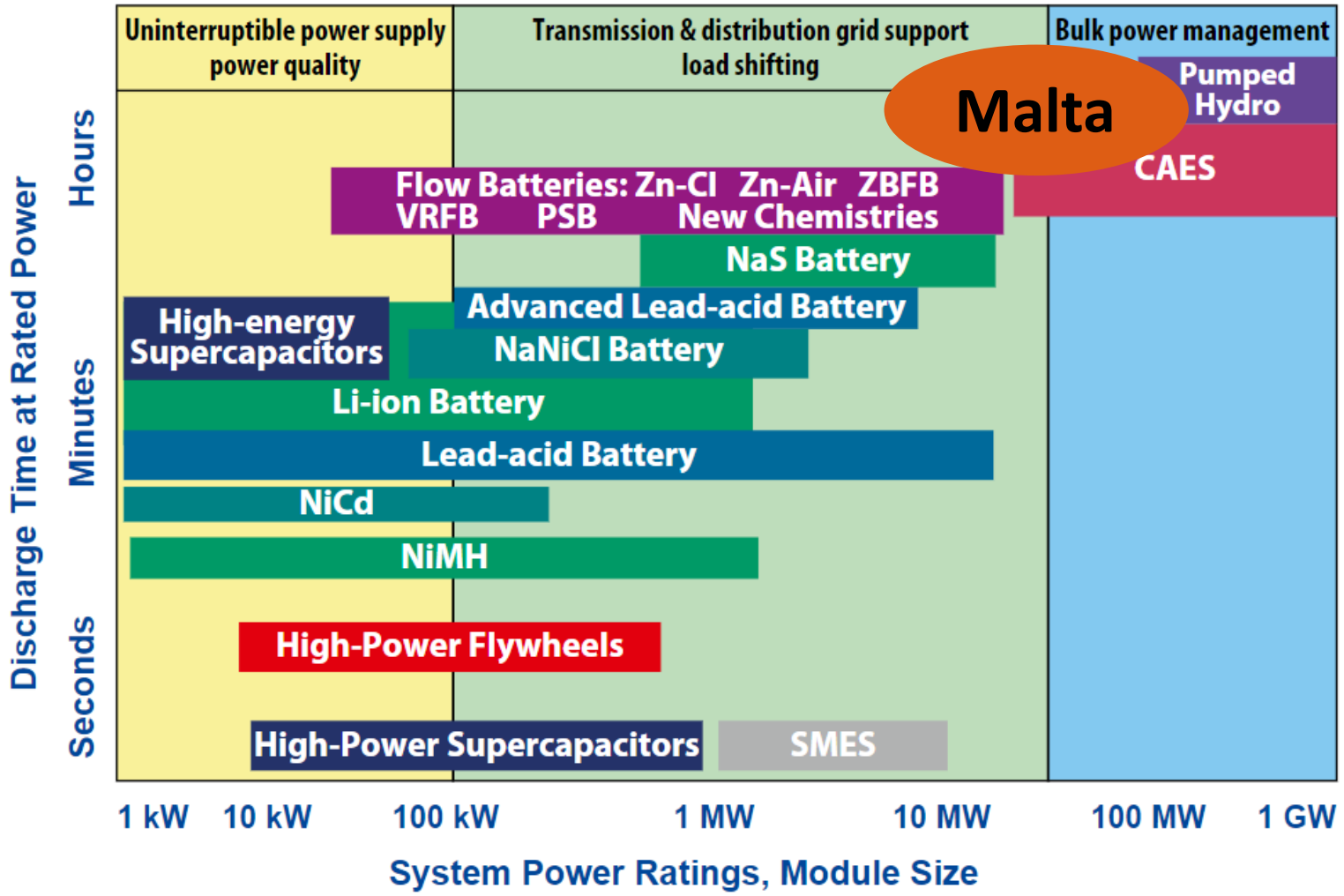
The Competitive Landscape

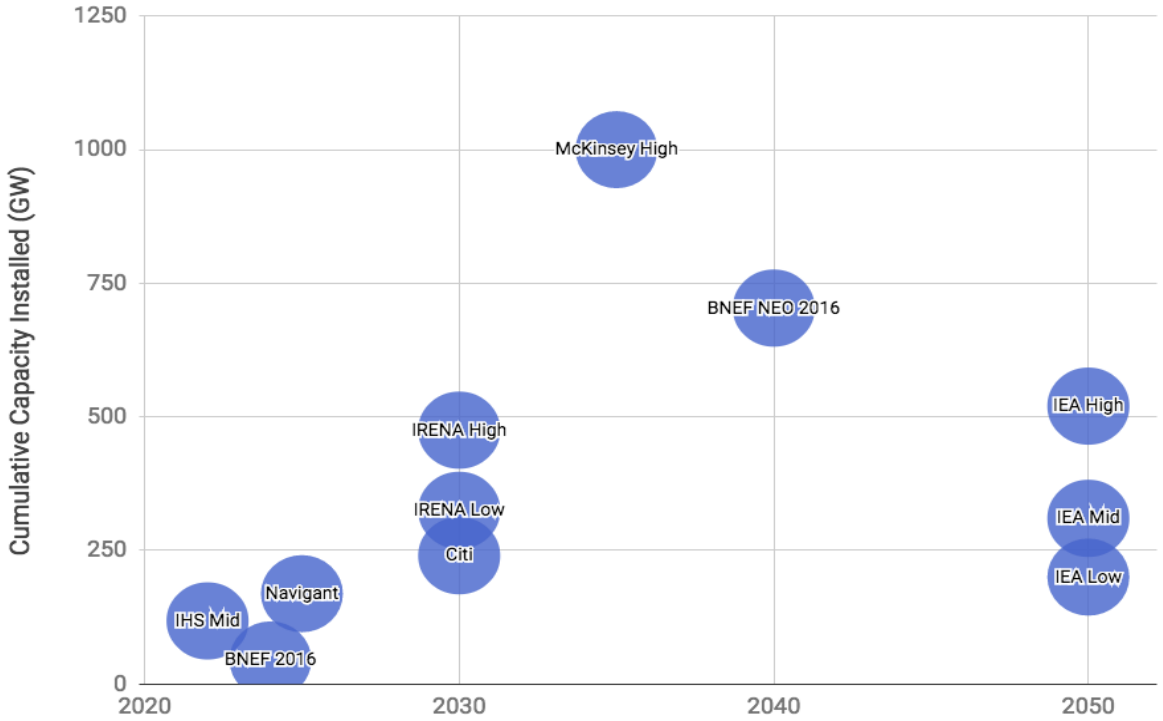


Source: US DOE/EPRI, 2015

Large Addressable Storage Market

Estimates for energy storage vary significantly

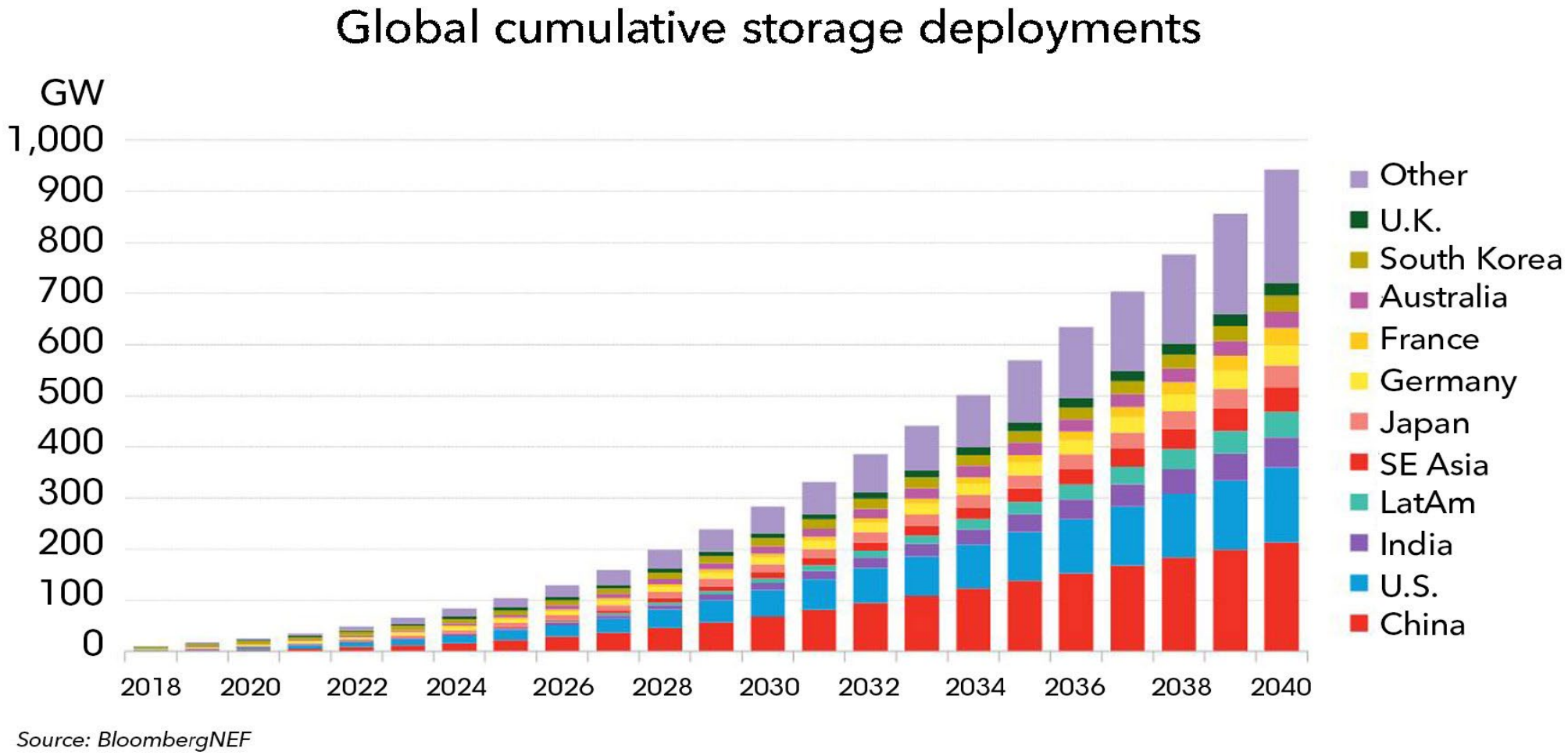
Even in the lowest estimates, 100s of GW will be installed worldwide by 2030



Report	Cumulative Capacity (GW)	Year	CAGR (%)
IHS Mid	118	2022	66.7
Navigant	169	2025	37.3
IRENA High	475	2030	29.5
IRENA Low	325	2030	24.6
McKinsey High	1000	2035	24.5
Citi	240	2030	20.7
BNEF NEO 2016	703.5	2040	14.9
BNEF 2016	45	2024	10.6
IEA High	520	2050	7.2
IEA Mid	310	2050	4.7
IEA Low	200	2050	2.4

BNEF 2016 Projection for 2040: 700 GW

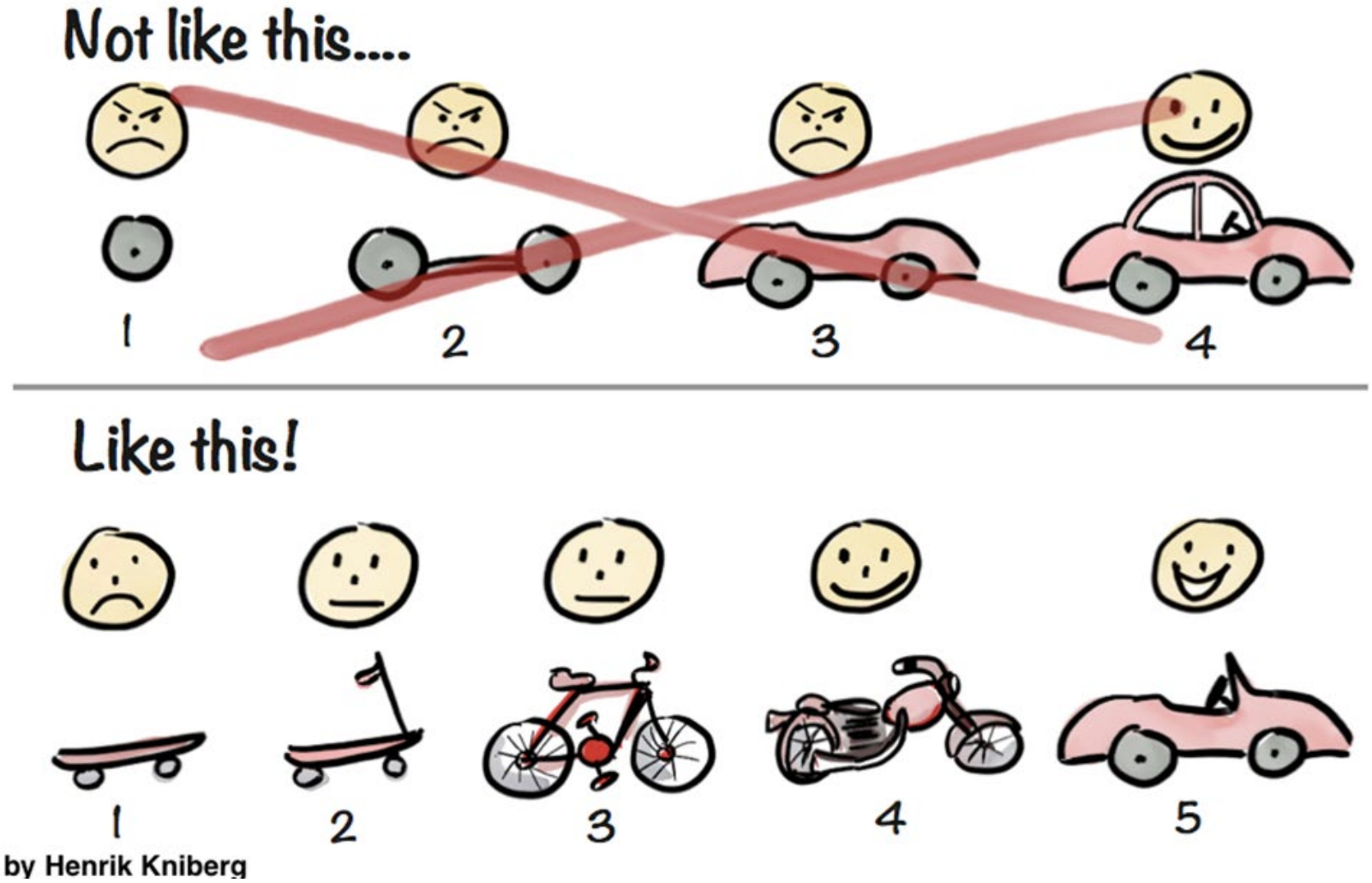
BNEF 2018 Projection: 950 GW by 2040



Source: BloombergNEF

A Philosophy of Targeting the MVP for First Pilot

- Time to market, cost, and efficiency are key
- MVP to Gen 1 to Gen 2 product approach critical



The Growing Case in the US for Long-Duration Energy Storage

Renewable Energy Penetration	Creates a need to balance supply and demand, utilizing curtailed energy	High Penetration Challenges Cost Effectiveness	Over 360 GW of Capacity Additions Projected through 2030
Thermal Generation Retirements	Multiple Gigawatts of Retirements Creates Need for Capacity Additions	Reliability Challenges Develop that Ultimately Appear in Eroded Reserve Margins	27 GW of Confirmed Retirements Through 2022 with 91 GW in Stress Test Case
New Types of Load Growth Coming	New Load can be Tremendous with Electrification of Transportation Alone	The Availability of Electrical Energy and Capacity Enables New Electrification	80 TWh/yr of Sustained Load Growth for EVs alone with GWs of Peak Demand Additions
Transmission Thermal and Voltage Violations	Retirements and Remote Generation Driving Violations	New Generation Locations Alters the Grid Architecture	$20B in year-over-year investment

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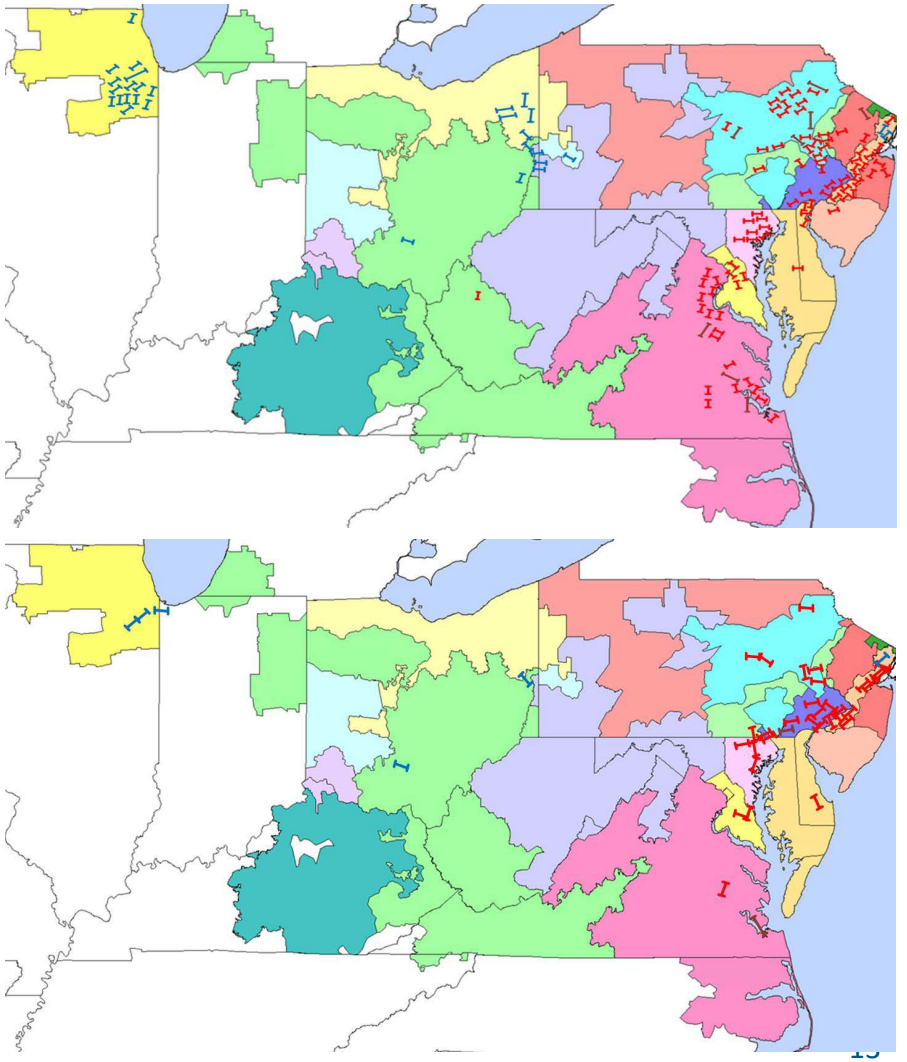
Why Transmission Violations Matter…

Location, Location, Location…

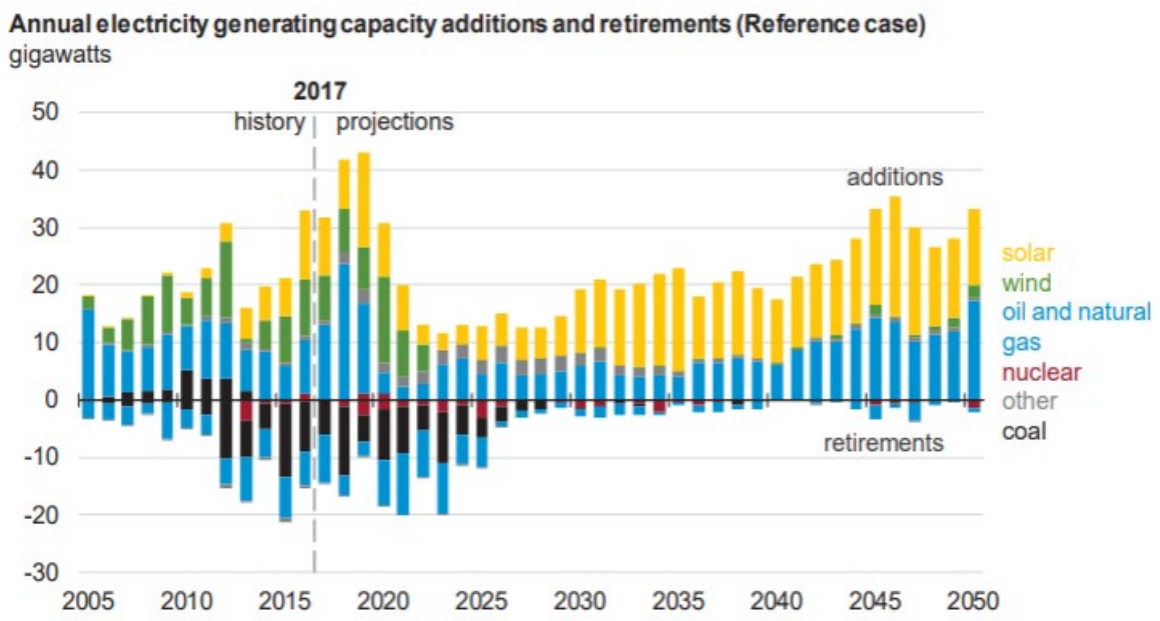
- Retirements and additions *change load flows* on the grid leading to thermal and voltage violations
- Transmission planning hadn't yet fully adopted long-duration, location-independent energy storage as a complete alternative but will
- Social pressure with wildfires may limit transmission installations favoring localized energy storage solutions…this will drive the market to seek *Non-Transmission Alternatives*



* PSE&G Thermal Violation Locations for 2022 Case (Summer and Winter

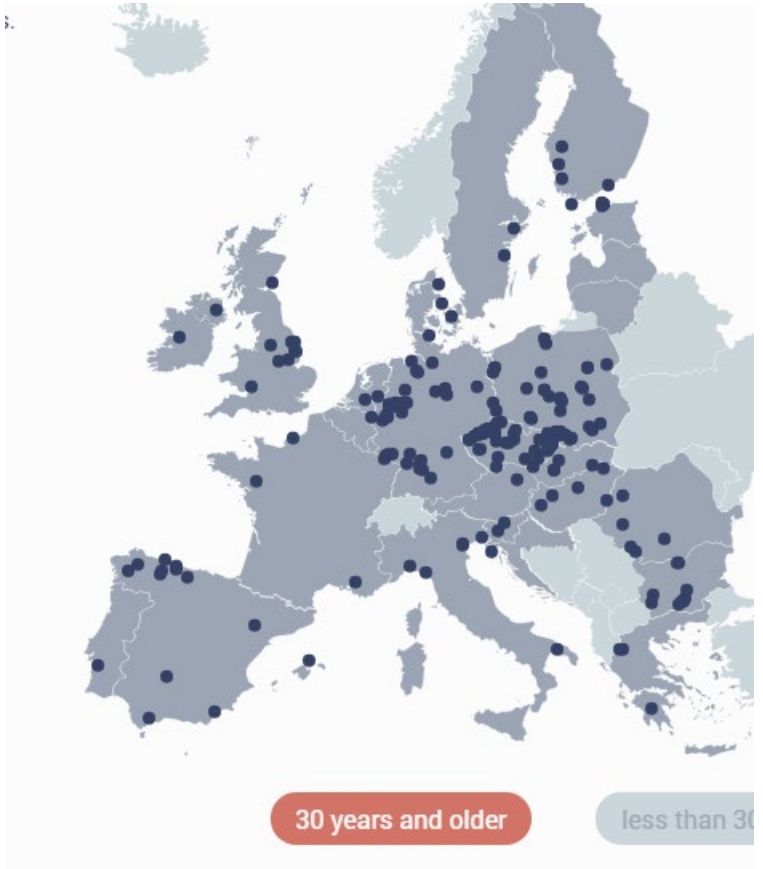
Classical Thermal Generation is Disappearing

- Electrification is increasing
- New fossil fuel generation in low demand
- Wind and solar plants are on back-order
- **Future of electricity generation is gated by the success of (thermal) electricity storage**



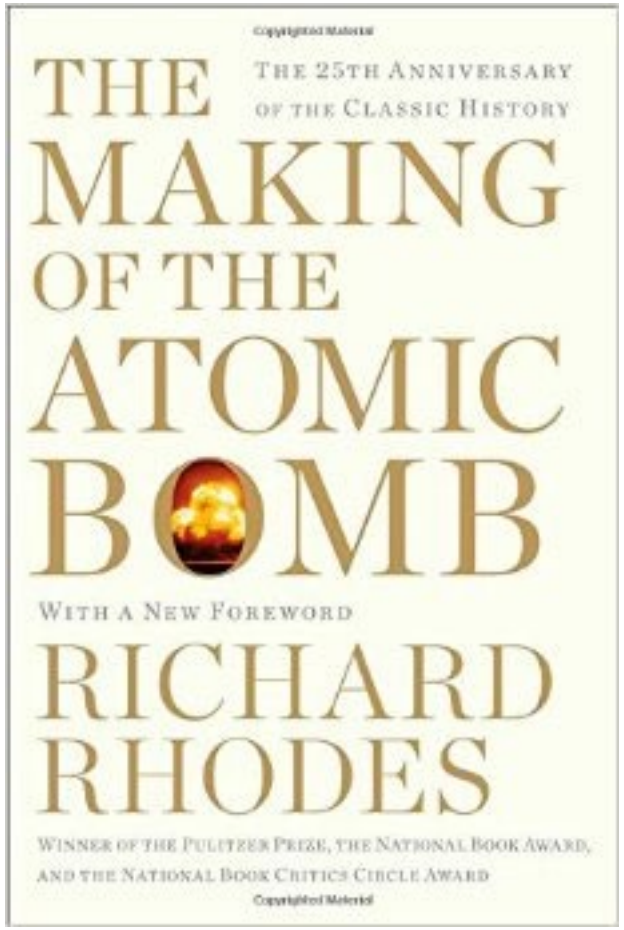
Source: Annual Energy Outlook, EIA 2018

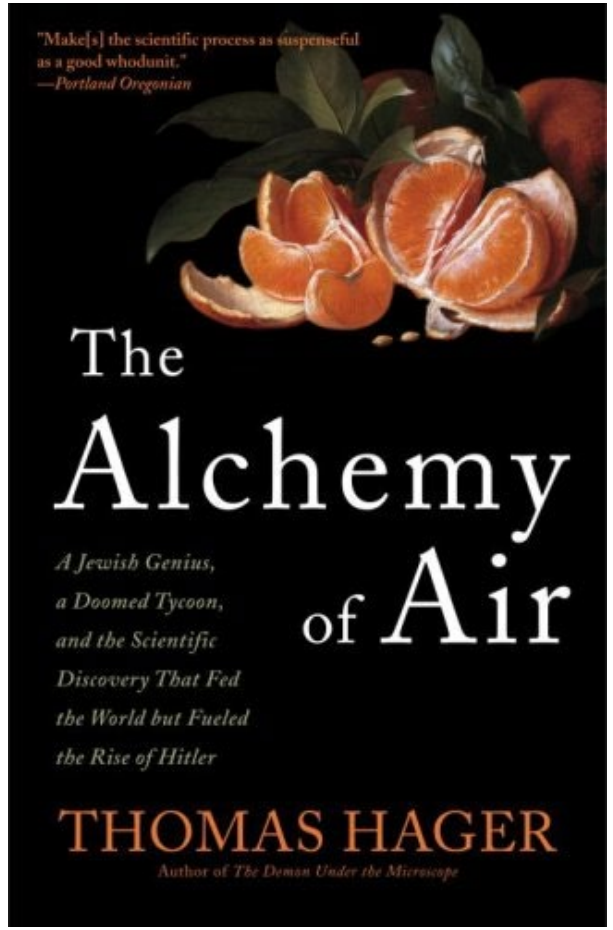
European Coal Plants @ >30 yrs old



Smooth the Path to Implementation

- Need to **establish an ecosystem as well as a technology**
  - EPCs
  - Manufacturing
  - O&M supply chains and protocols
  - Formation of new codes and standards
- **Tech-to-market strategies**
  - Staged development (identifying the MVP)
  - Staged funding sources
  - Staged teaming





Thank You