Lifespan Analysis of Utility Scale Energy Storage Options

Evaluating investment and technology development opportunities for carbon-free, grid-scale power systems

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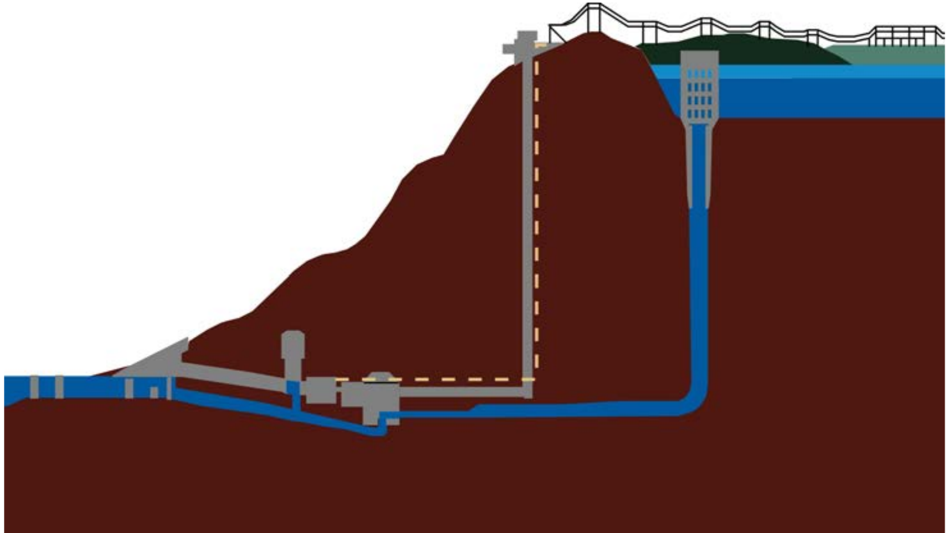


Our Hypothesis

A carbon free economy based on exploiting continuous current incoming energy flux must be cheaper than exploiting hydrocarbon-based energy stored in the ground over the ages.

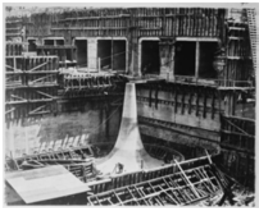
AND "green energy" must be so cheap that nobody can refuse abandoning their sunk investments or bother to waste time exploiting hydrocarbon energy stores.

> Photosynthetic workers squirreled carbon away long ago for bio-sequestration, before the rise of lignin decomposers.

To do this we have to understand where/what are the costs, what are the physics of the costs, and then innovate relentlessly to drive them down while maximizing the impact of the resources we can allocate to the task.

> Hype and hope cannot be relied upon as there is no time to waste on what makes us feel good but has no real impact.
>
> *Just as physical metrology and measurement standards are critical for industry to commercialize ideas, an analog is needed in finance and business aspects of green energy systems over entire life cycle*

Considerations



Longevity: Infrastructure investments are intrinsically long term:

- Must last for generations
- 100 years typical for hydropower plants.

Storage capacity: carbon free resources are dominated by intermittent options: wind and solar

- Eschewing dispatchable sources obligates extended run times on stored energy

Project financing:

- Appropriate models need to fit the risk profile

Models developed to guide decision making must be open-source and peer reviewable to ensure integrity

- The consequences of failing to optimize resource application are global and potentially existential.

Finance + Physics => Innovation

Innovation Discovery path:

- Find
  - biggest costs
  - dominant contributor
- Identify
  - dominant physics
    - Which variables raised to the highest power most affect cost
  - Prior art and its limitations
- Innovate
  - New product
  - New machines to make the product

Peanut Butter and Jelly

Pumped Storage Hydropower and Chemical Batteries

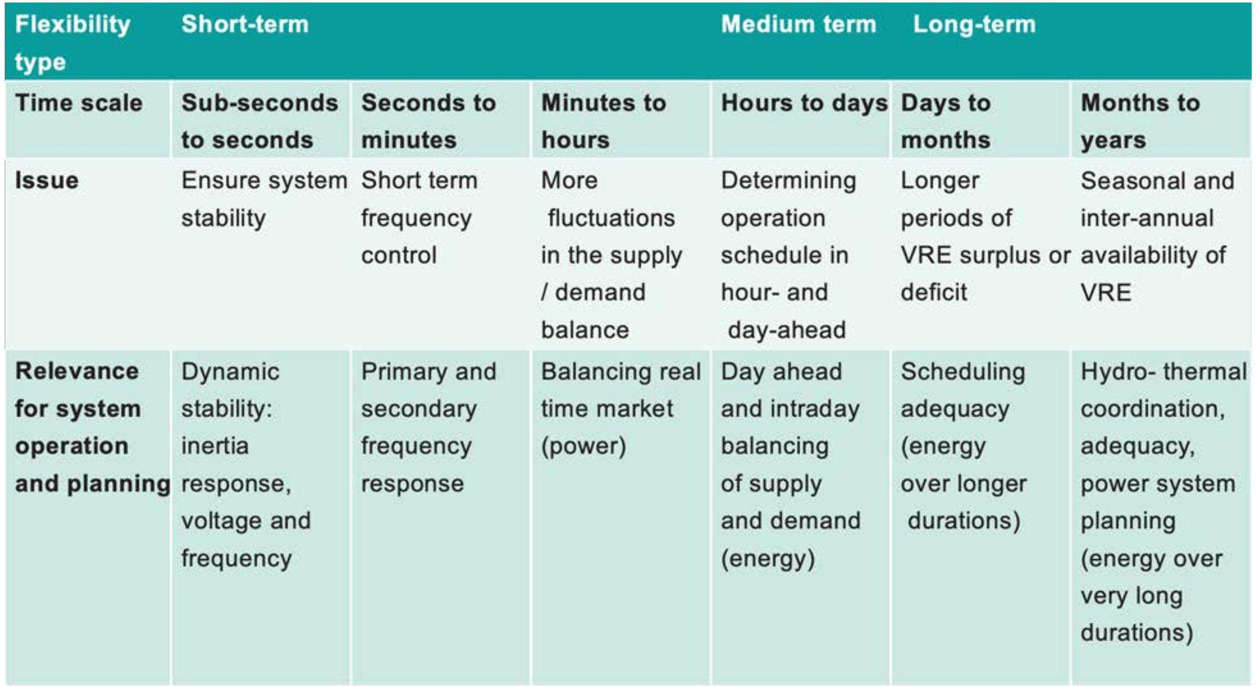
This is NOT a presentation on which is better…

- One is a source of long-term energy
- The other gives a quick sugar rush
- Other forms of nutrition also can be considered (gravity, flywheels…)

How much of each depends on the journey…

- And what are the unknowns…
  - Cold weather needs more calories…
  - Hot weather needs more salt…
- You can only carry so much!
- The relative “goodness” of infrastructure scale investments is dominated by long-term, multi-decade to century-scale modeling.
- No single solution solves all problems.

Different timescales of power system flexibility (source: IEA, 2018)

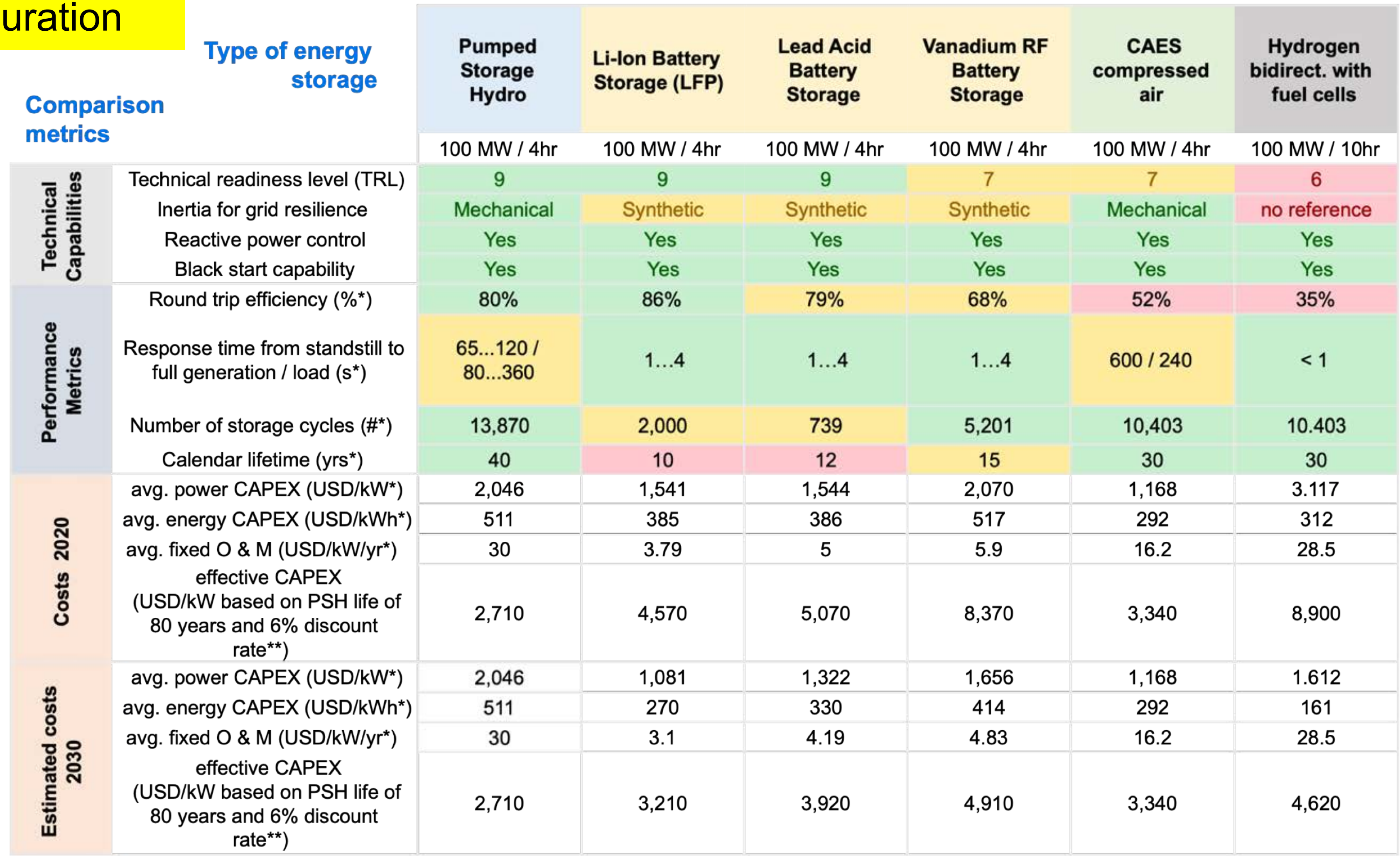


Flexibility type	Short-term			Medium term	Long-term	
Time scale	**Sub-seconds to seconds**	**Seconds to minutes**	**Minutes to hours**	**Hours to days**	**Days to months**	**Months to years**
Issue	Ensure system stability	Short term frequency control	More fluctuations in the supply / demand balance	Determining operation schedule in hour- and day-ahead	Longer periods of VRE surplus or deficit	Seasonal and inter-annual availability of VRE
Relevance for system operation and planning	Dynamic stability: inertia response, voltage and frequency	Primary and secondary frequency response	Balancing real time market (power)	Day ahead and intraday balancing of supply and demand (energy)	Scheduling adequacy (energy over longer durations)	Hydro- thermal coordination, adequacy, power system planning (energy over very long durations)

Source: Pumped Storage Hydropower International Forum: Capabilities, Costs & Innovation Working Group September 2021 (www.hydropower.org)
https://www.ieahydro.org/media/51145259/IEAHydroTCP_AnnexIX_White%20Paper_Oct2019.pdf

Comparison of energy storage technologies for 100 MW and 4-hour duration in 2020 and 2030

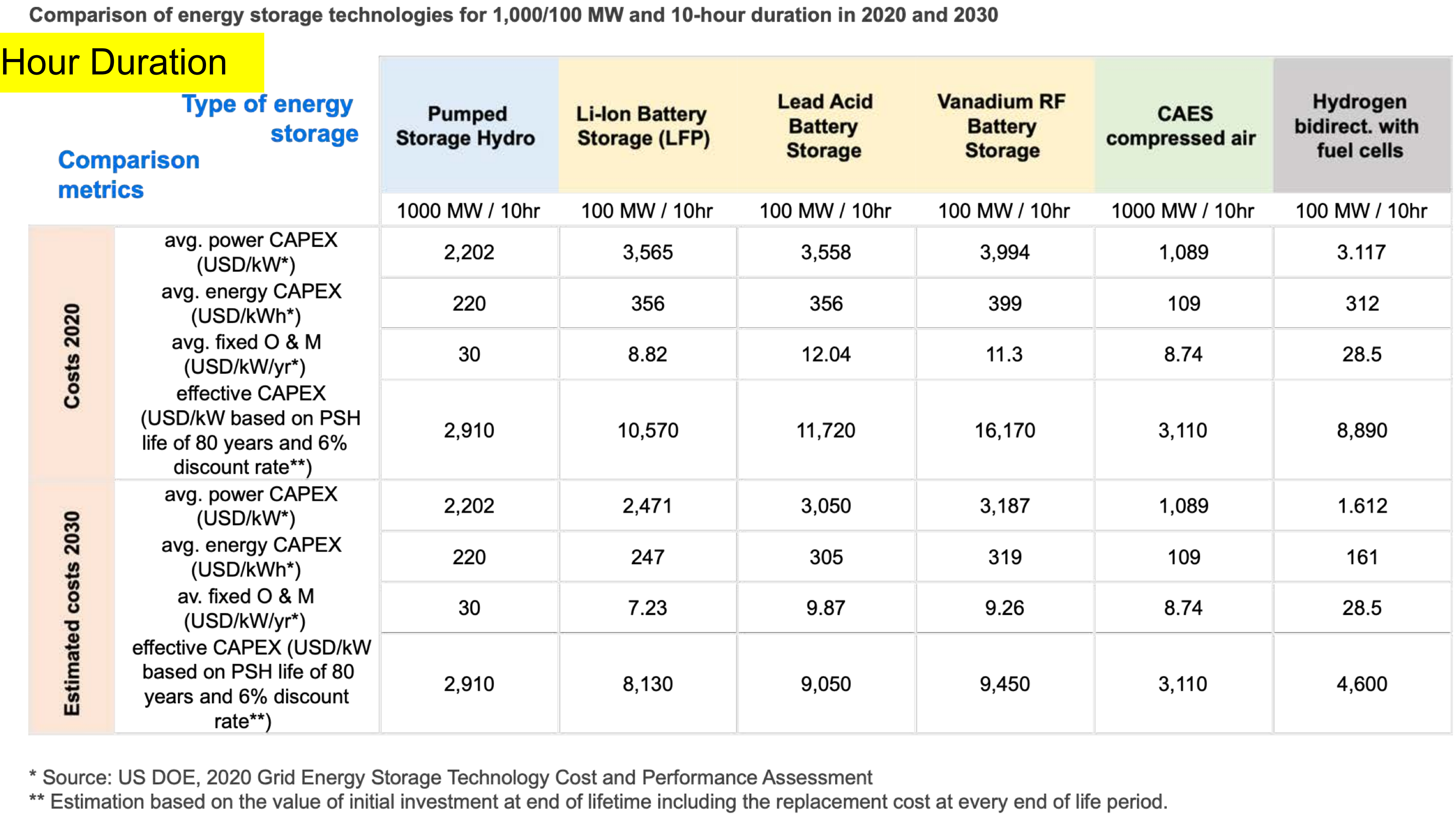
4 Hour Duration



Comparison metrics	Type of energy storage	Pumped Storage Hydro	Li-Ion Battery Storage (LFP)	Lead Acid Battery Storage	Vanadium RF Battery Storage	CAES compressed air	Hydrogen bidirect. with fuel cells
		100 MW / 4hr	100 MW / 4hr	100 MW / 4hr	100 MW / 4hr	100 MW / 4hr	100 MW / 10hr
Technical Capabilities	Technical readiness level (TRL)	9	9	9	7	7	6
	Inertia for grid resilience	Mechanical	Synthetic	Synthetic	Synthetic	Mechanical	no reference
	Reactive power control	Yes	Yes	Yes	Yes	Yes	Yes
	Black start capability	Yes	Yes	Yes	Yes	Yes	Yes
Performance Metrics	Round trip efficiency (%*)	80%	86%	79%	68%	52%	35%
	Response time from standstill to full generation / load (s*)	65...120 / 80...360	1...4	1...4	1...4	600 / 240	< 1
	Number of storage cycles (#*)	13,870	2,000	739	5,201	10,403	10.403
	Calendar lifetime (yrs*)	40	10	12	15	30	30
Costs 2020	avg. power CAPEX (USD/kW*)	2,046	1,541	1,544	2,070	1,168	3.117
	avg. energy CAPEX (USD/kWh*)	511	385	386	517	292	312
	avg. fixed O & M (USD/kW/yr*)	30	3.79	5	5.9	16.2	28.5
	effective CAPEX (USD/kW based on PSH life of 80 years and 6% discount rate**)	2,710	4,570	5,070	8,370	3,340	8,900
Estimated costs 2030	avg. power CAPEX (USD/kW*)	2,046	1,081	1,322	1,656	1,168	1.612
	avg. energy CAPEX (USD/kWh*)	511	270	330	414	292	161
	avg. fixed O & M (USD/kW/yr*)	30	3.1	4.19	4.83	16.2	28.5
	effective CAPEX (USD/kW based on PSH life of 80 years and 6% discount rate**)	2,710	3,210	3,920	4,910	3,340	4,620

Source: US DOE, 2020 Grid Energy Storage Technology Cost and Performance Assessment tabulated for Pumped Storage Hydropower International Forum: Capabilities, Costs & Innovation Working Group, September 2021 (www.hydropower.org)
https://assets-global.website-files.com/5f749e4b9399c80b5e421384/61432796645661f940f277a8_IFPSH%20-%20PSH%20Capabilities%20and%20Costs_15%20Sept.pdf

10 Hour Duration



Comparison of energy storage technologies for 1,000/100 MW and 10-hour duration in 2020 and 2030

	Type of energy storage Comparison metrics	Pumped Storage Hydro	Li-Ion Battery Storage (LFP)	Lead Acid Battery Storage	Vanadium RF Battery Storage	CAES compressed air	Hydrogen bidirect. with fuel cells
		1000 MW / 10hr	100 MW / 10hr	100 MW / 10hr	100 MW / 10hr	1000 MW / 10hr	100 MW / 10hr
Costs 2020	avg. power CAPEX (USD/kW*)	2,202	3,565	3,558	3,994	1,089	3.117
	avg. energy CAPEX (USD/kWh*)	220	356	356	399	109	312
	avg. fixed O & M (USD/kW/yr*)	30	8.82	12.04	11.3	8.74	28.5
	effective CAPEX (USD/kW based on PSH life of 80 years and 6% discount rate**)	2,910	10,570	11,720	16,170	3,110	8,890
Estimated costs 2030	avg. power CAPEX (USD/kW*)	2,202	2,471	3,050	3,187	1,089	1.612
	avg. energy CAPEX (USD/kWh*)	220	247	305	319	109	161
	av. fixed O & M (USD/kW/yr*)	30	7.23	9.87	9.26	8.74	28.5
	effective CAPEX (USD/kW based on PSH life of 80 years and 6% discount rate**)	2,910	8,130	9,050	9,450	3,110	4,600

* Source: US DOE, 2020 Grid Energy Storage Technology Cost and Performance Assessment

** Estimation based on the value of initial investment at end of lifetime including the replacement cost at every end of life period.

Source: US DOE, 2020 Grid Energy Storage Technology Cost and Performance Assessment tabulated for Pumped Storage Hydropower International Forum: Capabilities, Costs & Innovation Working Group, September 2021 (www.hydropower.org)
https://assets-global.website-files.com/5f749e4b9399c80b5e421384/61432796645661f940f277a8_IFPSH%20-%20PSH%20Capabilities%20and%20Costs_15%20Sept.pdf

Forward Projections

Optimism is warranted, but economic projections and investments must be grounded in defensible reality.

Projecting sparse and unstable data forward is a fool’s errand yet is the only reasonable path we have.

“Then a miracle occurs” (e.g., *Fusion!)* is not a rational basis for planning.

“It’s tough to make predictions, especially about the future”

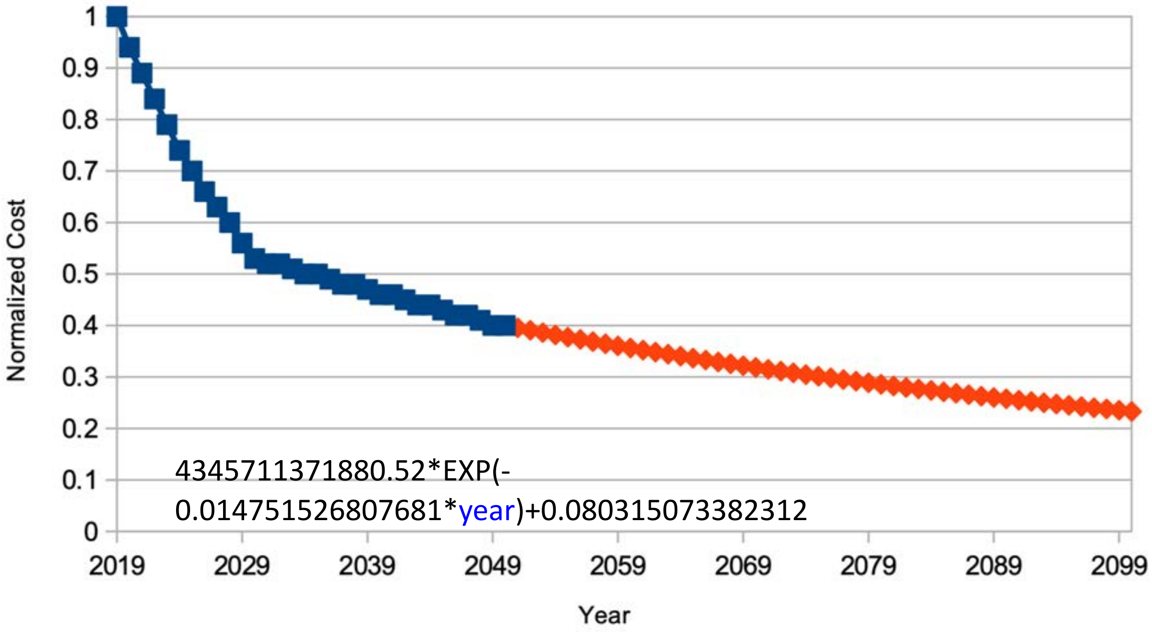
- Yogi Berra

Long Term Projections Example: Battery Cost

Forward projecting from forward projections means high uncertainty

Good decision making is predicated on continuous and diligent data collection

Humanity will have to live with the results for many decades



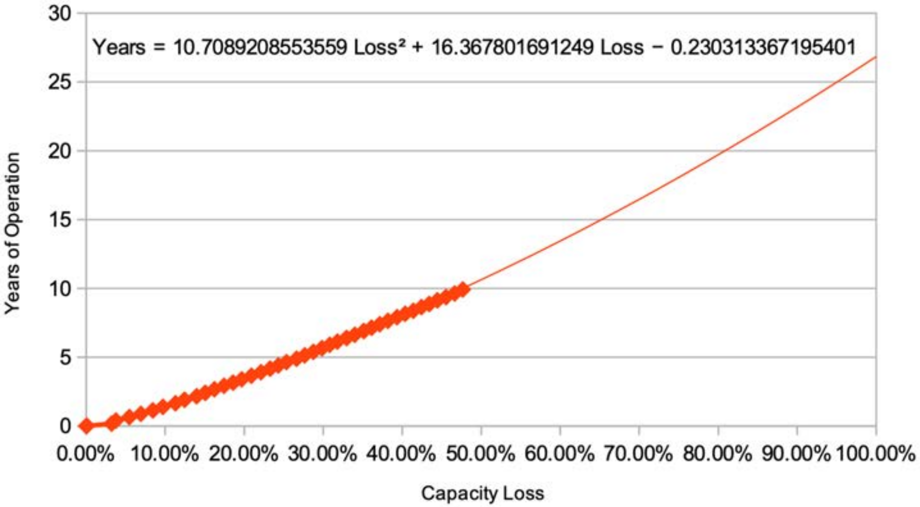
Battery cost forward projection per KW*h

Base data source: Cost Projections for Utility-Scale Battery Storage: 2020 Update https://www.nrel.gov/docs/fy20osti/75385.pdf

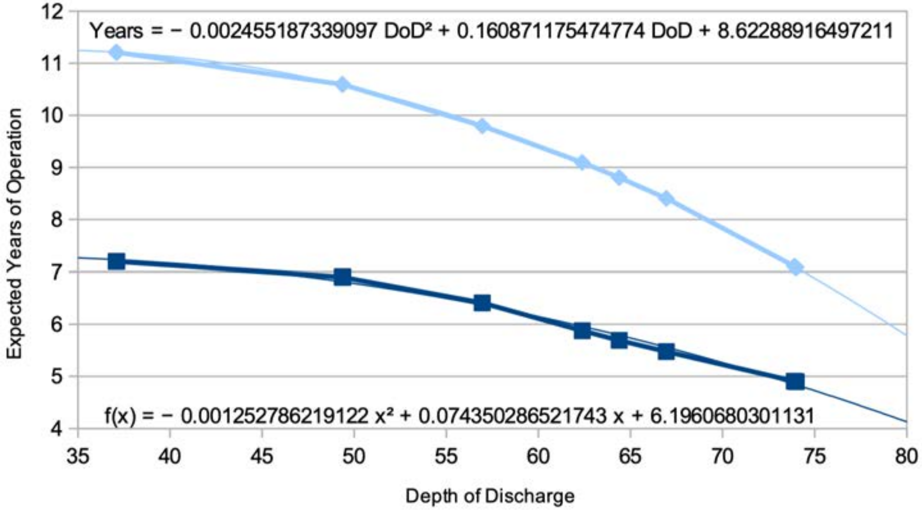
Projecting outside normal operating envelopes for full system analysis

Example: analysis of depth of discharge and aging.

All significant components need forward regression.

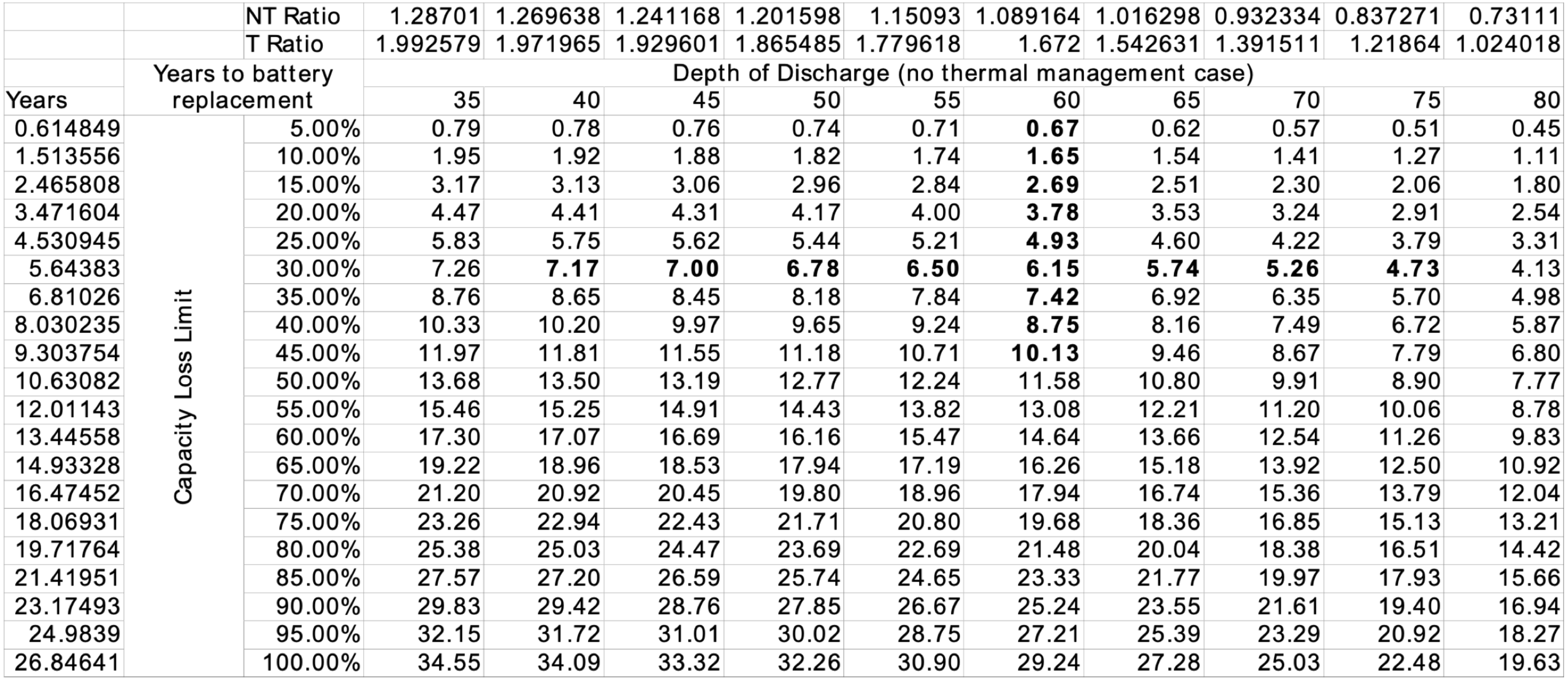


Base data source: Life Prediction Model for GridConnected Li-ion Battery Energy Storage System https://www.nrel.gov/docs/fy17osti/67102.pdf



Base data source: Capacity Fade in Lithium-Ion Batteries and Cyclic Aging over Various State-of-Charge Ranges https://www.mdpi.com/2071-1050/11/23/6697

Building data models to integrate into large scale economic models



		NT Ratio	1.28701	1.269638	1.241168	1.201598	1.15093	1.089164	1.016298	0.932334	0.837271	0.73111
		T Ratio	1.992579	1.971965	1.929601	1.865485	1.779618	1.672	1.542631	1.391511	1.21864	1.024018
	Years to battery replacement		Depth of Discharge (no thermal management case)									
Years			35	40	45	50	55	60	65	70	75	80
0.614849	Capacity Loss Limit	5.00%	0.79	0.78	0.76	0.74	0.71	**0.67**	0.62	0.57	0.51	0.45
1.513556		10.00%	1.95	1.92	1.88	1.82	1.74	**1.65**	1.54	1.41	1.27	1.11
2.465808		15.00%	3.17	3.13	3.06	2.96	2.84	**2.69**	2.51	2.30	2.06	1.80
3.471604		20.00%	4.47	4.41	4.31	4.17	4.00	**3.78**	3.53	3.24	2.91	2.54
4.530945		25.00%	5.83	5.75	5.62	5.44	5.21	**4.93**	4.60	4.22	3.79	3.31
5.64383		30.00%	7.26	**7.17**	**7.00**	**6.78**	**6.50**	**6.15**	**5.74**	**5.26**	**4.73**	4.13
6.81026		35.00%	8.76	8.65	8.45	8.18	7.84	**7.42**	6.92	6.35	5.70	4.98
8.030235		40.00%	10.33	10.20	9.97	9.65	9.24	**8.75**	8.16	7.49	6.72	5.87
9.303754		45.00%	11.97	11.81	11.55	11.18	10.71	**10.13**	9.46	8.67	7.79	6.80
10.63082		50.00%	13.68	13.50	13.19	12.77	12.24	11.58	10.80	9.91	8.90	7.77
12.01143		55.00%	15.46	15.25	14.91	14.43	13.82	13.08	12.21	11.20	10.06	8.78
13.44558		60.00%	17.30	17.07	16.69	16.16	15.47	14.64	13.66	12.54	11.26	9.83
14.93328		65.00%	19.22	18.96	18.53	17.94	17.19	16.26	15.18	13.92	12.50	10.92
16.47452		70.00%	21.20	20.92	20.45	19.80	18.96	17.94	16.74	15.36	13.79	12.04
18.06931		75.00%	23.26	22.94	22.43	21.71	20.80	19.68	18.36	16.85	15.13	13.21
19.71764		80.00%	25.38	25.03	24.47	23.69	22.69	21.48	20.04	18.38	16.51	14.42
21.41951		85.00%	27.57	27.20	26.59	25.74	24.65	23.33	21.77	19.97	17.93	15.66
23.17493		90.00%	29.83	29.42	28.76	27.85	26.67	25.24	23.55	21.61	19.40	16.94
24.9839		95.00%	32.15	31.72	31.01	30.02	28.75	27.21	25.39	23.29	20.92	18.27
26.84641		100.00%	34.55	34.09	33.32	32.26	30.90	29.24	27.28	25.03	22.48	19.63

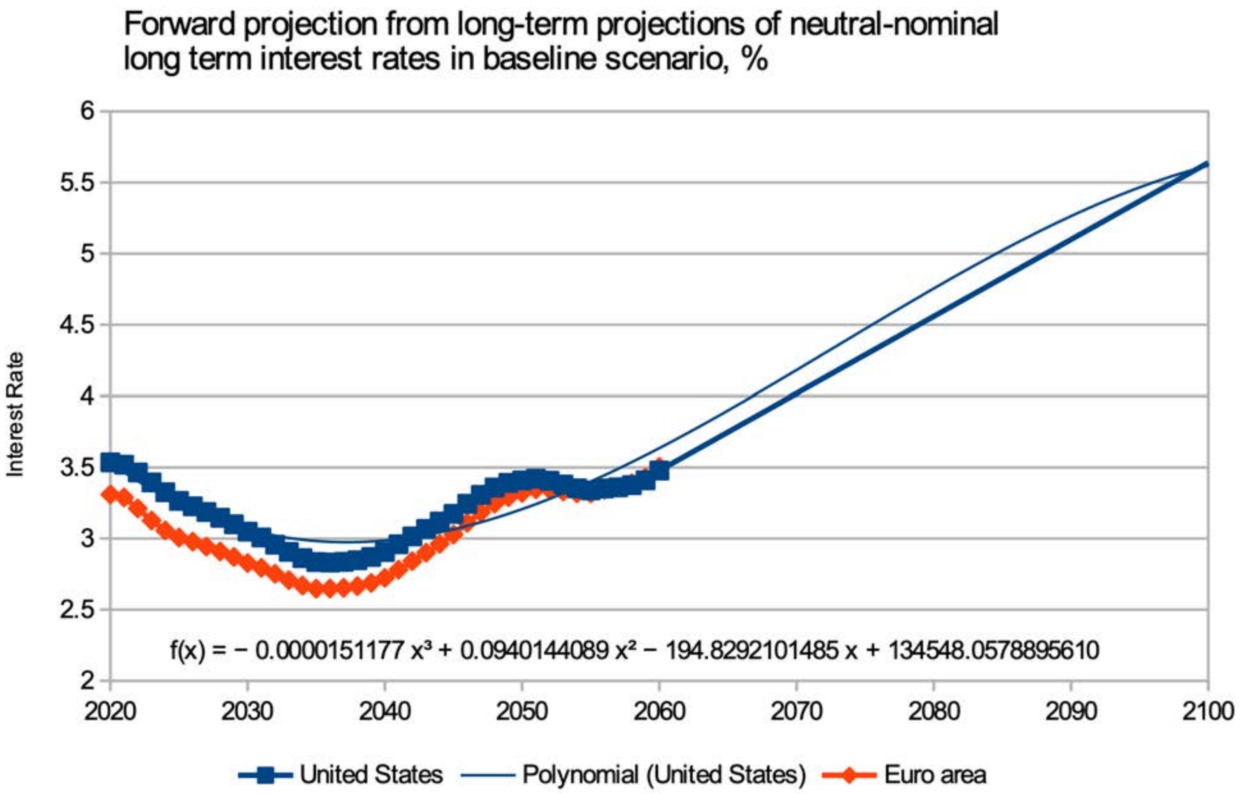
No Thermal Management Years of operation = $-0.001252786219122\,DoD^2 + 0.074350286521743\,DoD + 6.1960680301131$

Thermal Management years of operation = $-0.002455187339097\,DoD^2 + 0.160871175474774\,DoD + 8.62288916497211$

Capacity loss with years of operation = $0.7089208553558\,Loss^2 + 16.367801691249\,Loss - 0.230313367195403$

Interest rates, inflation, WACC, etc

Economics is a “dismal science” and near term projections of key economic variables are notoriously unreliable; planning for century-scale investments requires a high tolerance for risk and WACC-a-mole.



Forward projection from long-term projections of neutral-nominal long term interest rates in baseline scenario, %

Base data source: The Long View: Scenarios for the World Economy to 2060 https://www.oecd-ilibrary.org/economics/the-long-view_b4f4e03e-en;jsessionid=_ptP2X-S_uPctk74QTDgy-jE.ip-10-240-5-84

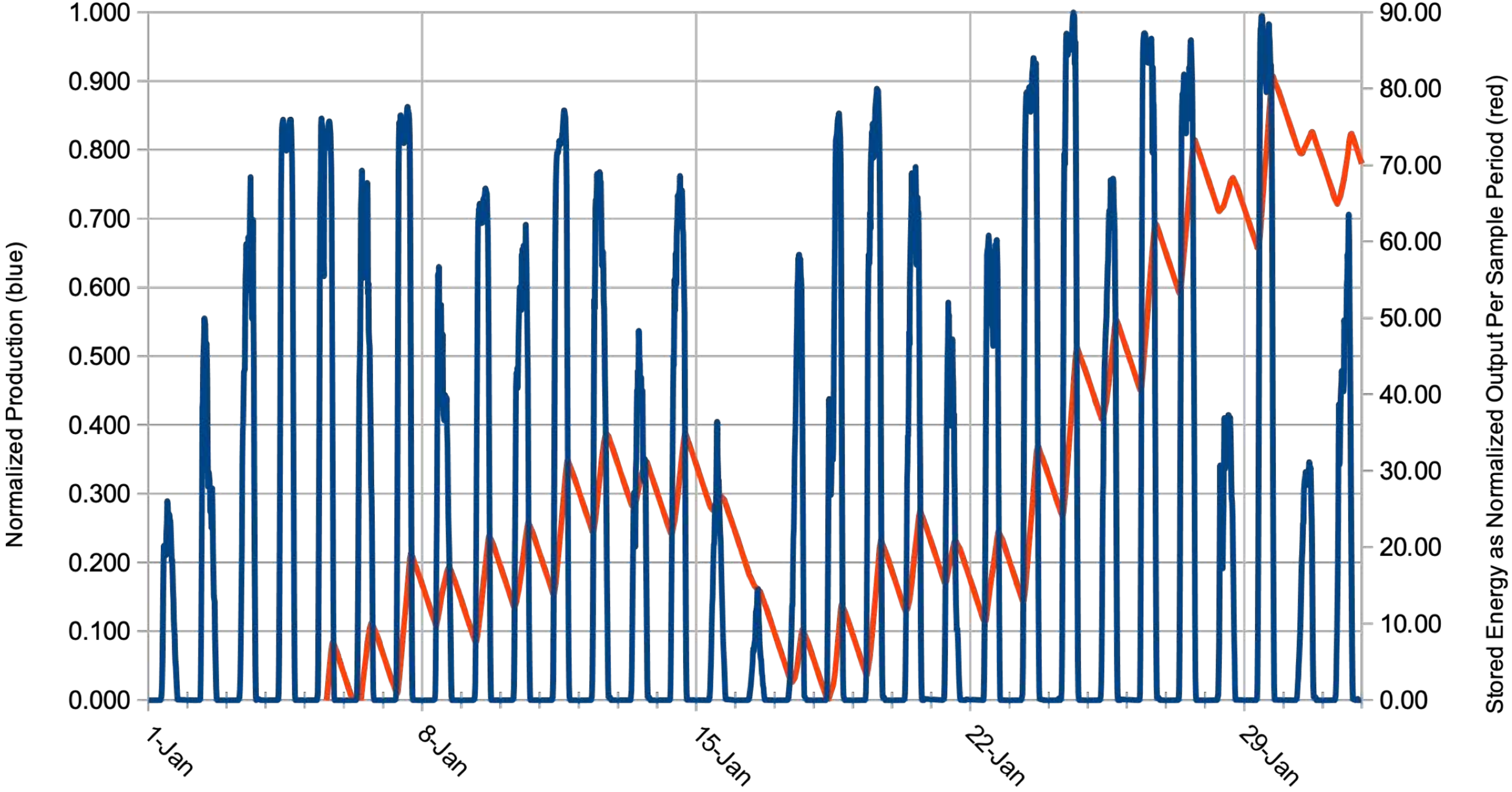
Source Intermittency & Storage

Capacity to avoid outage: 81.66 15 minute periods or 20.42 Hours

Peak generation to rated output: 6.24x

Assuming 80% RT efficiency

ERCOT Normalized Solar Output and calculated net PSH Storage in 15 minute intervals, January 2020



Base data source: ERCOT Interval Generation By Fuel Report 2020 http://www.ercot.com/content/wcm/lists/181766/FuelMixReport_PreviousYears.zip

Modeling long term operating costs

Initial capital expenditures are well understood, but MRO over century spans are less fully explored.

- Intrinsically, long term projections have high uncertainties.

Low “beta” for established technologies

- Core power distribution infrastructure is fairly stable and has been predictable
- Historical stability does not deny the possibility of future innovations.
- To achieve climate goals, innovation needed from photon to wall-plug.

How to do for not-yet-invented technology improvements?

- Chemical battery systems must continue to be area of active development.
- Lower costs and longer service life are reasonably predicted.
- Timing and significance of innovations resists explicit scheduling.
- Project from the best data available and update as new data arrives.

Peanut Butter and Jelly

Pumped Storage Hydropower and Chemical Batteries

Storage requirements for fully renewable systems dictate 20+ hour run times, depending on local renewable intermittency data.

Battery scaling is a significant multiplier on system cost and requires oversizing to trade lifetime for depth of discharge and age-related loss of capacity.

- Cost of replacement vs. frequency of replacement.
- Cost and capacity are volumetric.

PSH capacity is scaled by capacity and typically limited by geography.

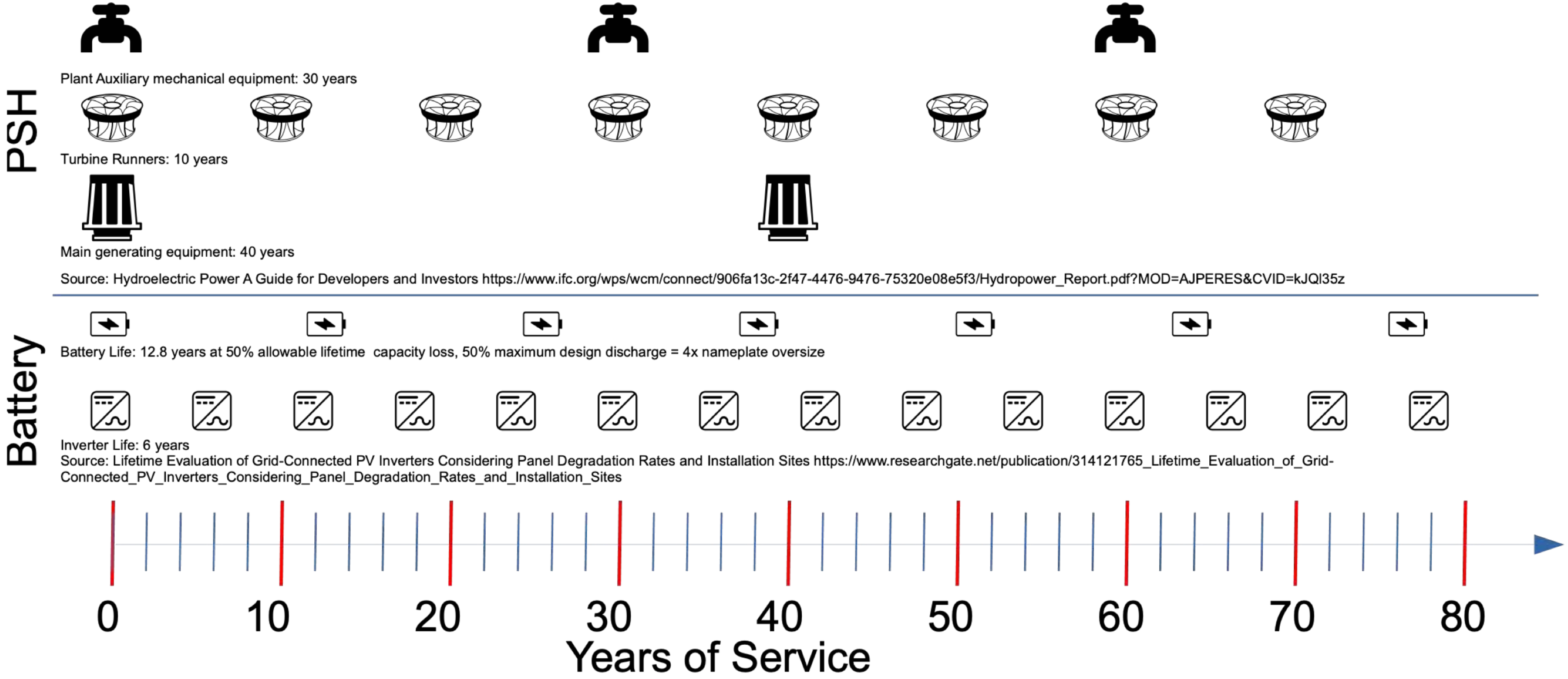
- Capacity is volumetric
- Cost of volume is driven by the surface area of the reservoirs.

Battery/inverter systems provide near instantaneous load response times while PSH systems are responsive in time scales of minutes.

- Note hydrocarbon fueled steam turbines may take an hour to spin up unless they are kept spinning on idle as they spew CO2.

Timeline of MRO & Replacements

PSH: Core technology is mature and replacement schedule predictions are low risk
Battery: Improvements in battery and inverter technology will likely lower cost of future replacements and extend replacement intervals



Plant Auxiliary mechanical equipment: 30 years

Turbine Runners: 10 years

Main generating equipment: 40 years

Source: Hydroelectric Power A Guide for Developers and Investors https://www.ifc.org/wps/wcm/connect/906fa13c-2f47-4476-9476-75320e08e5f3/Hydropower_Report.pdf?MOD=AJPERES&CVID=kJQl35z

Battery Life: 12.8 years at 50% allowable lifetime capacity loss, 50% maximum design discharge = 4x nameplate oversize

Inverter Life: 6 years
Source: Lifetime Evaluation of Grid-Connected PV Inverters Considering Panel Degradation Rates and Installation Sites https://www.researchgate.net/publication/314121765_Lifetime_Evaluation_of_Grid-Connected_PV_Inverters_Considering_Panel_Degradation_Rates_and_Installation_Sites

PSH Resource Distribution

Automatically identified sites to support at least 5GW/18 hour PSH storage

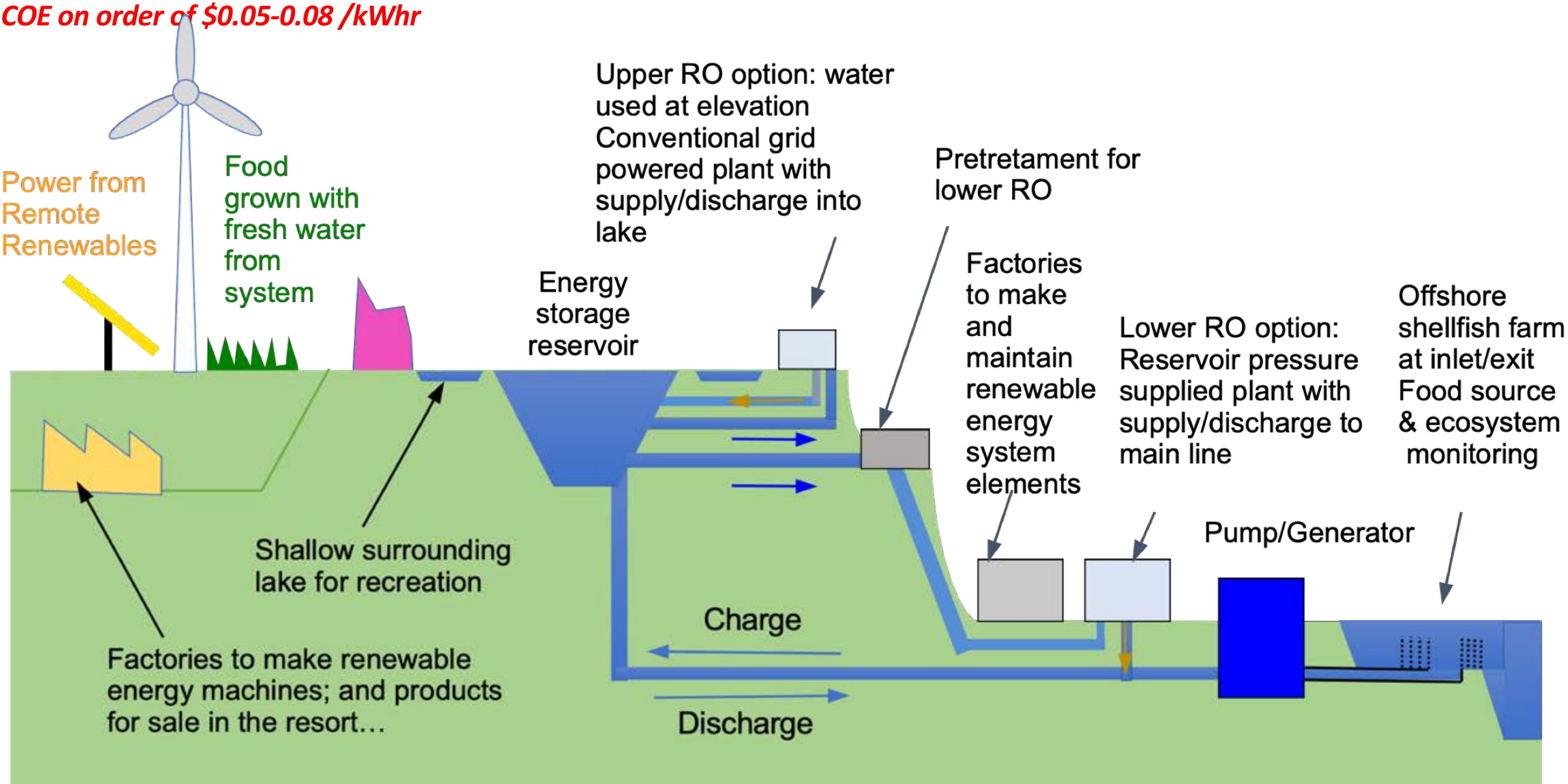
“An approximate guide to storage requirements for 100% renewable electricity, based on analysis for Australia, is 1 Gigawatt (GW) of power per million people with 20 hours of storage, which amounts to 20 GWh per million people*... Local analysis is required for an individual country. For example, ... the USA needs about 7000 GWh (and has storage potential that is 200 times larger).”

* 90–100% renewable electricity for the South West Interconnected System of Western Australia
https://www.sciencedirect.com/science/article/pii/S0360544217300774

Source: A global atlas of pumped hydro energy storage
http://re100.eng.anu.edu.au/research/phes/
https://www.nationalmap.gov.au/#share=s-wrVZwivI1ytIKKYliajuUr3592X

IPHROS: Integrated Pumped Hydro Reverse Osmosis System: *Ocean based PSH with desalination*

- Many drought stricken coastal regions have mountains near coast
- Pumped Hydro Head = 500-700 m, = RO desal head: http://www.sciencedirect.com/science/article/pii/S2213138816300492
- 20m^3 water => 2kWe, 1 m^3 => 500l freshwater
- ***With wind&solar farms, 1 km^2 lake @600m serves power & freshwater needs for 1 million people!***
  - *Install cost on the order of $5/Watt for 24/7 power and water*
  - *LCOE on order of $0.05-0.08 /kWhr*



Power from Remote Renewables

Food grown with fresh water from system

Energy storage reservoir

Upper RO option: water used at elevation Conventional grid powered plant with supply/discharge into lake

Pretretament for lower RO

Factories to make and maintain renewable energy system elements

Lower RO option: Reservoir pressure supplied plant with supply/discharge to main line

Offshore shellfish farm at inlet/exit Food source & ecosystem monitoring

Pump/Generator

Shallow surrounding lake for recreation

Charge

Discharge

Factories to make renewable energy machines; and products for sale in the resort…

Example: One point of Light of the 1000's needed…

Lowering Cost of Wind Energy by 10%

Physics says bigger machines are more efficient:

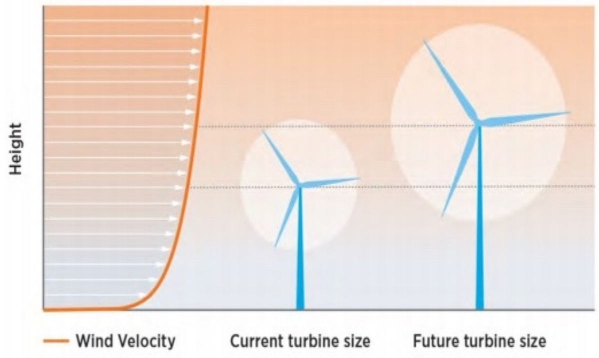
- Class III @ 80 m sites => Class 4 sites @ 120-140m
  - State of Maine in the US goes from 6 GW potential to 60 GW potential!

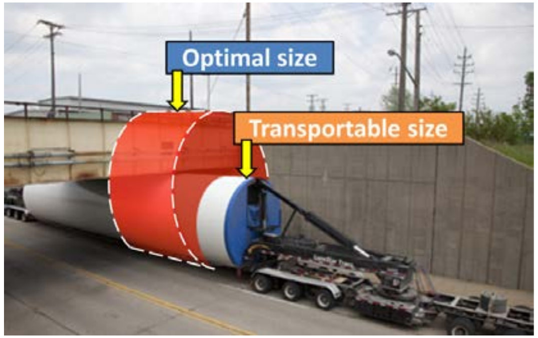
Wind turbine total cost to install: 30% can be the pole!

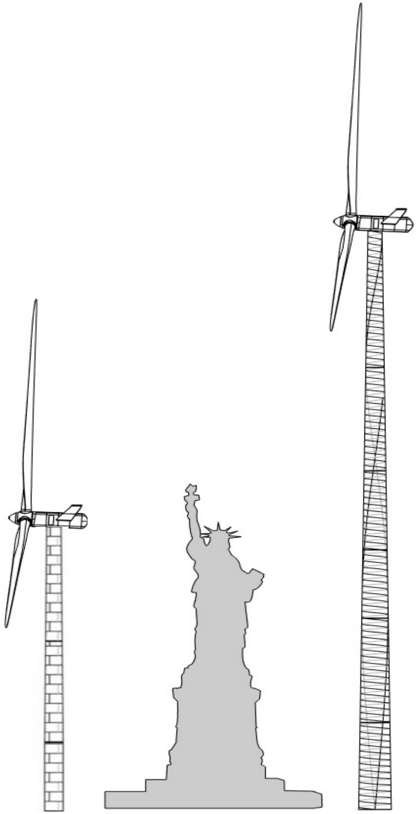
- Diameter is limited to 4.3m so it can be transported to site
- Wall thickness ends up being about 75+mm

Tower cost a function of physics

- Stiffness =>D^3t strength => D^2t Mass => Dt
- Buckling D/t ratio can be up to 300

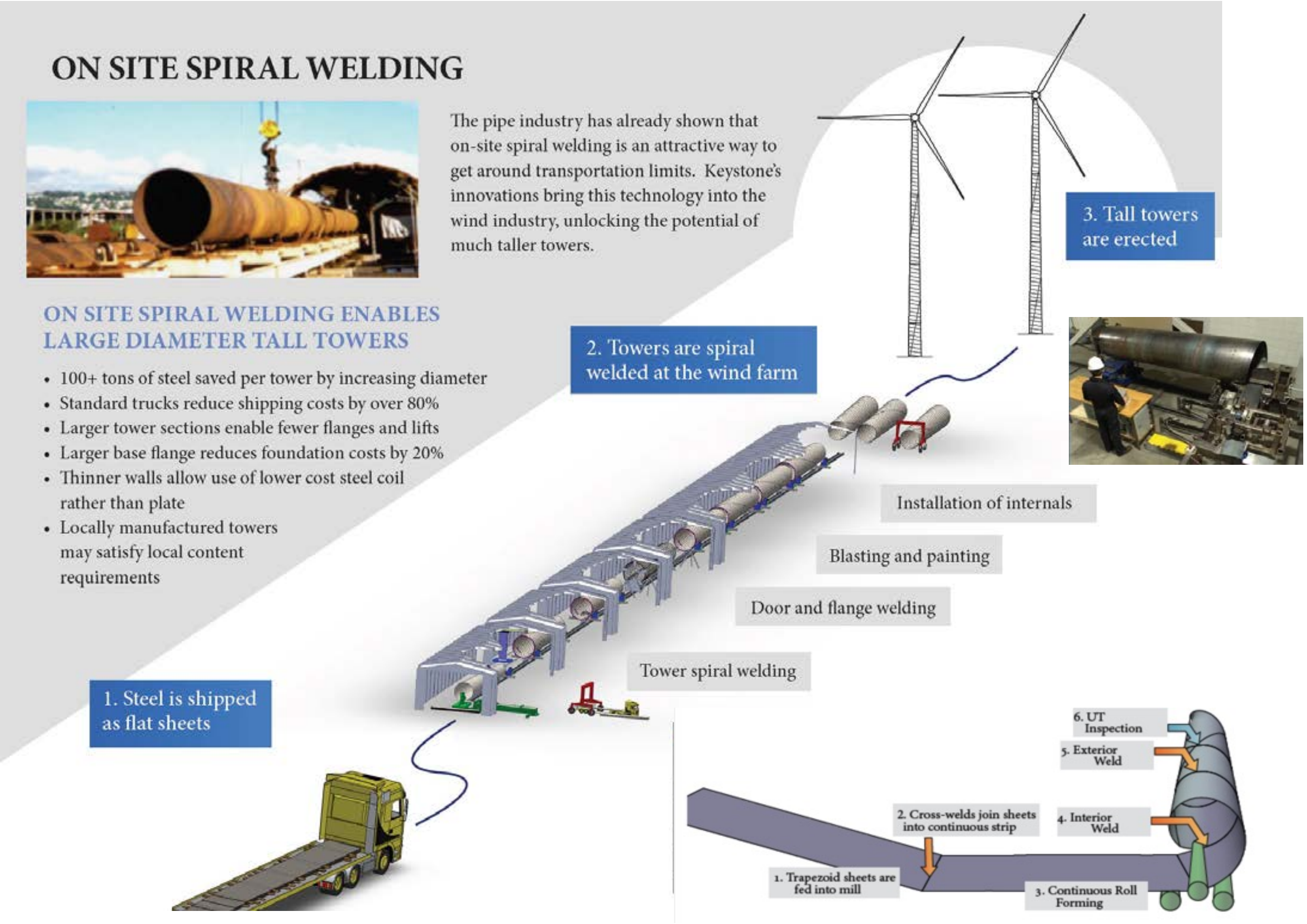






www.keystonetowersystems.com

Founded by MIT alums



ON SITE SPIRAL WELDING

The pipe industry has already shown that on-site spiral welding is an attractive way to get around transportation limits. Keystone's innovations bring this technology into the wind industry, unlocking the potential of much taller towers.

ON SITE SPIRAL WELDING ENABLES LARGE DIAMETER TALL TOWERS

- 100+ tons of steel saved per tower by increasing diameter
- Standard trucks reduce shipping costs by over 80%
- Larger tower sections enable fewer flanges and lifts
- Larger base flange reduces foundation costs by 20%
- Thinner walls allow use of lower cost steel coil rather than plate
- Locally manufactured towers may satisfy local content requirements

Conclusions

To fully displace fossil fuels for electricity generation we need to plan for complete replacement.

- This may seem tautological but is not the premise most often modeled, particularly with respect to storage capacity.

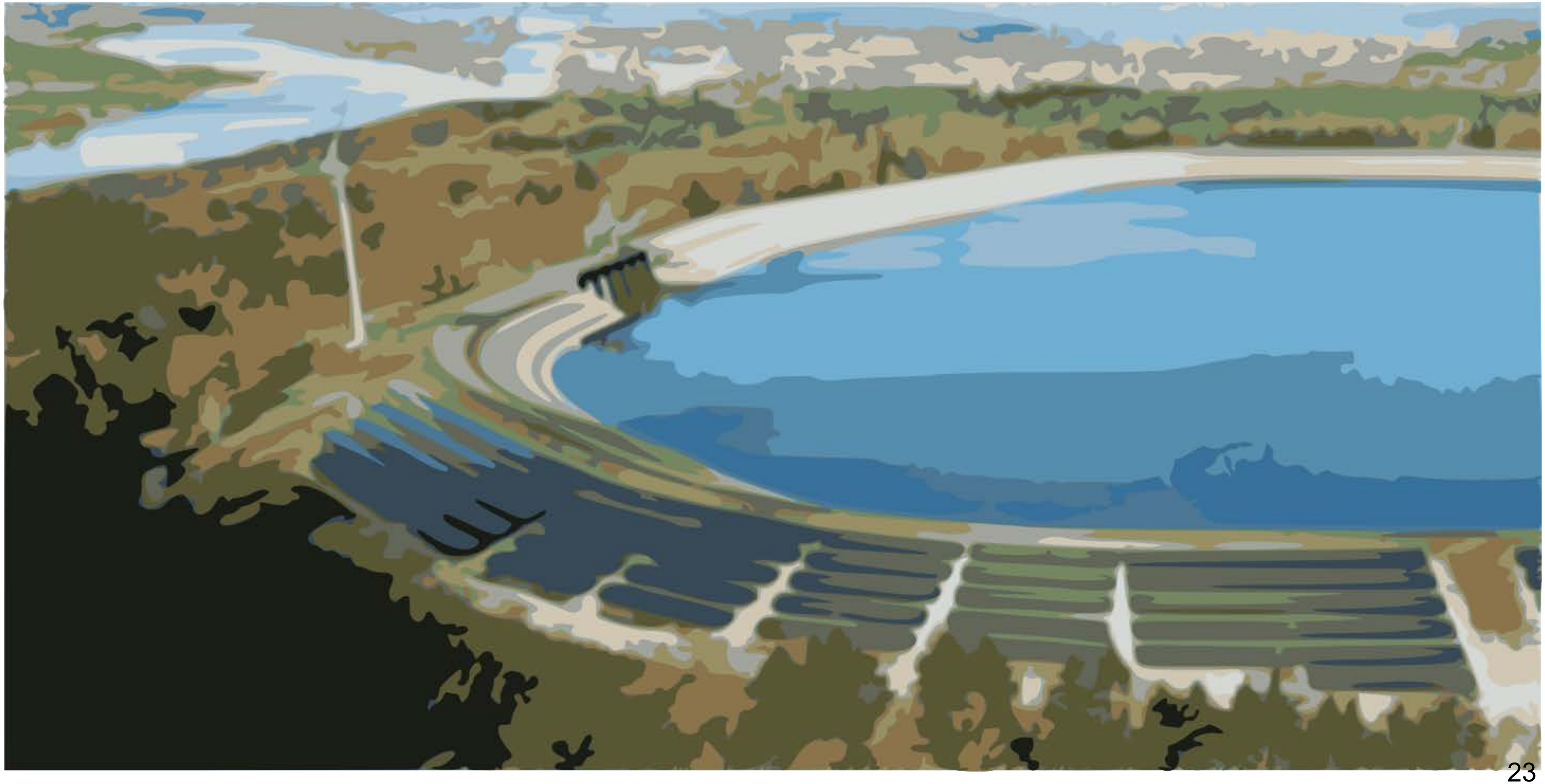
Infrastructure is a very long-term investment: we still use roads from Roman times, dams from 19th century, and power plants from early 20th century.

- Planning replacements must look forward in time scales measured decades and centuries, not years.

Applying these requirements to energy storage necessary to complement carbon free generation technologies, current technologies and forward projections favor pumped storage hydroelectricity where appropriate geography exists.

- Batteries are the Jelly to the peanut butter of PSH, and the grid is the bread upon which both rely

Supplemental Data



Case Study: Los Angeles

An impossibly expensive risky venture?

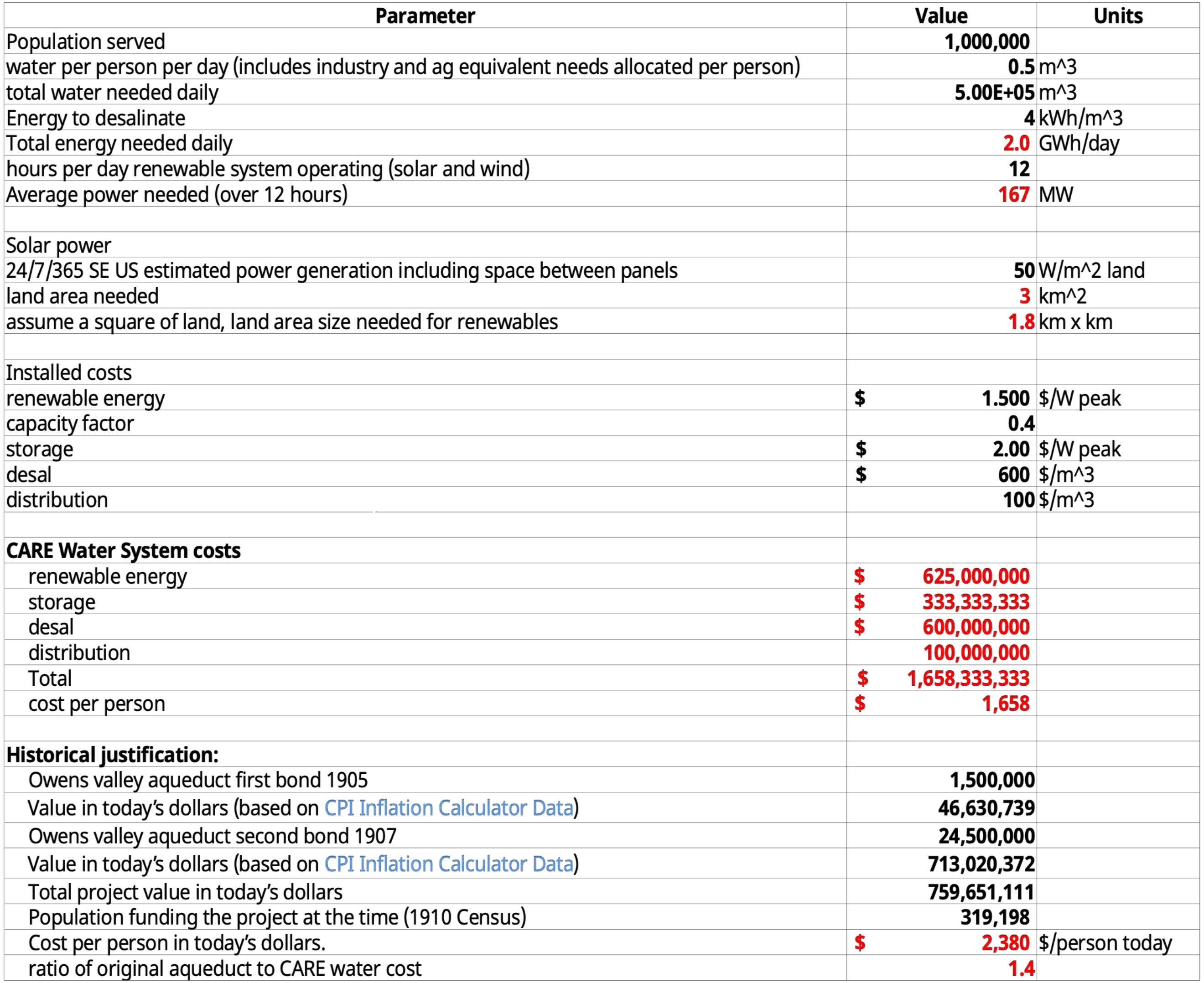
- Mulholland did it long ago with faith in people, engineering, & public finance and corporation
  - Finance harder than the engineering!
  - Was it ethical/moral…?

Short and long term *Social Impact Factor* of decisions must also be considered!

- Good of many vs good of few
- Cost to future generations
- Full disclosure and open peer review are the best means to ensure best outcomes

opernicus, Data SIO, NOAA, U.S. Navy, NGA, GEBCO, Data LDEO-Columbia, NSF, NOAA, Map data ©2018 Google, INEGI

A synergistic hybrid solution is cost favorable at today’s dollars.

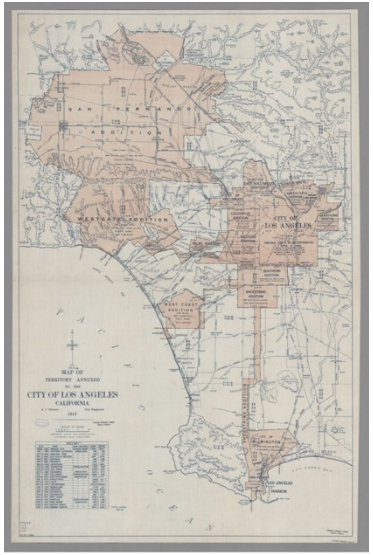


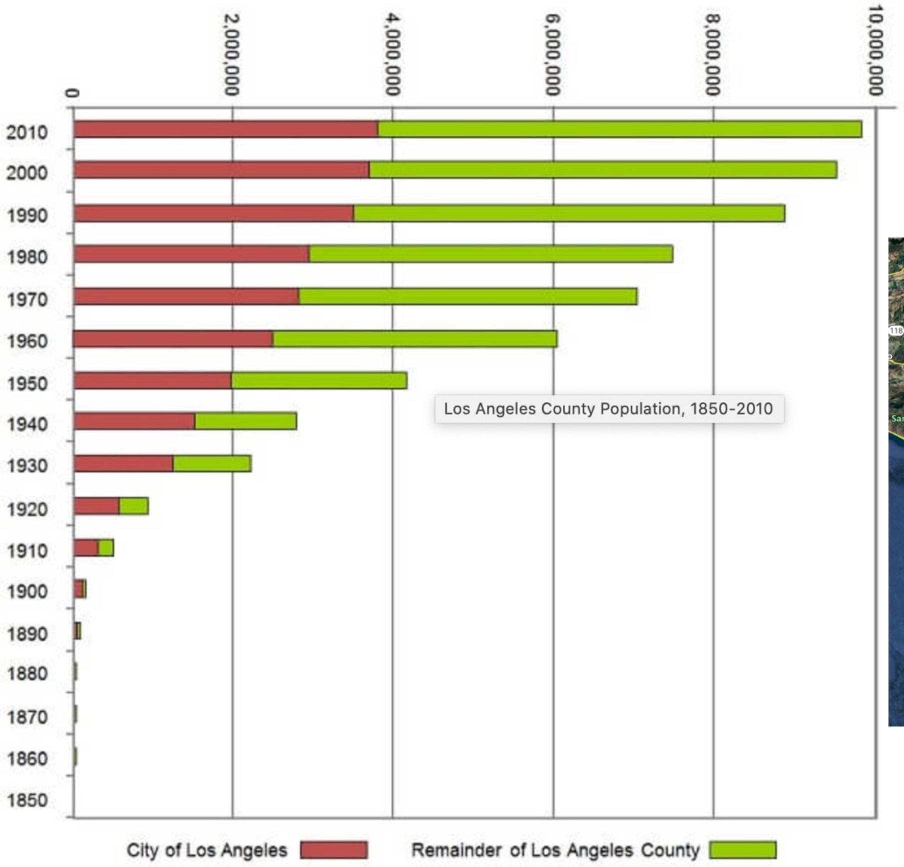
Parameter	Value	Units
Population served	1,000,000	
water per person per day (includes industry and ag equivalent needs allocated per person)	0.5	m^3
total water needed daily	5.00E+05	m^3
Energy to desalinate	4	kWh/m^3
Total energy needed daily	2.0	GWh/day
hours per day renewable system operating (solar and wind)	12	
Average power needed (over 12 hours)	167	MW
Solar power		
24/7/365 SE US estimated power generation including space between panels	50	W/m^2 land
land area needed	3	km^2
assume a square of land, land area size needed for renewables	1.8	km x km
Installed costs		
renewable energy	$ 1.500	$/W peak
capacity factor	0.4	
storage	$ 2.00	$/W peak
desal	$ 600	$/m^3
distribution	100	$/m^3
CARE Water System costs		
renewable energy	$ 625,000,000	
storage	$ 333,333,333	
desal	$ 600,000,000	
distribution	100,000,000	
Total	$ 1,658,333,333	
cost per person	$ 1,658	
Historical justification:		
Owens valley aqueduct first bond 1905	1,500,000	
Value in today’s dollars (based on CPI Inflation Calculator Data)	46,630,739	
Owens valley aqueduct second bond 1907	24,500,000	
Value in today’s dollars (based on CPI Inflation Calculator Data)	713,020,372	
Total project value in today’s dollars	759,651,111	
Population funding the project at the time (1910 Census)	319,198	
Cost per person in today’s dollars.	$ 2,380	$/person today
ratio of original aqueduct to CARE water cost	1.4	

Los Angeles Population

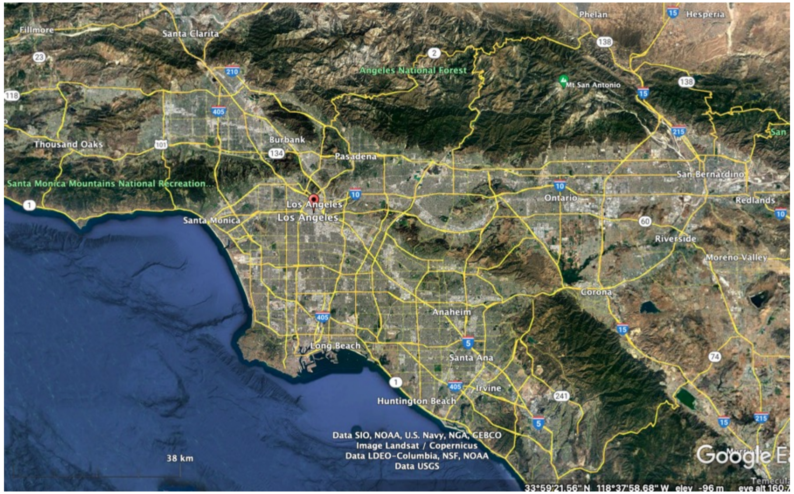
Source: U.S. Census Bureau

1920





2021



htsman ; A.C. Hansen, City Engineer ; del. by L. P. Abell. -

Annexations to city of Los Angeles to 1918

Public Domain
File: Annexations sm.jpg
Created: 1 January 1918

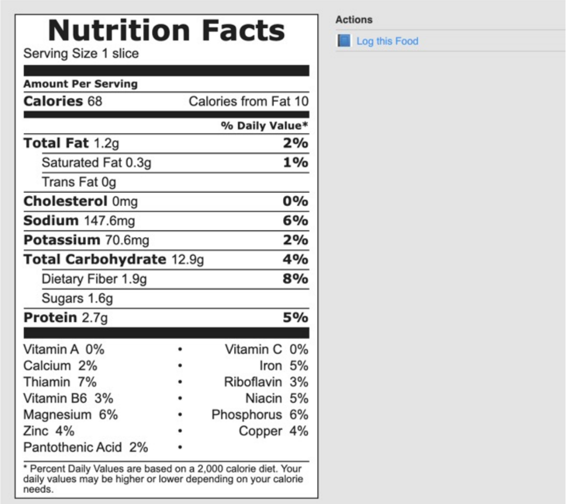
Very basic simple spreadsheet example

Far more detailed complete models are available (e.g., from NREL and DoE)

This is presented here to illustrate the type of output that would be the result of considering timeline of MRO and replacements

Weighted Average Cost of Capital	**7.0%**	
Capital recovery period set equal to battery life (years)	10	
Number of battery replacement cycles	8	
	PSH	Battery
Power (MW)	**100**	**100**
hours storage	**4**	**4**
Assumed life	**80**	**10**
Life assumed for comparison	80	10
Cost: assume cost to install includes MOR ($/W power output capability), & with time NPV cost of batteries stays same as tech gets better	**$ 2.05**	**$ 1.61**
Initial investment ($MM)	$ 205	$ 161
Single-Payment Future Worth Factor (value of initial investment at end of life) with replacement cost at every end of life period ($MM)	$ 45,878	$ 73,193
Total equivalent effective present day cost to install system to last life of PSH ($/W)	$ 5.73	$ 9.15

Nutritional Information, Diet Info and Calories in Whole Wheat Bread, Cp



Nutrition Facts

Serving Size 1 slice

Amount Per Serving	
Calories 68	Calories from Fat 10
	% Daily Value*
Total Fat 1.2g	**2%**
Saturated Fat 0.3g	**1%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 147.6mg	**6%**
Potassium 70.6mg	**2%**
Total Carbohydrate 12.9g	**4%**
Dietary Fiber 1.9g	**8%**
Sugars 1.6g	
Protein 2.7g	**5%**

Vitamin A 0%	Vitamin C 0%
Calcium 2%	Iron 5%
Thiamin 7%	Riboflavin 3%
Vitamin B6 3%	Niacin 5%
Magnesium 6%	Phosphorus 6%
Zinc 4%	Copper 4%
Pantothenic Acid 2%	

* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

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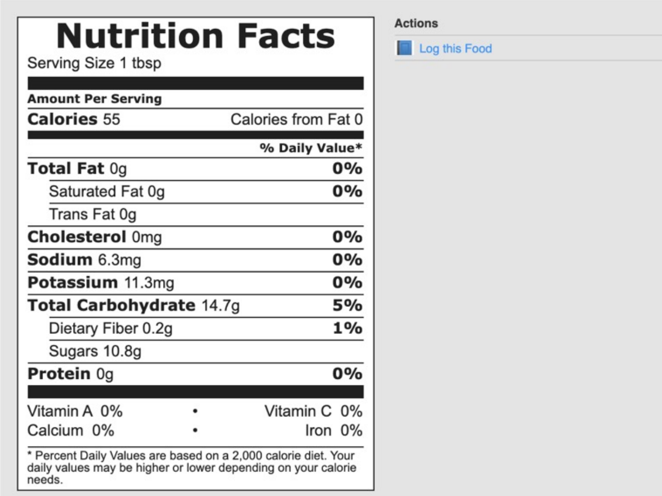
Nutritional Information, Diet Info and Calories in Jelly



Nutrition Facts

Serving Size 1 tbsp

Amount Per Serving	
Calories 55	Calories from Fat 0
	% Daily Value*
Total Fat 0g	**0%**
Saturated Fat 0g	**0%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 6.3mg	**0%**
Potassium 11.3mg	**0%**
Total Carbohydrate 14.7g	**5%**
Dietary Fiber 0.2g	**1%**
Sugars 10.8g	
Protein 0g	**0%**

Vitamin A 0%	Vitamin C 0%
Calcium 0%	Iron 0%

* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

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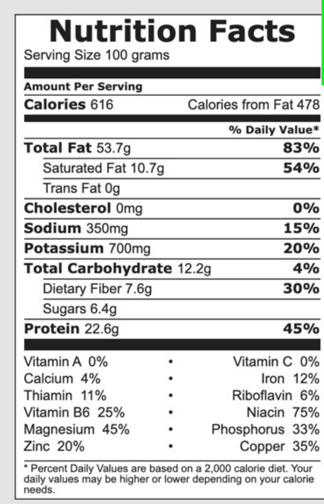
Nutritional Information, Diet Info and Calories in Peanut Butter



Nutrition Facts

Serving Size 100 grams

Amount Per Serving	
Calories 616	Calories from Fat 478
	% Daily Value*
Total Fat 53.7g	**83%**
Saturated Fat 10.7g	**54%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 350mg	**15%**
Potassium 700mg	**20%**
Total Carbohydrate 12.2g	**4%**
Dietary Fiber 7.6g	**30%**
Sugars 6.4g	
Protein 22.6g	**45%**

Vitamin A 0%	Vitamin C 0%
Calcium 4%	Iron 12%
Thiamin 11%	Riboflavin 6%
Vitamin B6 25%	Niacin 75%
Magnesium 45%	Phosphorus 33%
Zinc 20%	Copper 35%

* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

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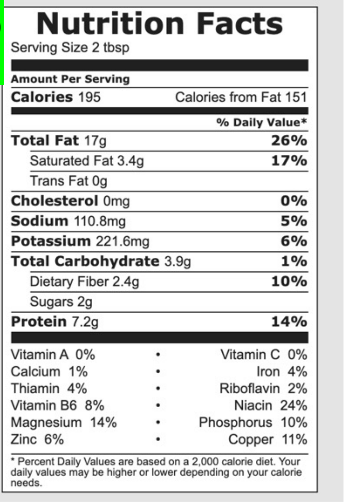

Nutrition Facts

Serving Size 2 tbsp

Amount Per Serving	
Calories 195	Calories from Fat 151
	% Daily Value*
Total Fat 17g	**26%**
Saturated Fat 3.4g	**17%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 110.8mg	**5%**
Potassium 221.6mg	**6%**
Total Carbohydrate 3.9g	**1%**
Dietary Fiber 2.4g	**10%**
Sugars 2g	
Protein 7.2g	**14%**

Vitamin A 0%	Vitamin C 0%
Calcium 1%	Iron 4%
Thiamin 4%	Riboflavin 2%
Vitamin B6 8%	Niacin 24%
Magnesium 14%	Phosphorus 10%
Zinc 6%	Copper 11%

* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

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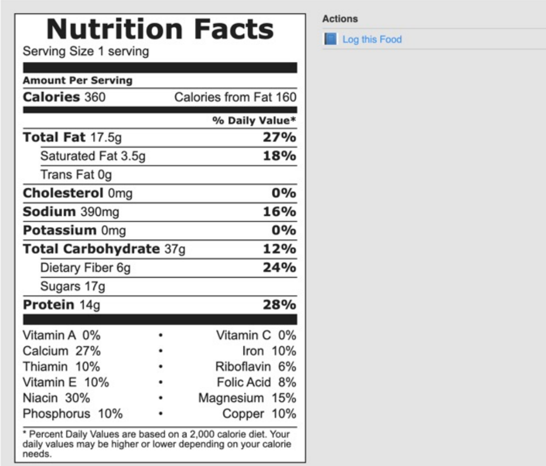
Nutritional Information, Diet Info and Calories in Peanut butter and jelly sandwich



Nutrition Facts

Serving Size 1 serving

Amount Per Serving	
Calories 360	Calories from Fat 160
	% Daily Value*
Total Fat 17.5g	**27%**
Saturated Fat 3.5g	**18%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 390mg	**16%**
Potassium 0mg	**0%**
Total Carbohydrate 37g	**12%**
Dietary Fiber 6g	**24%**
Sugars 17g	
Protein 14g	**28%**

Vitamin A 0%	Vitamin C 0%
Calcium 27%	Iron 10%
Thiamin 10%	Riboflavin 6%
Vitamin E 10%	Folic Acid 8%
Niacin 30%	Magnesium 15%
Phosphorus 10%	Copper 10%

* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.