Our Team's Design Solution

An exemplar student slide deck.

Our current grid relies on natural gas

Benefits:

- Could meet 90% of demand during a winter storm.
- Could provide electricity for unlimited hours, if fuel supply .

Costs and Risks:

- Emits about 4000 kg per person per year, five times what it should be to reach net zero carbon emissions.
- Most gas comes from fracking, which “often releases pollutants into the water, which can end up in the water supply for both humans and animals.”

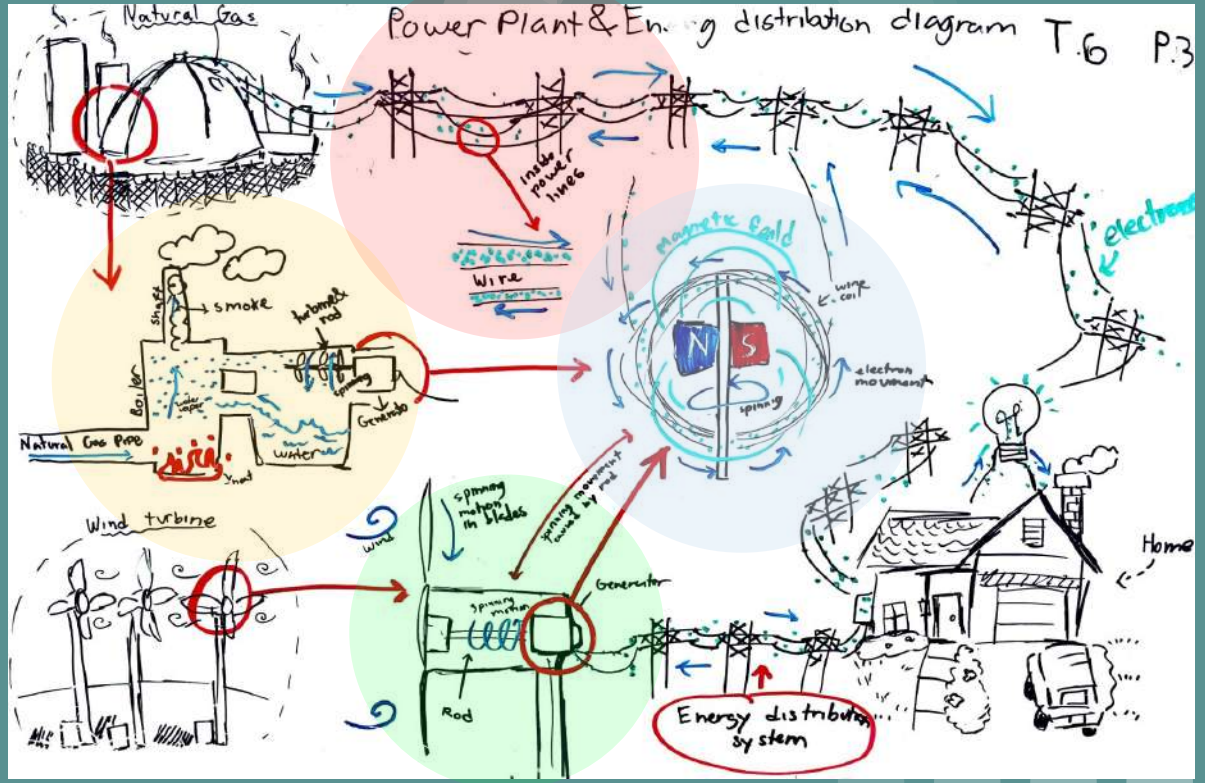
What is a grid?

More energy is lost in longer wires

Natural gas can burn more or less fuel to meet demand.

Wind can be unreliable since we can't control it.

Both of these sources change magnetic fields in generators.



Energy Grid Calculator

A computational model.

Proposed Grid Solution #2		Maximum Production	Max Supply After Wire Losses	Cost per Person per year*	Total Life Cycle Cost	Carbon Emitted per Person per year**	Local Land Use (minus existing hydro)	Global Life Cycle Land Use
Reliability		2792	2502	$361.3	$7.6	1171	61578	88718
		MW	MW	$/yr	$Billion	kg	acres	acres
"Winter Crisis" - What percent of demand can be met if there is a winter crisis like in Texas, '21?		Maximum Demand:		2287 MW			62.2%	89.6%
93%		Wind & Solar:		76.7%		Current CO2	of City Area	of City Area
"Windless Night" - For how many hours will ALL people have power if wind & solar drop to zero?	Plant Quantity	Build Inside City?	Winterize?	Efficiency (%)	Distance to Site (mi)	Max Power Output (MW)	Capacity Factor (%)	Average Power Output (MW)	Power After Wire Losses (MW)
12.8 hrs									
ispatchable:		*(check for yes)*							
Ultra-Supercritical Coal Plant	0	☐	☐	39%	50	250	85%	0.00	0.00
90% Carbon Capture Coal Plant	0	☐	☐	27%	50	250	85%	0.00	0.00
Combined Cycle Natural Gas Plant	0	☐	☐	54%	50	250	87%	0.00	0.00
Nuclear Plant *(slowly dispatchable)*	0	☐	☐	33%	50	1000	90%	0.00	0.00
Biomass Plant	0	☐	☐	25%	50	50	90%	0.00	0.00
Geothermal Plant	0		☐	39%	50	50	83%	0.00	0.00
Hydroelectric Dam	0		☐	90%	50	20	54%	0.00	0.00
esource-Constrained:					***Warning:** Do not make changes here!*				
Wind Turbine (Closer, Lower Wind)	0	☐	☐	30%	50	1	30%	0.00	0.00
Wind Turbine (Farther, Higher Wind)	500		☑	30%	50	2	43%	428.57	364.29
Offshore Wind Farm	0		☐	30%	1000	4	52%	0.00	0.00
1000 Rooftop Solar Units	400	☑		20%	0	12	22%	1058.40	952.56
Large One-Megawatt Solar Array	0	☐		20%	50	1	22%	0.00	0.00

[See Sample Energy Grid Calculator, Solution 2]

Our Priorities

Reliability is priority #1.

Other Priorities:

- Low Carbon Emissions: less than 1500 kg per person per year.
- Low Cost: Only 30% more money than today's grid.

Reliability	
"Winter Crisis" - What percent of demand can be met if there is a winter crisis like in Texas, '21?	**93%**
"Windless Night" - For how many hours will ALL people have power if wind & solar drop to zero?	**12.8 hrs**

Maximum Production	Max Supply After Wire Losses	Cost per Person per year*	Total Life Cycle Cost	Carbon Emitted per Person per year**
2792	2502	$361.3	$7.6	1171
MW	MW	$/yr	$Billion	kg
Maximum Demand:		2287	MW	Current CO2
	Wind & Solar:	76.7%		

Our Changes

We demolished:

- 1 coal plant
- 3 gas plants.

We replaced them with:

- 500 wind turbines
- 500,000 rooftop solar systems
- 2 pumped storage facilities.

Trade-Offs

Positive Changes:

- 70% less carbon
- Less land use from fracking & surface mining
- New construction jobs

Negative Changes:

- 30% more cost to energy consumers
- Loss in fracking and mining jobs
- Batteries or pumped storage needed to ensure reliability.

Why Do We Need Batteries?

- We included **500 high wind turbines**, and **400 rooftop solar units**..
- This means it **depends 100% in renewable sources**, which as we know, can be **unpredictable, and sometimes unreliable**.
- During a windless night, it means that there is no energy supply from solar or wind, so **everyone would lose energy**.
- **By adding 20 Gravity storage unit**s, we could store enough energy to **supply energy during 14.2 hours** in a windless night.
- 14.2 hours will allow the system to meet the demand until the sun comes out next day. During a winter crisis, **the system will be able to meet 93% of the energy demand**. This means that some small power outages will need to happen.

Why Do We Need Batteries?

High Wind

local grid

100

Transport

40

Homes

50

Battery

Charges

Heats up

10

Surroundings

Zero Wind

local grid

40

Homes

Transport

45

Charged Battery

Discharges

Heats up

5

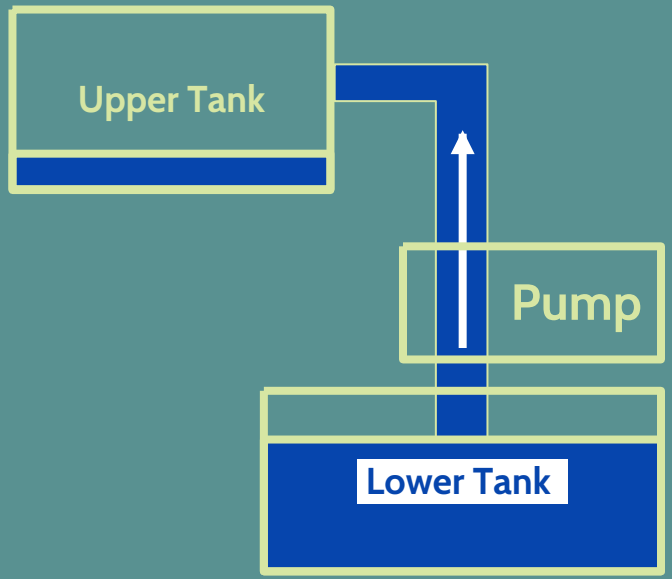
Surroundings

Heats up

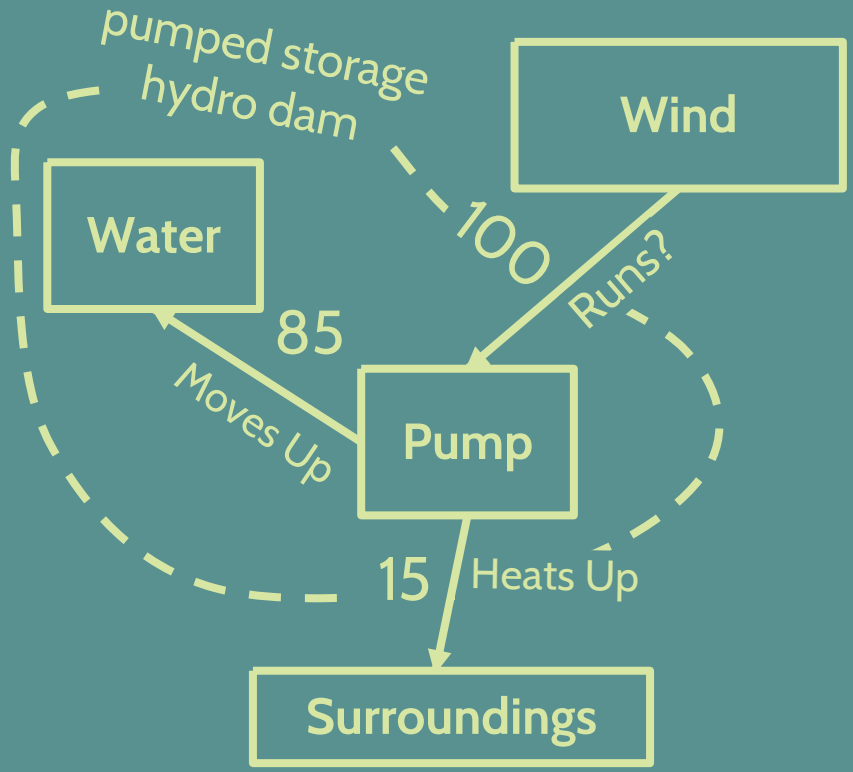
5

What is Pumped Storage?

Matter:



Energy:



Trade-Offs

Pumped storage is positive because:

- It’s cheaper than Li-Ion batteries.
- Cobalt mining is dangerous for workers.
- Constructing pumped storage facilities would provide local jobs.

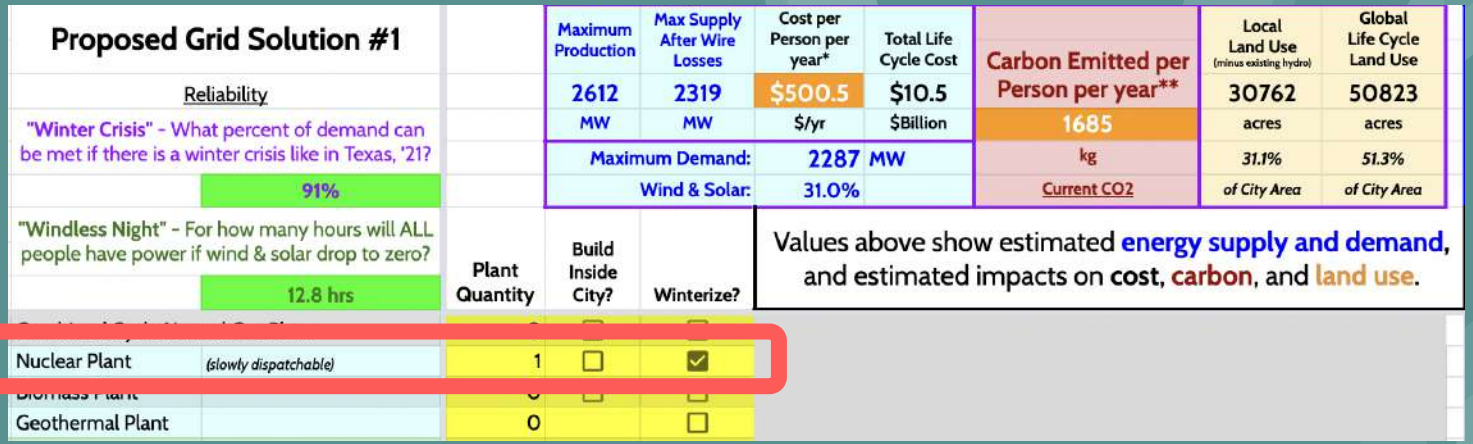
Trade-Offs

Pumped storage is negative because:

- There are not many undammed sites left in the US, so most pumped storage is far away.
- Long wires means more energy loss.
- Dams can kill wildlife and destroy people's homes.

Alternate Solution

Nuclear is carbon neutral. If the plant is winterized then fuel use can be increased to meet higher demand.



Proposed Grid Solution #1				Maximum Production	Max Supply After Wire Losses	Cost per Person per year*	Total Life Cycle Cost	Carbon Emitted per Person per year**	Local Land Use (minus existing hydro)	Global Life Cycle Land Use
Reliability				2612	2319	$500.5	$10.5	1685	30762	50823
"Winter Crisis" - What percent of demand can be met if there is a winter crisis like in Texas, '21?				MW	MW	$/yr	$Billion	kg	acres	acres
	91%			Maximum Demand:		2287	MW		31.1%	51.3%
"Windless Night" - For how many hours will ALL people have power if wind & solar drop to zero?				Wind & Solar:		31.0%		Current CO2	of City Area	of City Area
	12.8 hrs	Plant Quantity	Build Inside City?	Winterize?						
Nuclear Plant	(slowly dispatchable)	1	☐	☑						
Geothermal Plant		0		☐						

Values above show estimated energy supply and demand, and estimated impacts on cost, carbon, and land use.

However, nuclear energy has other drawbacks:

- Cancer risk
- Toxic waste
- Very expensive

Alternate Solution

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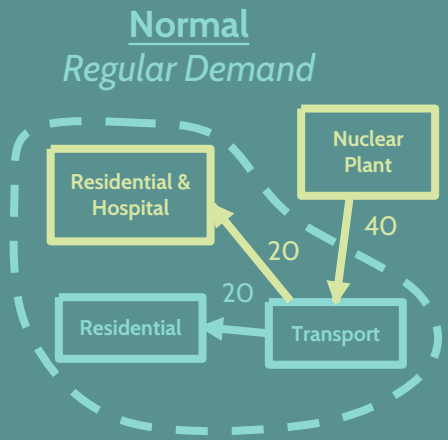

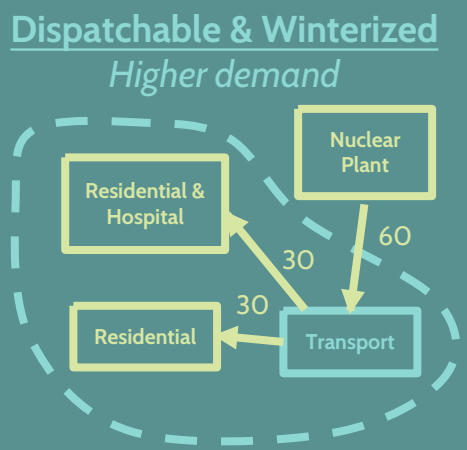

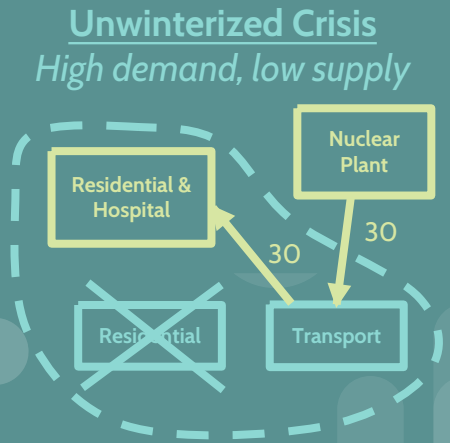

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