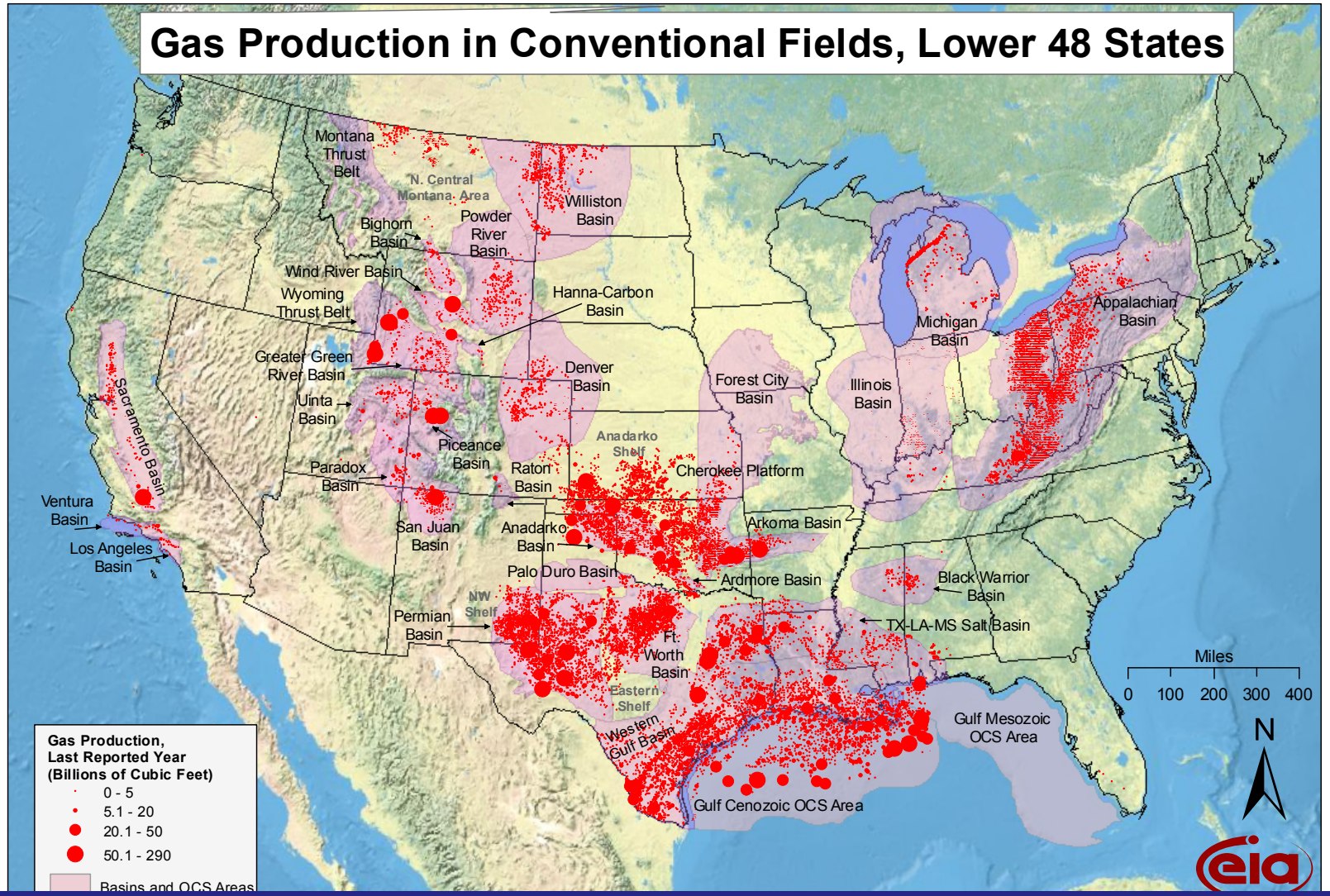
Intro To Electricty and a Little on Gas

Objectives

- Need some idea of how we get natural gas and electricity
- Need to know some of the ways we regulate those two at both state and federal level

Where is it produced? Just conventional



More in the shale areas.

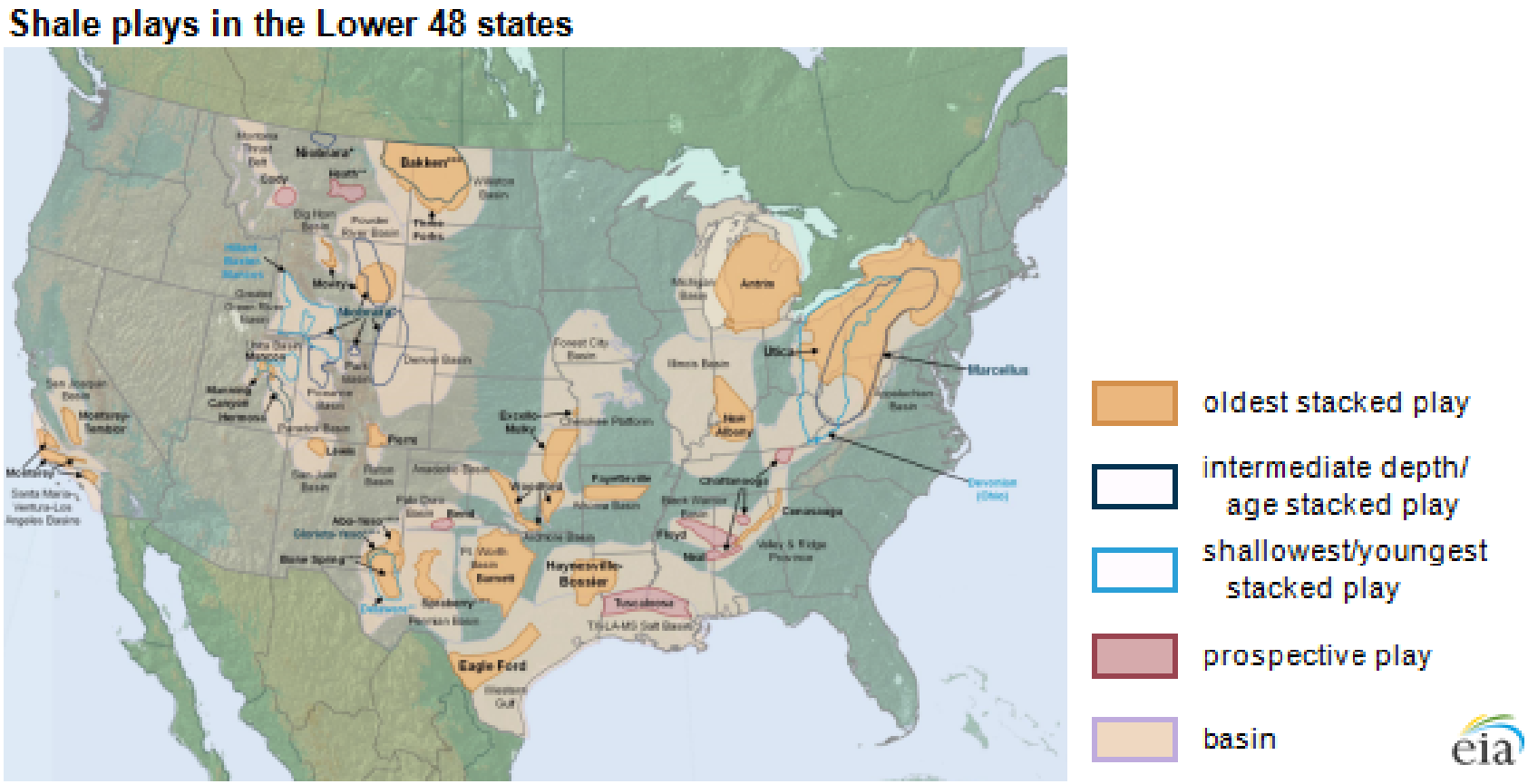


Figure 1:
https://www.eia.gov/todayinenergy/images/2015.04.17/main.png

How do you move it within the US? Pipelines (Interstate only).

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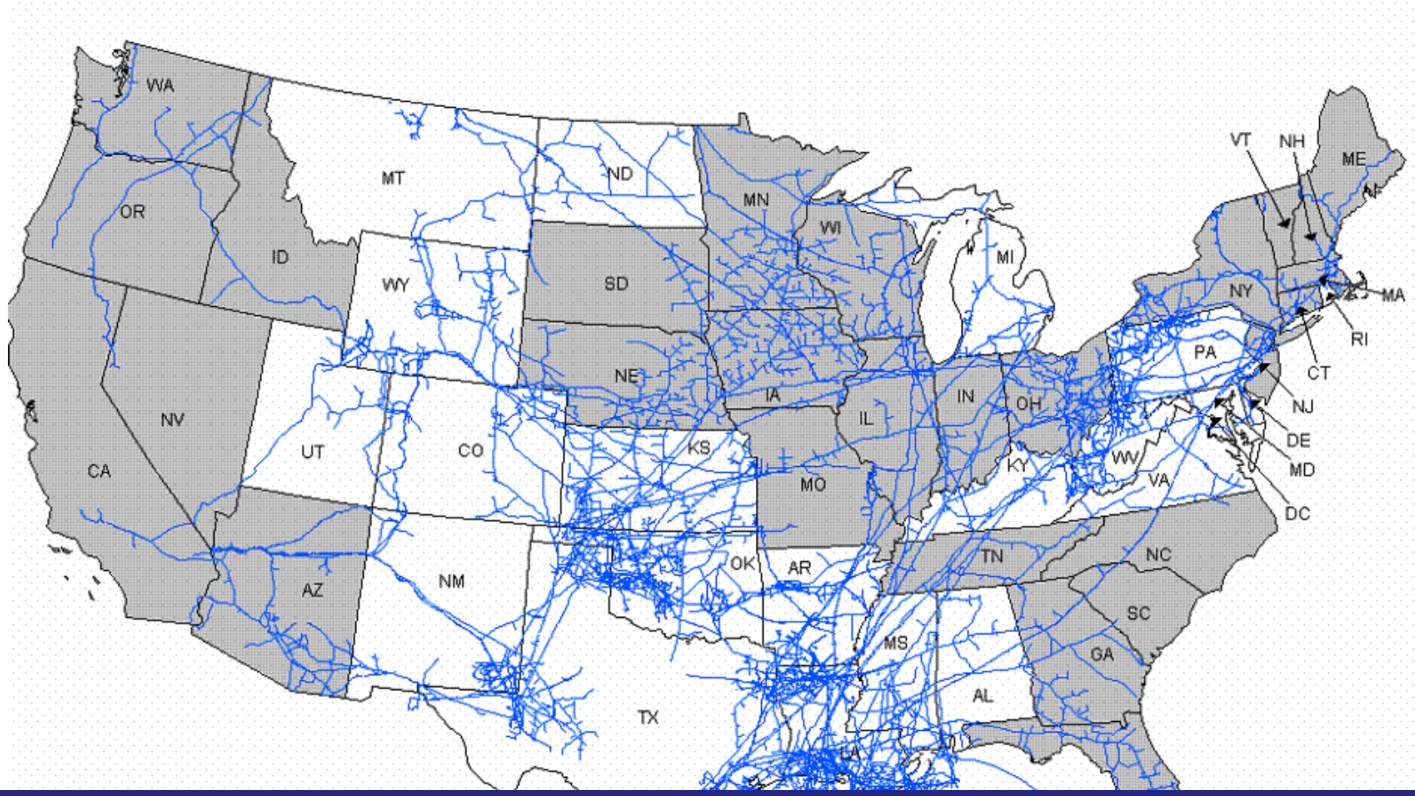


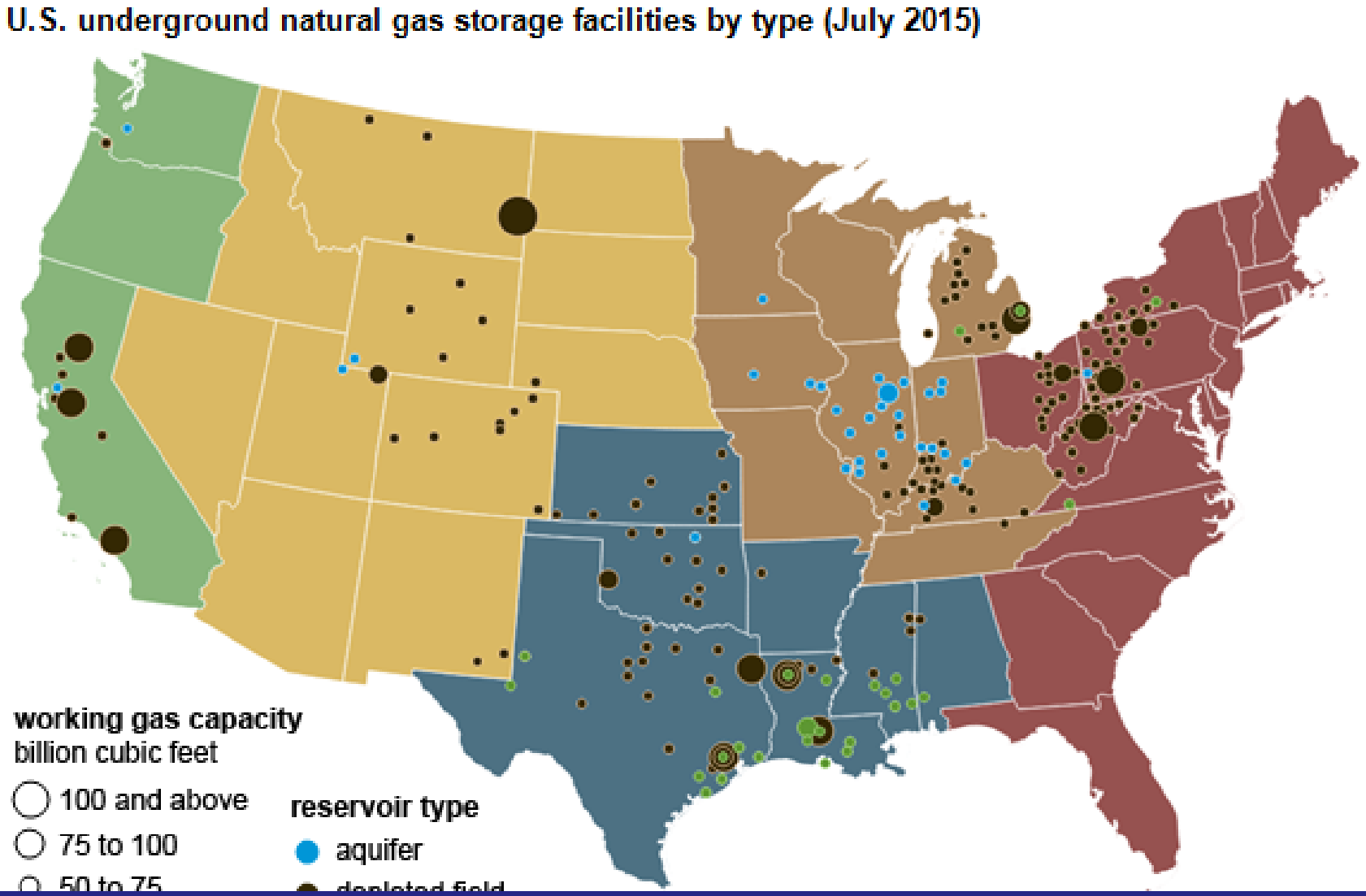
What about those pipelines?

- There are more intrastate pipelines than shown, plenty in TX and CA but also other states
- Read more here https://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/transcorr.html
  - Picture pipes ranging from a foot to three+ feet for trunk lines.
  - Compressor stations every 50-100 miles, ~1,500 total
  - 200 psi to 1,500 depending
- They are privately owned https://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/MajorInterstatesTable.html
  - Open access, posted prices, is a thing.
  - For intrastate, within, state PUC regulate
  - For interstate, FERC regulates (You can find current Tariffs at http://etariff.ferc.gov/TariffList.aspx)

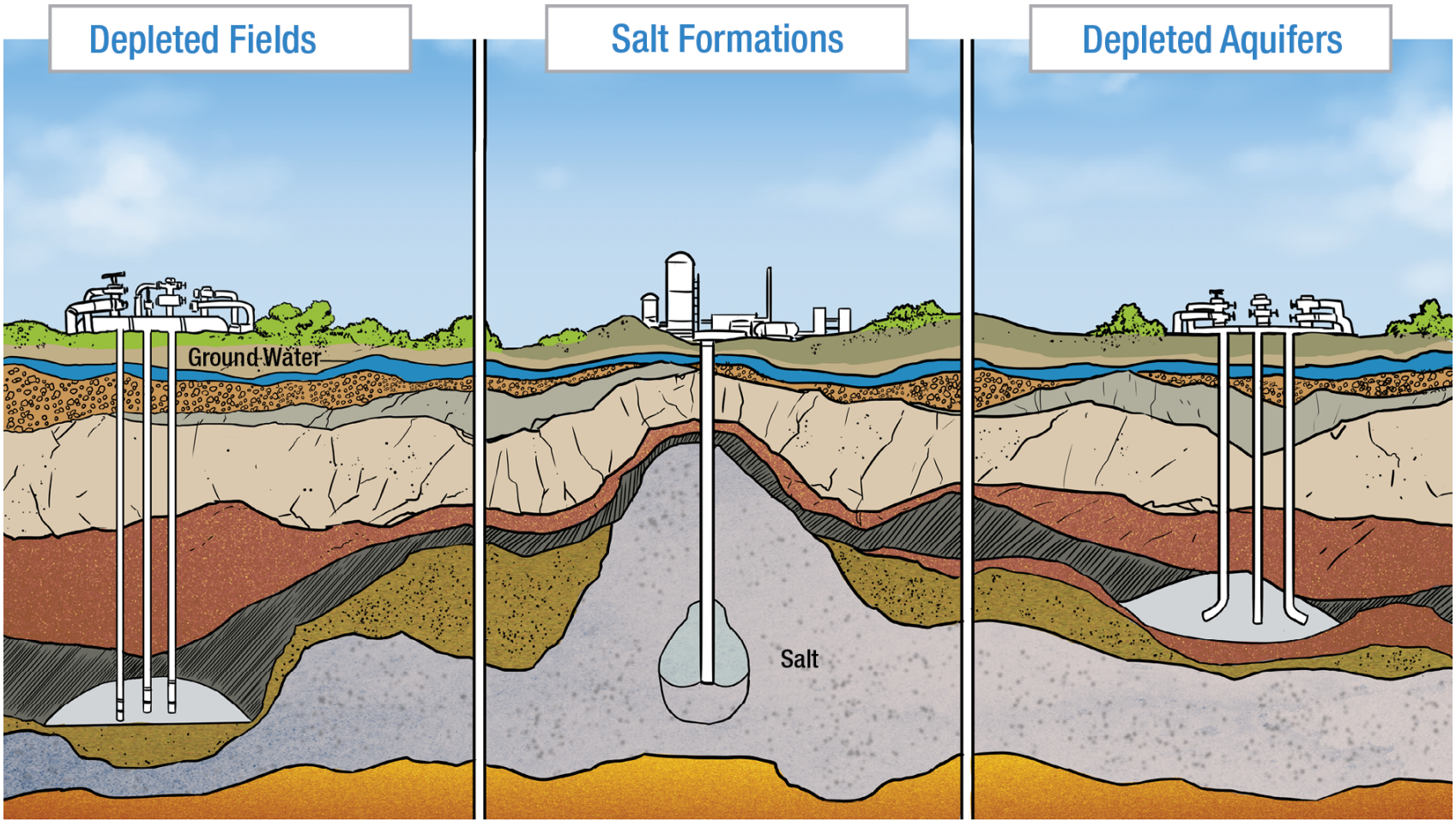
Compressors

Compressor Station

Storage is important



Most Storage is just old gas wells



Storage is very seasonal

There is a weekly report on storage by EIA
http://www.eia.gov/dnav/ng/hist/nw2_epg0_swo_r48_bcfw.htm

- Note the seasonality
- Note the factor of 2+ changes over the term

Hubs, where transactions are made

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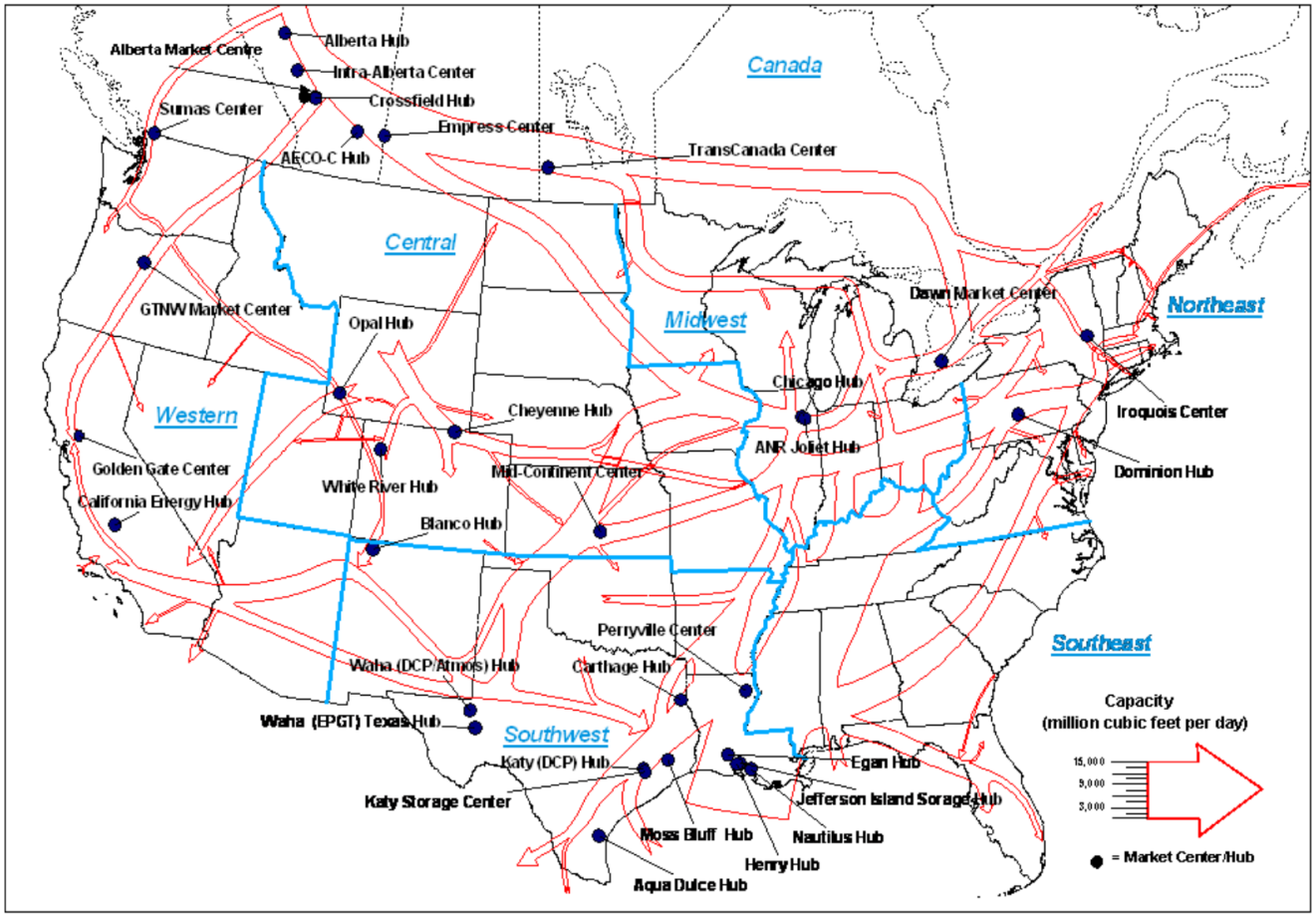

Part of Henry Hub LA

Getting to Prices

- You will see wellhead prices, but
- Most references prices are at the hubs.
  - Henry Hub in LA is the most common reference hub for prices
  - There are fairly firm relationships between other hubs and HH except when there is congestion.
  - Changes in the usual difference are usually called basis blowout. Term is not specific to energy.
- Intercontinental Exchange for Gas Itself
  - https://www.theice.com/products/OTC/Physical-Energy/Natural-Gas
- FERC for transportation tariffs (Regulated)
  - http://etariff.ferc.gov/TariffList.aspx
  - Some are fixed and some have a market rate component.

It is hard to talk about gas separate from transportation.

What Makes Electricity Interesting

- We somehow start with a fuel (Counting wind, geothermal and sunlight in this).
- Transport it from where we found it to a generating facility.
- Turn it into electricity losing some energy as heat.
- Run it along long wires to where people want to use it, losing yet more energy.
- From there send it out to every small location (losing more), and
- Because electricity is not *easily* stored, adjust the rate at which we generate electricity moment-by-moment to make sure there is just enough.

This is a logistical miracle.

Basic Units

- $Watts = AmpsVolts$ first thing everyone learns.
  - Pro tip on units, if it is someones name, capitalize it.
  - Volt is analogous to height.
  - Amp is analogous to a weight.
  - Watt is what it happens when that weight is dropped from that height.

kW vs kWh

- kW is instantaneous and called power
- kWh is the integral over time and called energy.
- 100 W light bulb uses 100 Wh = 1/10 kWh per hour
- Get used to flipping between 1,000,000,000 W = 1,000,000 kW = 1,000 MW = 1 GW

Lets Generate Some Electricity

- Turbine – spin something in a magnetic field to induce a current.
- Lots of ways to spin a turbine
  - Coal, grind it up, burn it, make steam, use steam to spin the turbine.
  - Nuclear, use the heat to make steam, use steam to spin a turbine.
  - Biomass, burn stuff to ...
  - Gas, burn it to spin a turbine ...
  - Fuel Oil or Diesel
  - Solar thermal, use the sun to make steam ...
  - Water, falling water hits a turbine and spins it
  - Wind, spin a turbine
  - etc.
- Or don't spin a turbine and go for photo-voltaic, PV.

Characteristics

- Nameplate, fully loaded under ideal conditions (MW)
- Ramp rate, how fast power (MW) can change MW/min
  - Not always constant, can differ by capacity factor (fraction of nameplate)
  - Not always symmetric, up different from down.
  - Used to follow the load.
- Heat rate, BTU in/ BTU out, only used for generation that uses a fuel.
  - 1 is impossible but 1 kW = 3412 BTU.
  - Recent average from EIA, https://www.eia.gov/electricity/annual/html/epa_08_01.html

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Coal from the outside

Coal on the inside

- Pulverize the coal, picture something that can do 20 Tons/hr
- Blow it into combustion chamber to burn
- Steam turns turbine, etc. https://youtu.be/IdPTuwKEfmA
- Clean up
  - NOx with ammonia common but plenty of others
  - Recover fly ash and sell it, great for concrete.
  - SOx, Mercury and other. BTW Radiation

Nuclear

Radiation to heat water and then . . . similar to coal. Just a reaction chamber

Local Reactor Columbia Generating Station

- 1,170 MW usually runs as load following. It reacts fast enough.
  - France is ~70% nuclear and they load follow.
- Most nuclear is run as base load, i.e., all the time since low variable cost and high fixed cost.
- Palo Verde (AZ) is larger 3.3GW

So, about nuclear

- So what to do with spent fuel.
- They probably produce less radiation than coal
- Can produce cheap, in the marginal cost sense, power. More on this later.

Natural Gas Conventional and Combined Cycle

- Combined cycle means
  - Taking more than one pass at extracting energy.
  - Spin the turbines first.
  - Take the heat and run a steam turbine.
  - Take the remaining heat and use a different working fluid (with different phase change properties) to extract more.
- CCNG
  - Plants are more expensive
  - Have lower heat rates, which means more efficient.
- Conventional
  - Cheap
  - Commonly run as peaking units.

Biomass

- Tend to be combined heat and power. Another way of using waste heat.
  - Cogeneration like this is common.
  - We have steam and chill water systems on campus
- While renewable, it is not, in general, clean
  - Particulates
  - Heavy metal concentration
  - etc.
- All this is improving.

Biomas One in Eugene. 30 MW and keeps catching on fire.

Geothermal

- Drill a hole down to where the temperature is high enough.
  - If it is dry, add water to make steam.
  - If wet, get steam
  - If temp is not high enough, use a few working fluids to generate electricity.
- Run through a turbine.

Neal Hot Spring in Malheur. 30 MW

Diesel and other Fuel Oils

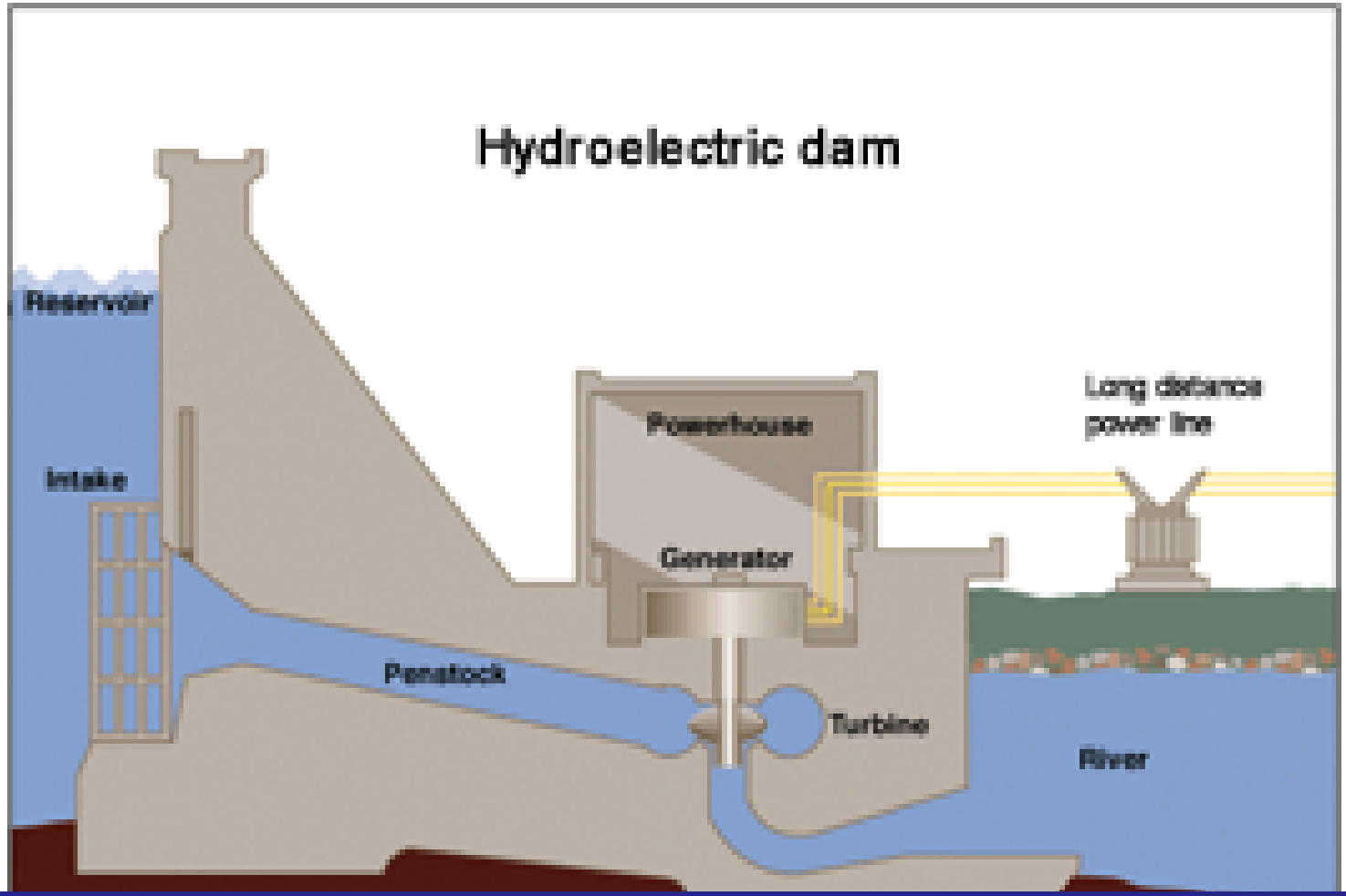
- You know the drill . . .
- Less than 1% in the US for electricity generation.
  - Still common heating fuel.
  - Backup fuel for NG generation
  - May be used in small distributed generation
- More common in less developed countries

Solar Thermal

- You have seen the low and mid temperature designs for heating and cooling.
- High temperature designs are:
  - Dish
  - Tower
  - Trough
- Fluids:
  - Oil
  - Salt
  - Water steam
- Low and mid temperature are similar to roof top residential that you have seen.

Hydro

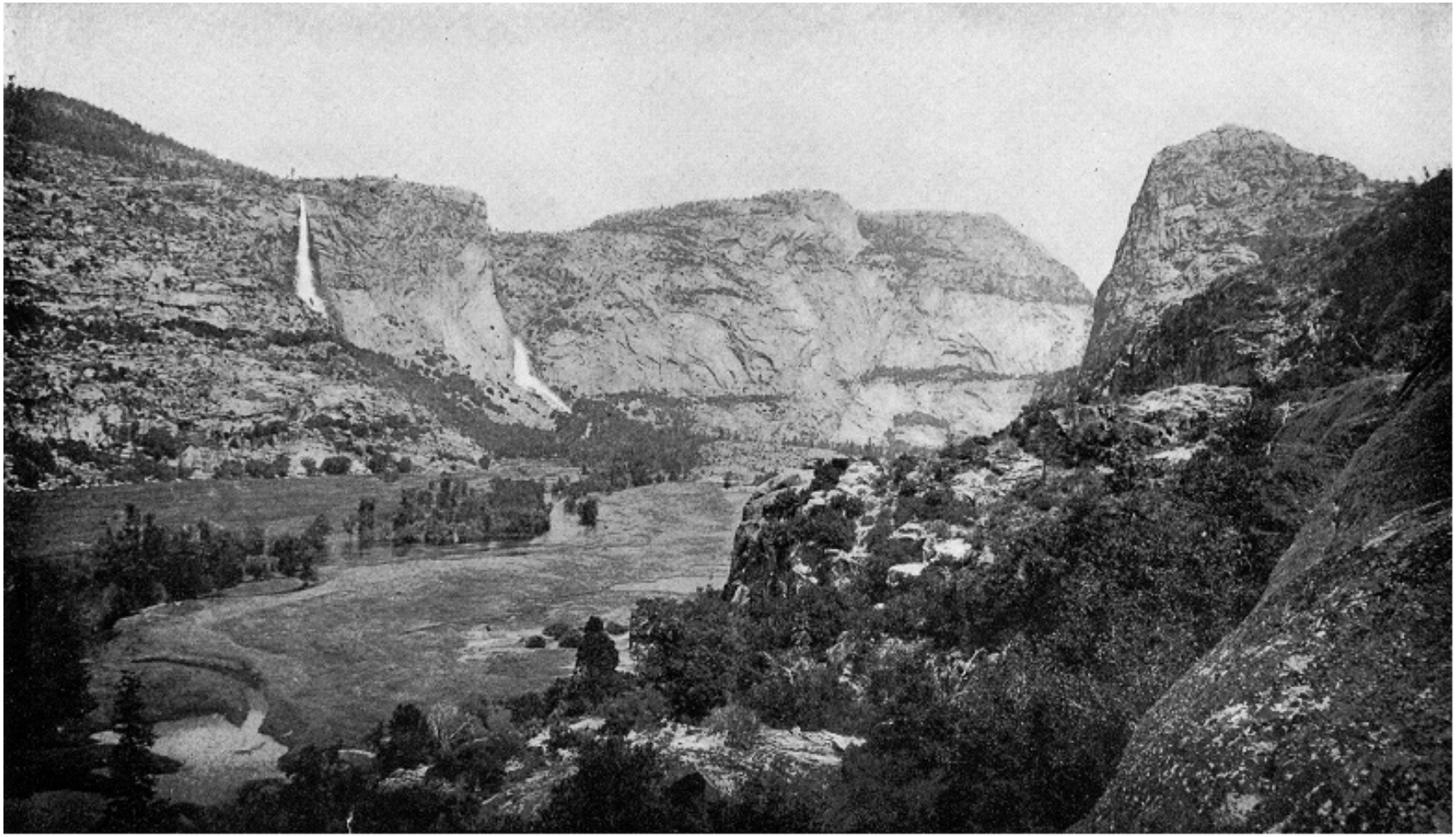
So, you spin a turbine



Hydro can be complex

- Many constraints
  - Intra and interseason storage requirements
  - Temperature and turbidity constraints
  - Treaties and contracts
  - Minimum and maximum flow constraints
  - Dredging
  - Water quality
- Can you go all hydro?
  - US ~6%
  - Norway ~95%

Everything Comes with a cost



Hetch Hetchy Valley 1908. Photo by Isaiah West Taber

Wind

- You find a good wind resource NREL Class 3 and up (http://www.nrel.gov/gis/wind_detail.html)
- Put up a suitably rated 2.5–3 MW windmill (Larger over time). 8MW is the largest I've hear about.
- Maintain them, upgrade them and if need be demo them.
- What people complain about
  - Noise – Can't hear after a mile or two
  - Raptor and bat kills – Less now with larger slower moving designs.
  - Ugly – In in the eye of the beholder.

PV

- Does not spin a turbine.
- PV effect generates DC electricity which is then converted to AC though an inverter

Levelized Cost of Electricity (LCOE) and Levelized Cost of Avoided Electricity (LACE)

- https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf Table 1
  - CC is Carbon Capture.
  - CCS is Carbon Capture and Storage

The Players

- Investor Owned Utilities (IOUs)
  - BIG
  - Holding companies with multiple subsidiaries.
  - Sister companies with common parent.
- Public
  - Muni – City owned
  - PUD – Own district with boards
  - Co-ops – Private non-profit (rural)

Types of Players

- Vertically integrated – G + T (>115kV) + D (<35kV)
  - They own some of each but buy some too.
  - Often D is all them.
- Distribution Only – D
  - Don't own T or D but buy on the market.
  - Look at restructured states for this.
  - SDG&E recently said they were interested.
- Note that T is open access, like a toll road with posted prices.

Multiple Jurisdictions for Siting

These overlap:

- EPA, BLM and others have some say.
- FERC handles most Federal
  - If Hydro or Nuke sighting the FERC
- If other type off generation then local PUC.

General Pattern

If you can make it work with a well designed market – do it.

If you can't – cost of service regulation.

Modern trend to incentive regulation.

Federal Power is Odd

- BPA is classic
  - The army corp of engineers runs the dams.
  - BPA (Power Marketing Agency) sells the power.
- Generally
  - Sell to local D or G/T/D company
  - Have other G + T resources

G Only

- Often called merchant power
- or IPP
- or non-utility generator

Public Owned

Tend to be D only but:

- Our local PUDs do own generation.
- Most power is from contract purchase
- BPA is often the supplier for the co-ops.

Do Customers Have Choice?

A: Sometimes

- Large customers
  - Billed for D by local utility
  - Purchase G on contract
  - Pay for T bundled with G or by OASIS posted prices.
- Residential and Others
  - In fully deregulated yes
  - Often the old local was default, exception Texas
  - Often marketing costs exceed profit so not done.
- Community Choice, big groups choosing G, is the next big wave.

Transmission

- The interconnects are in sync but not with each other.
- Still exchange power by DC connects.
- FERC covers rates and service standards for this.
  - Access via OATT/OASIS. OASIS is implementation of part of OATT.
  - OATT has a lot in it. Prices are only part.

Managing Transmission

- FERC delegated a lot of reliability to North American Electric Reliability Council (NERC).
- ISO/RTO voluntary but characteristics created by FERC
  - Plan, operate, dispatch and provide OASIS.
  - Notice OWN is not on the list.
  - Control area for their region
- Others operate control areas outside ISO/RTO territory
  - BPA
  - Our local IOUs
- ISO/RTO run markets
  - Ancillary services
  - Power Markets

Expanding ISO/RTO

- CAISO has plans for expanding
  - PGE and Pacific Power are tentatively on board
- Energy Imbalance Markets
  - Power market outside bounds of ISO

The Locals

- OPUC is governor appointed
- COUs and Co-ops are by vote
  - Sometimes per person (COU)
  - Sometimes per meter (Co-ops)
  - Rules for Co-ops vary.

What they Do

- Revenue requirement
- Allocate costs
- Design prices
- Quality Standards
- Check IOU finances
- Be a judge in disputes.

Consumer advocate is sometimes in or separate agency and sometimes separate. Oregon CUB is separate.

How Did We Get to the Current G-T-D Arrangement (MES Argument)

- Both large scale and small scale originally existed.
- Large scale developed
  - Lower AC
  - Higher MES
  - Speed of change up till 60s made this the dominant form.
- Small scale continued to develop
  - Right sized scale and MES
  - Decreasing AC
  - 1978 Qualifying Facilities Era was when they could sell power under some conditions.