Status of Battery Technology

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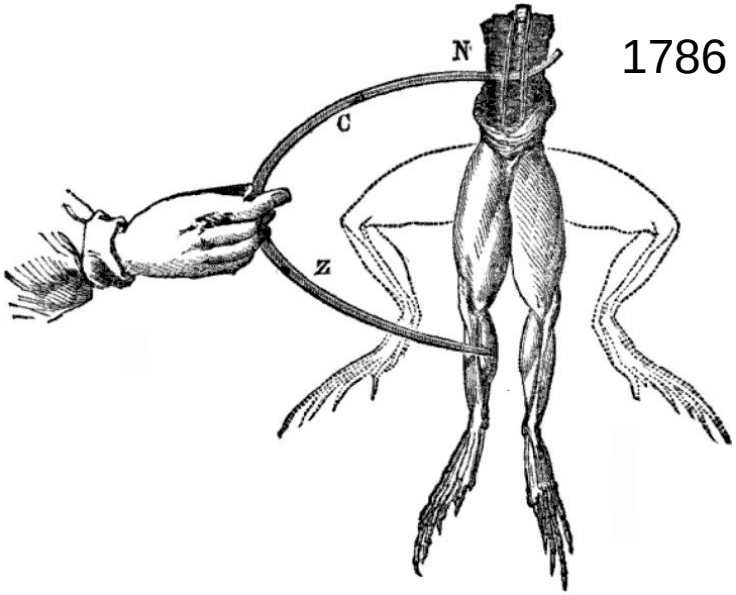
Utah Legislature
September 20, 2017

Scope of Briefing

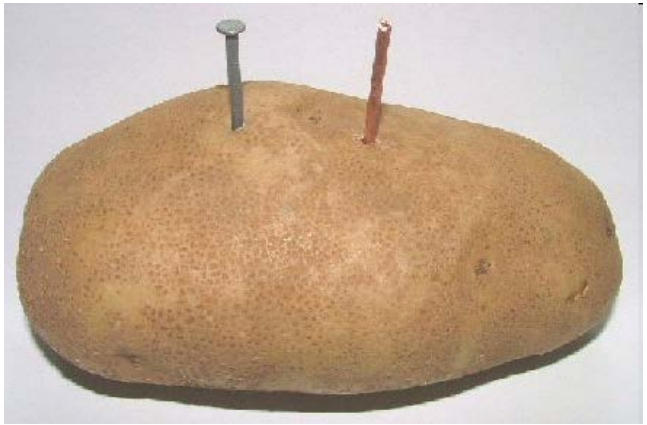
- Introduction to batteries and their challenges
- Batteries in electric vehicles
- Batteries in grid-scale storage

Some Battery History



1786 Luigi Galvani

1799 Alessandro Volta

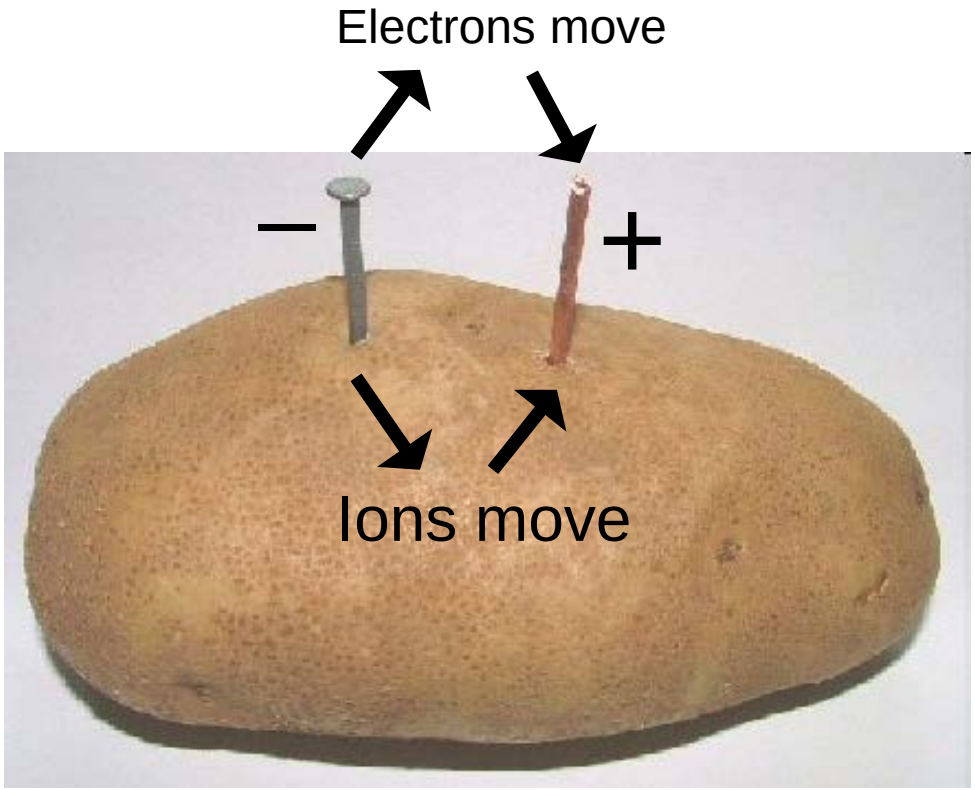


2017 science fair battery

Image sources: David Ames Wells, GuidoB/Wikipedia

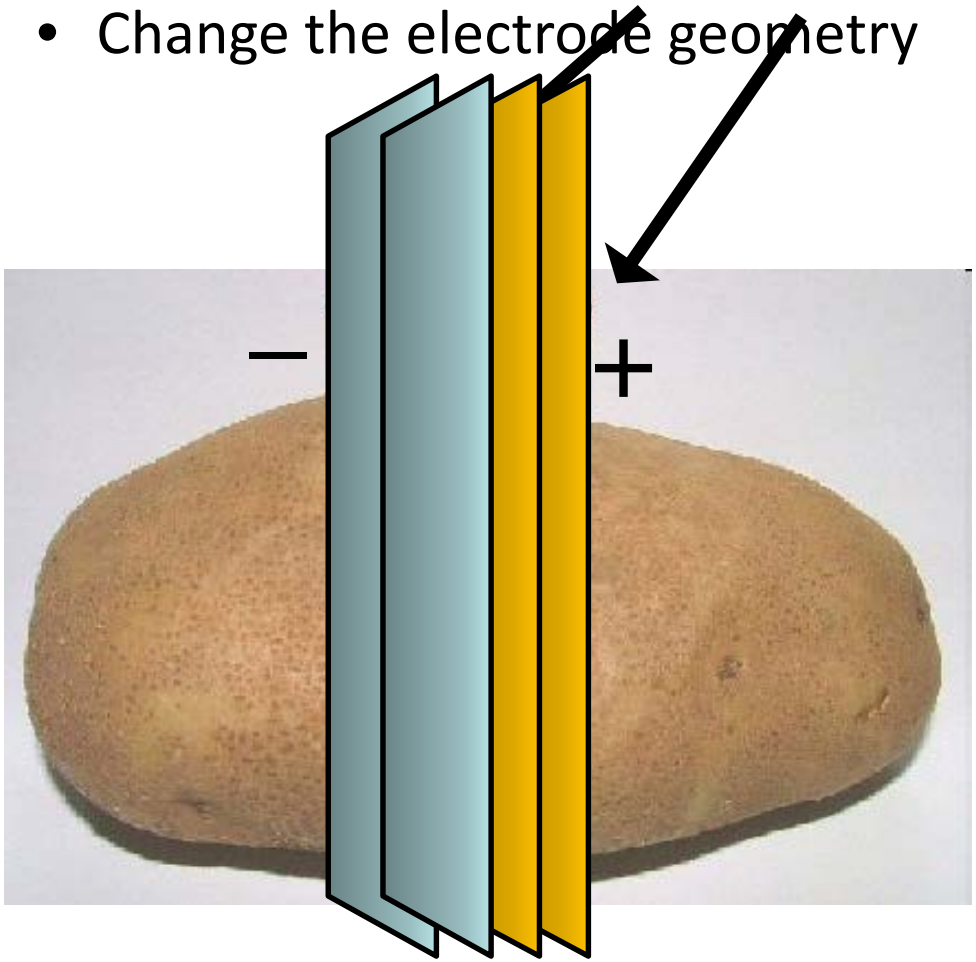
What Is Going on Inside Batteries?

- Electrons flow outside the battery
- Ions (charged molecules) flow between the electrodes inside the battery



How to Make Batteries Work Better?

- Change the electrode chemistry
- Change the electrode geometry



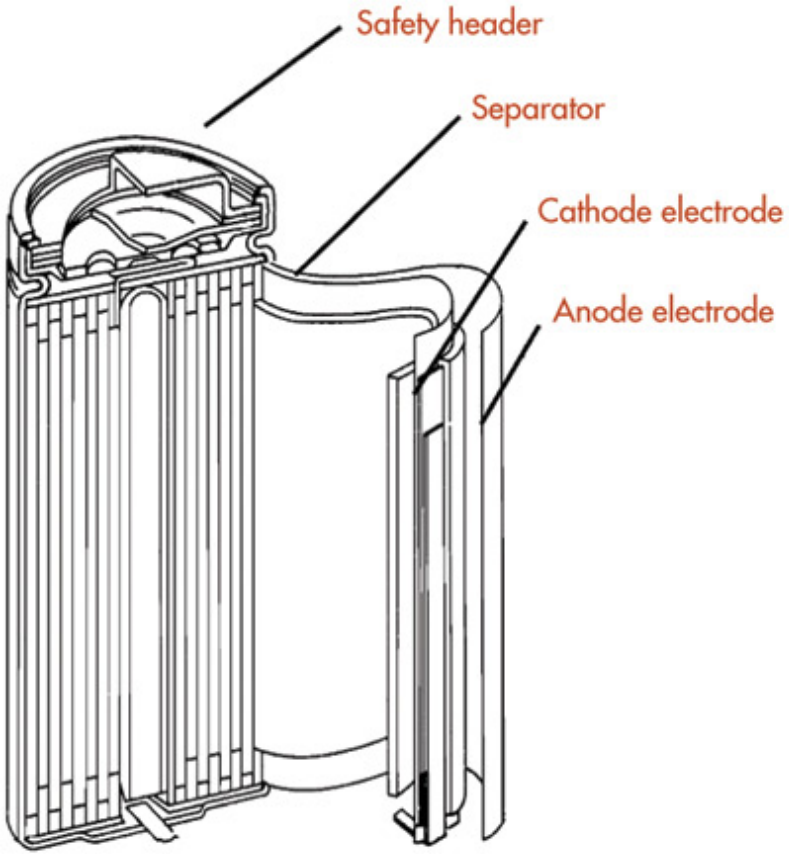
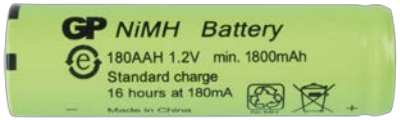


Image source: electronicdesign.com

Kinds of Rechargeable Batteries

- Lead acid (invented 1859) – $100/kWh

- Nickel cadmium, Ni metal hydride – $350/kWh
- Lithium-ion (commercialized 1990, light, long-lasting) – $400/kWh



- Others in development (5-20 years away?)
  - Beyond Li-ion: sodium-ion, Li-sulfur, Li-air
  - Flow batteries: vanadium
  - High temperature: liquid metal, molten salt

Image sources: voltaicsystems.com, megabatteries.com, amazon.com

Safety Is an Issue

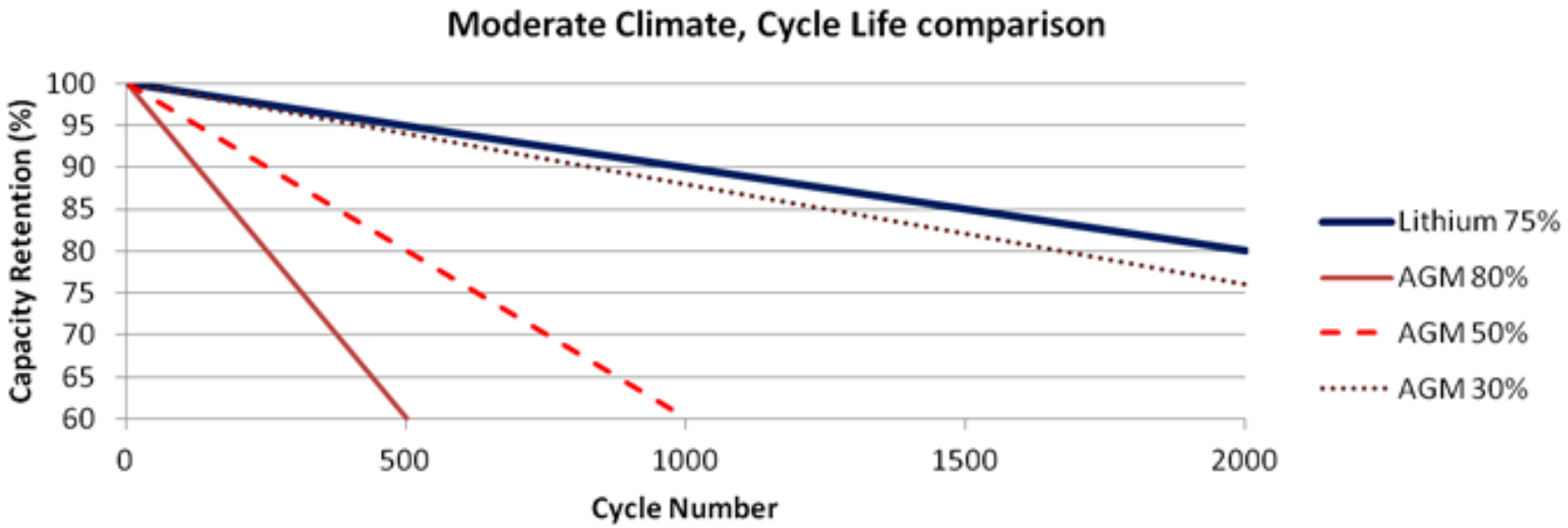
- Batteries store lots of energy in a small space
- Fire can result because of “thermal runaway”
- How to remediate?

Image from slate.com

Image from blog.tmcnet.com

Battery Life Is an Issue

- Batteries have “side reactions” that cause loss of capacity



- Controlling depth of discharge and temperature helps batteries last longer

Image source: altenergymag.com

How to Make Big Batteries

- Gasoline engines vs. batteries
- Battery packs & modules
  - Cooling/heating
  - Management system
- Elon Musk's (Tesla) innovation

AA cell vs.
18650 Li-ion cell

Nissan Leaf
battery module

Image sources: Lead Holder/Wikipedia, Tennen Gas/Wikipedia

Types of Electric Vehicles (EVs)

- Hybrid (HEV), Plug-in Hybrid (P-HEV), full-battery (BEV)
- Regenerative braking = get highway mileage even in city

Toyota Prius (HEV)
53 kg

Chevy Volt (P-HEV)
197 kg

Nissan Leaf (EV)
300 kg

Typical battery packs guaranteed for 8 years (100k miles) and degrade 10-30%

Outlook on Electric Vehicles

THE HILL

Electric car sales predictions are all over the map

BY DAN COHAN, OPINION CONTRIBUTOR - 01/24/17 05:30 PM EST

72 COMMENTS

- Currently 1% market share
- Predicted 8% market share by 2025
  (Energy Info Admin)

Nikola Motor Company (SLC)

VIA Motors (Orem)

The Need for Energy Storage in the Power Grid

- Electricity demand (load) fluctuates

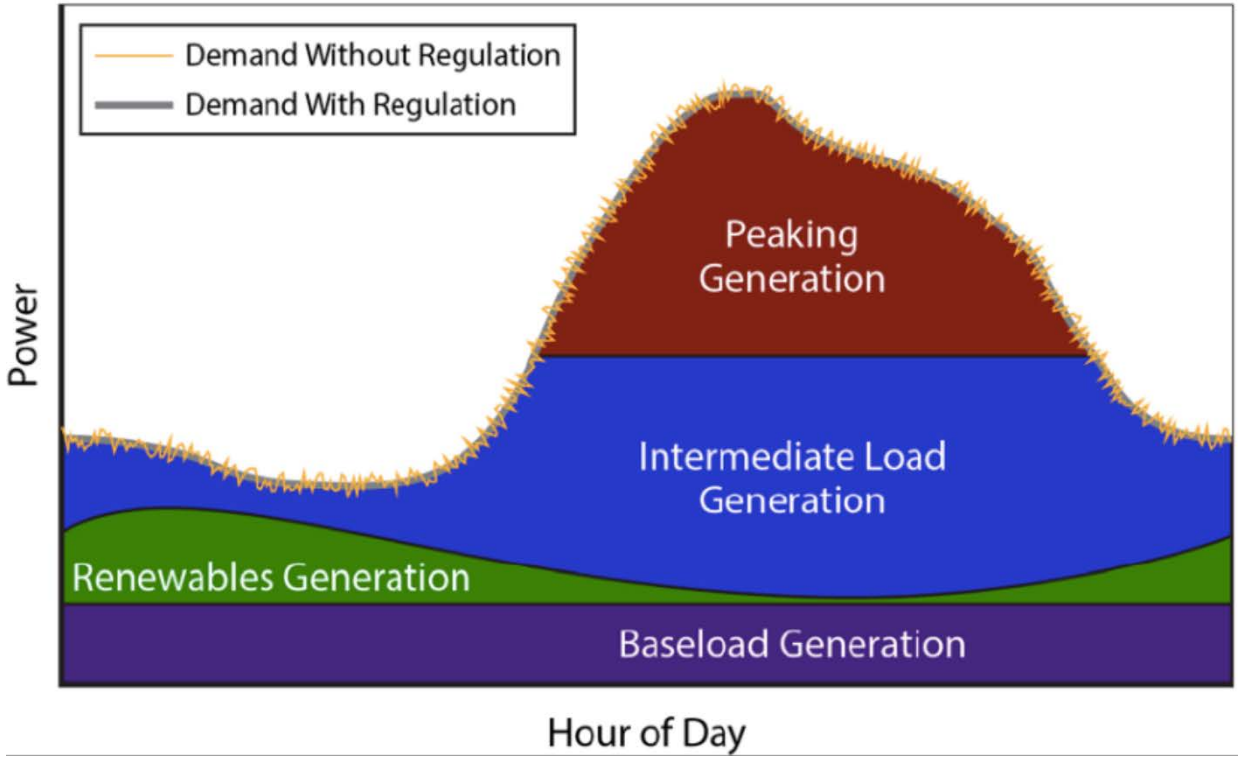


Image source:
US Dept Energy

- Fluctuations occur on different time scales
- Mismatch made worse by renewables (solar & wind)

Types of Grid-Scale Energy Storage

U.S. completed and planned projects as of 2013

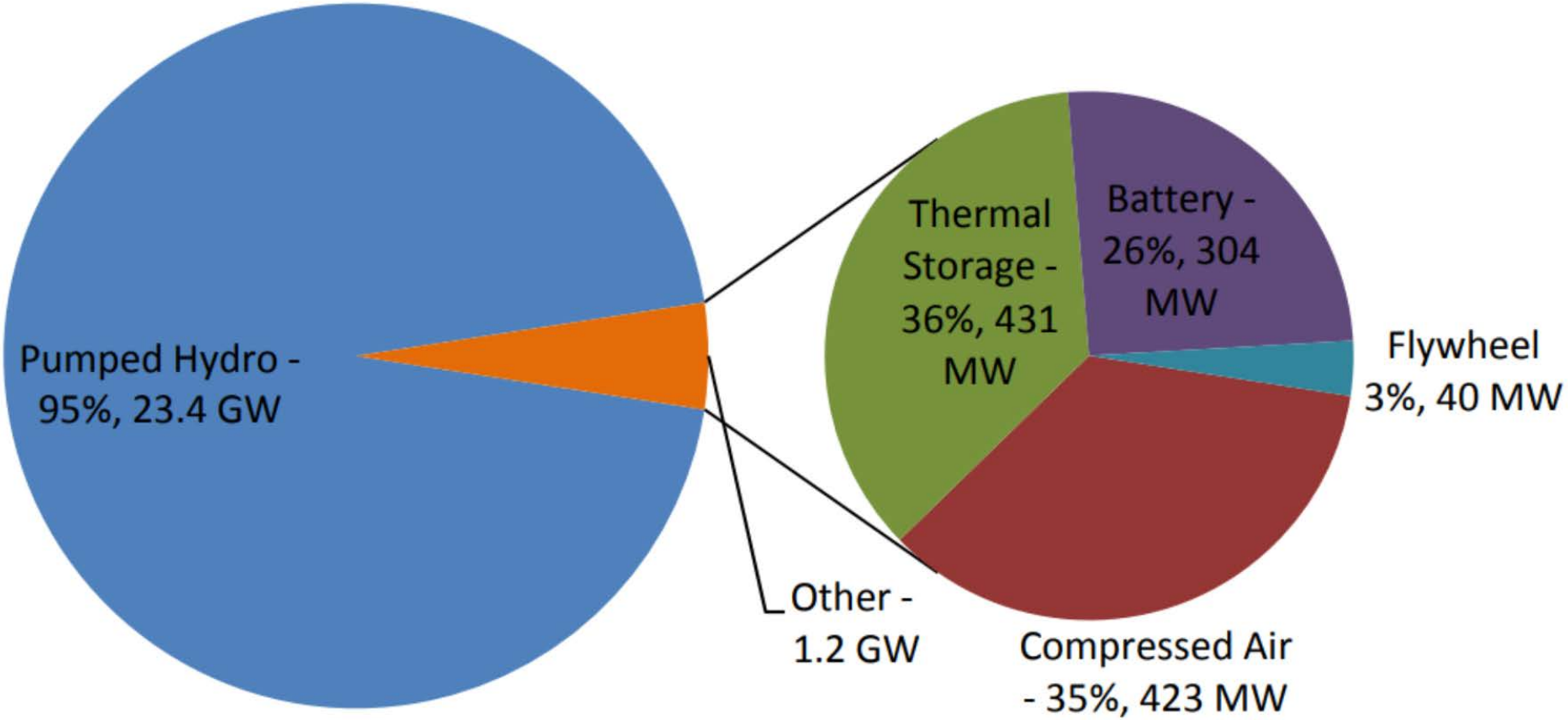


Image source: US Dept Energy

Electrochemical Energy Storage (i.e. Batteries) Pros and Cons

- Geography-independent
- Economic for short time scales (secs/mins)
- Expensive for long time scales (hours/days)
- Can be deployed on smaller size scales (microgrids)

Castle Valley, Utah (Case Study)

- Power lines not adequate
- 2002 – RMP installed Vanadium Flow Battery system (~$2M cost)
- 2008 – Decommissioned due to technical problems and vendor problems. Was never operational
- 2017 – RMP upgrading lines
- Town is pursuing Fed. grant to investigate locally produced energy

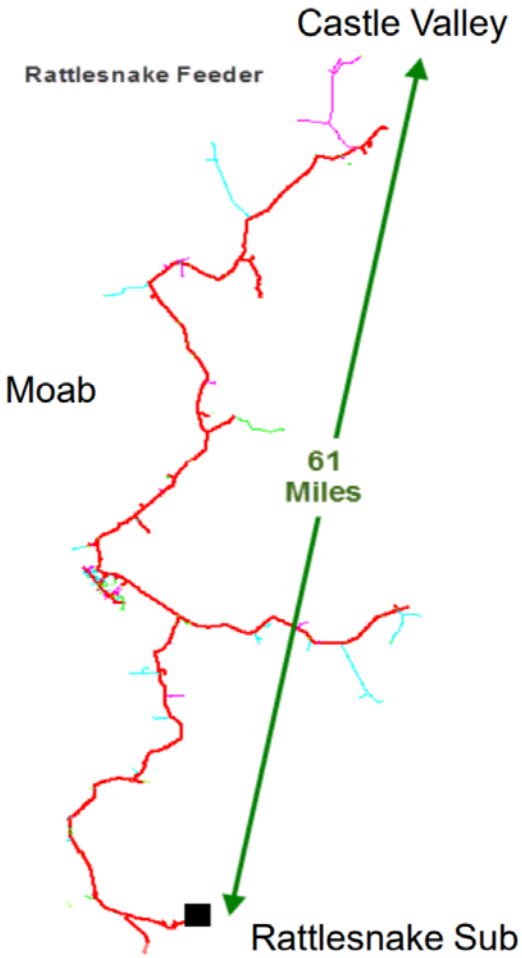


Image sources: Rocky Mtn Power/energy.utah.gov, US Dept Energy
Further acknowledgement: Bruce Keeler, Castle Valley

Outlook on Grid-Scale Batteries

- Large drop in price of photovoltaic (PV) systems is allowing rapid deployment – **distributed generation**
- Need major drop in battery costs for similar rapid deployment – **distributed storage**
- Coupling of residential PV + batteries will increase resilience of system, especially during disasters
- Need cooperation of electric utilities