STORAGE TECHNOLOGIES

Professor Olu Lafe
MIDATCO Group Chairman
PAWA774 Principal Partner

Presentation at
1st Nigeria Specific GSMA/IFC Green Power for Mobile working Group
Co-hosted by AIRTEL

January 30, 2013

Copyright 2013 MIDATCO Group

MIDATCO GROUP



TechVille

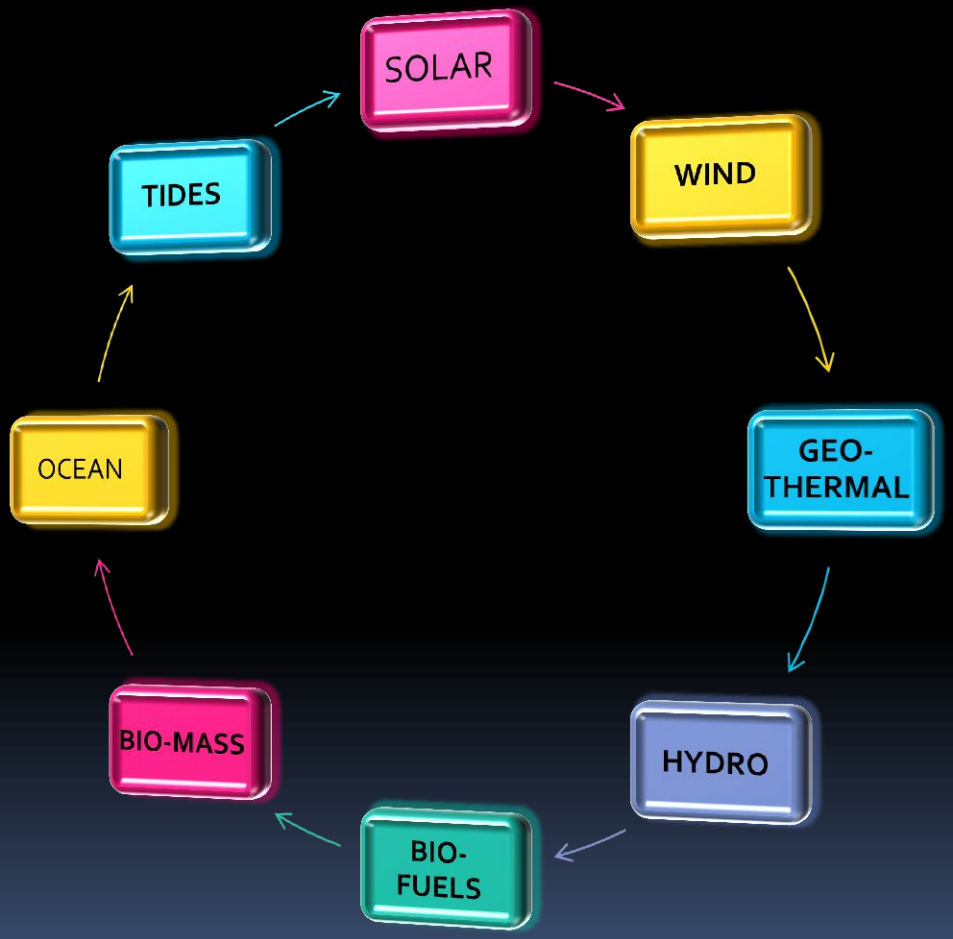
MIDATCO – cutting-edge technology developer and promoter (www.midatco.com)

PAWA 774 – initiative to generate 774 x 10MW clean power in all the 774 LGAs in Nigeria (www.pawa774.com)

TechVille – Public Private Partnership between MIDATCO and Ondo State Government. Capacity development in technology with particular emphasis on clean energy systems and ICT (www.techville.co)

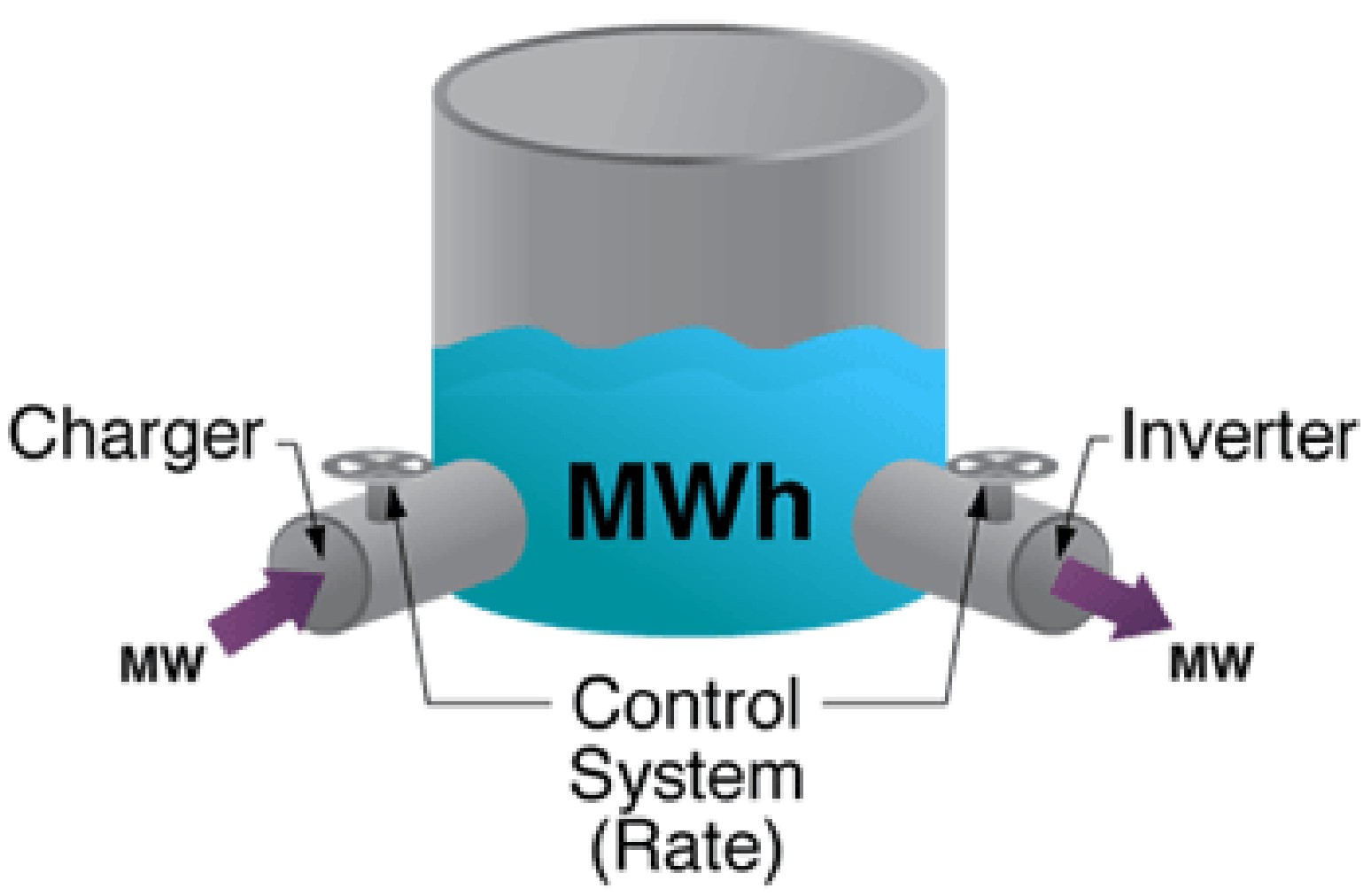
Copyright 2013 MIDATCO Group 2/13/2013

Renewable Energy Sources



Copyright 2013 MIDATCO Group

Power & Energy (MW & MWh)



Copyright 2013 MIDATCO Group

Daily Energy Usage in Nigeria - Estimate

- Common Residential Home – 10KWh/day
- Middle Class Residential Home – 30KWh/day
- Upper Class Residential Home – 100KWh/day
- Telco Base Station – 120KWh/day (assuming a 5KW generator running continuously for 24 hours)

Copyright 2013 MIDATCO Group

Daily Energy Usage in Nigeria - Estimate

- Common Residential Home – 10KWh/day
- No of homes – 28 million (assuming 7 people per home, for 167 million population)
- Energy required for all homes: 280,000 MWh/day
- Uninterruptible power generation required for common residential homes: 12,000MW

Copyright 2013 MIDATCO Group

Why Store Energy?

- Intermittency of renewable energy sources
  - The sun is not always shining
  - The wind is not always blowing
- Non uniform power usage
  - Peak hours
    - Offices/factories - during the day
    - Homes – evenings and during the night
- Economics
  - Fossil fuel generators are often sized to generate more energy than needed. Storage allows the excess energy to be available when the generator is not in use

Copyright 2013 MIDATCO Group

Batteries

- A battery is simply any device that stores electrical energy for later use.
- The storage can be in any form of recoverable energy system including
  - Electrochemical cells
  - Gravity
  - Pumped Heat
  - Fuel cells
  - Pumped Hydro
  - Compressed Air

Copyright 2013 MIDATCO Group

Common "off-the-shelf" Energy Storage Devices

- Deep Cycle Batteries.
- A deep-cycle battery is a lead-acid battery designed to be regularly deeply discharged using most of its capacity.
- A deep-cycle battery is designed to discharge between 50% and 80% depending on the manufacturer and construction of the battery.

Copyright 2013 MIDATCO Group

Common "off-the-shelf" Energy Storage Devices

- Lead Acid Batteries
  - Flooded (Standard will have removable caps)
  - AGM (Absorbed Glass Mat) - the electrolyte is absorbed in a fine Boron-Silicate fiber-glass mat
  - GEL (acid "gelled" by the addition of silica gel) – the cell has the electrolyte mixed with silica dust to form a gel.
- AGM & GEL Batteries are the so-called sealed and Valve Regulated Lead Acid (VRLA) Batteries. VRLA batteries do not require regular addition of water to the cells, and vent less gas than flooded lead-acid batteries. They are described as "maintenance free" unlike flooded batteries.

Copyright 2013 MIDATCO Group

Flooded Deep Cycle Batteries





Copyright 2013 MIDATCO Group

An AGM Battery



Copyright 2013 MIDATCO Group 2/13/2013

A GEL Battery



TechVille's 48KWh Energy Storage System Using AGM Batteries



Copyright 2013 MIDATCO Group

Energy Storage System Coupled to Solar Power Generator Built by TechVille



Copyright 2013 MIDATCO Group

TechVille-Installing a Solar Energy Harvesting System



Copyright 2013 MIDATCO Group

New Ideas & Community Energy Storage Systems

Copyright 2013 MIDATCO Group

Telcos & Energy Storage

- Important to look beyond just powering the base station
- Economy of scale advantage when both the energy needs of the base station and the surrounding community are considered
- Win-Win for Telco and the community
- Telco provides power (or aligns with provider of power) for the community while ensuring the base station is properly serviced
- Excellent ROI

Copyright 2013 MIDATCO Group

Liquid Metal Battery

how to think about inventing a colossal yet cheap battery: pose the right question

☞ start with a giant current sink

convert this…



aluminium potline

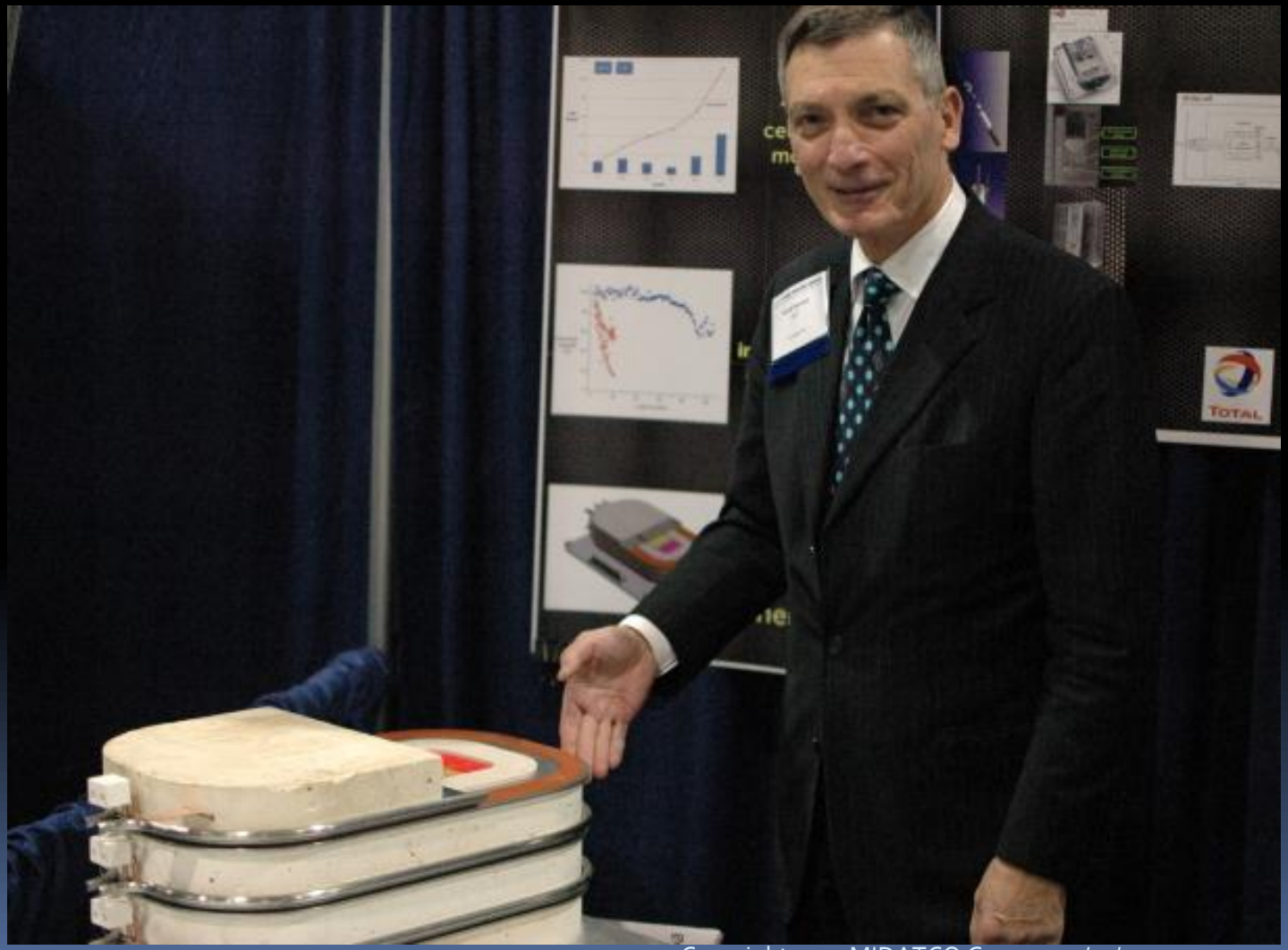
350,000 A, 4 V

…into this



Copyright 2013 MIDATCO Group

Liquid Metal Battery - MIT's Don Sadoway

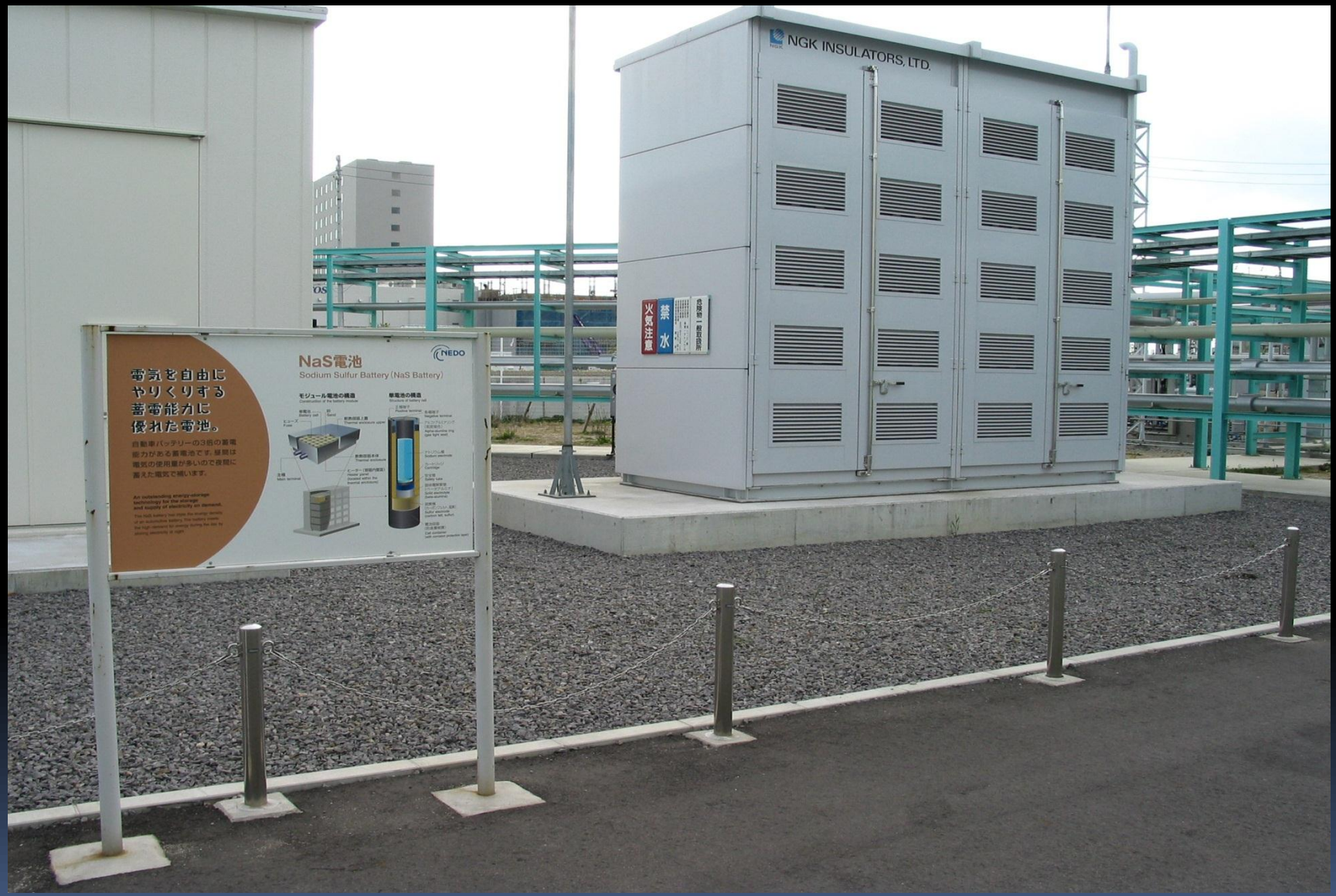


Copyright 2013 MIDATCO Group

Energy Storage Using Sodium Sulfide Batteries

Copyright 2013 MIDATCO Group

NAS - Sodium Sulfide Battery



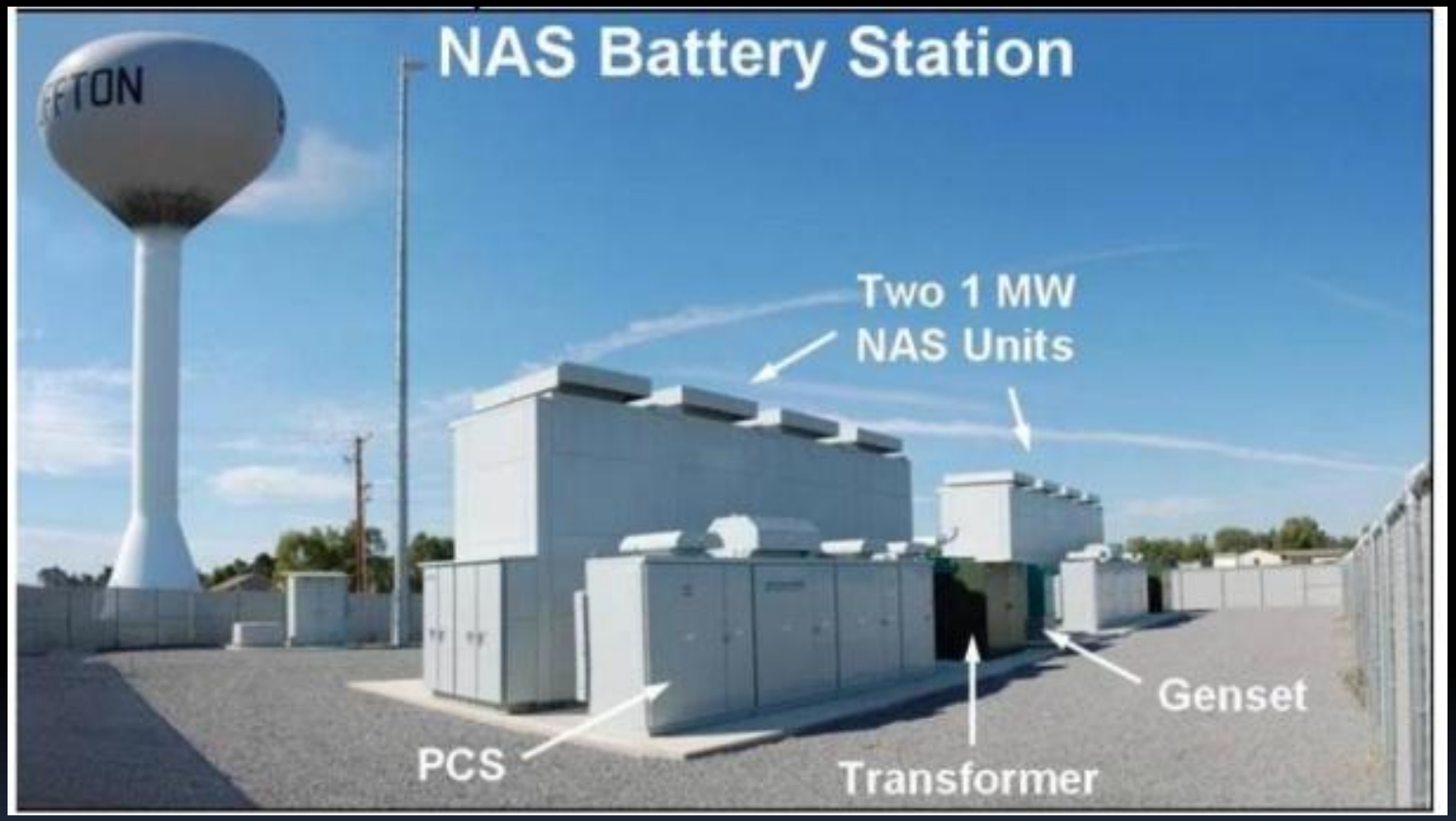
Copyright 2013 MIDATCO Group 2/13/2013

2MW Sodium Sulfide Battery



Copyright 2013 MIDATCO Group

Sodium Sulfide Battery



Ohio-based utility AEP is one of the most advanced in using storage to buffer energy on the grid. Here, a sulfur-sodium battery from NGK Insulators is installed at a substation. It provides back-up power and holds enough energy to supply the local grid during peak times. Each megawatt battery can hold about 7.2 megawatt-hours.

Copyright 2013 MIDATCO Group

Lithium Ion Energy Storage

Copyright 2013 MIDATCO Group

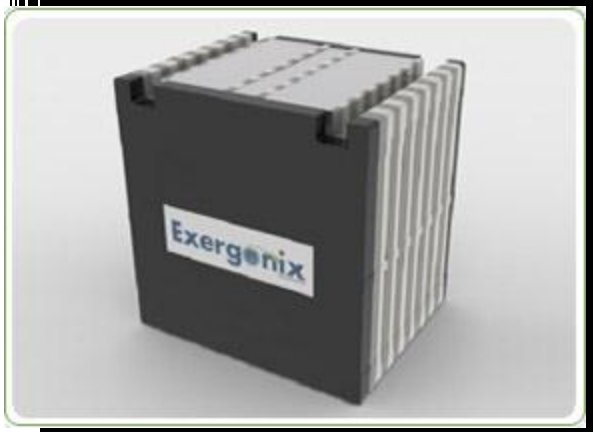
Xtreme Power (USA)



The Xtreme Power System installed in Hawaii is capable of delivering 30 megawatts of power and have 10 megawatt-hours of storage. That is enough to supply power to 1,000 common residential homes in Nigeria.

Copyright 2013 MIDATCO Group

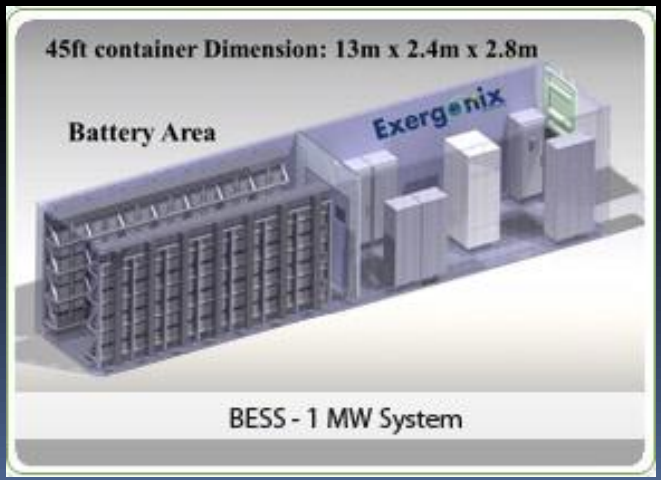
Energonix (USA)





Energonix (USA, Lithium Ion Battery) has designed a community scale energy storage system for smart grid applications. Note that large battery systems are built using smaller battery cells.





Copyright 2013 MIDATCO Group

S&C's Community Energy Storage



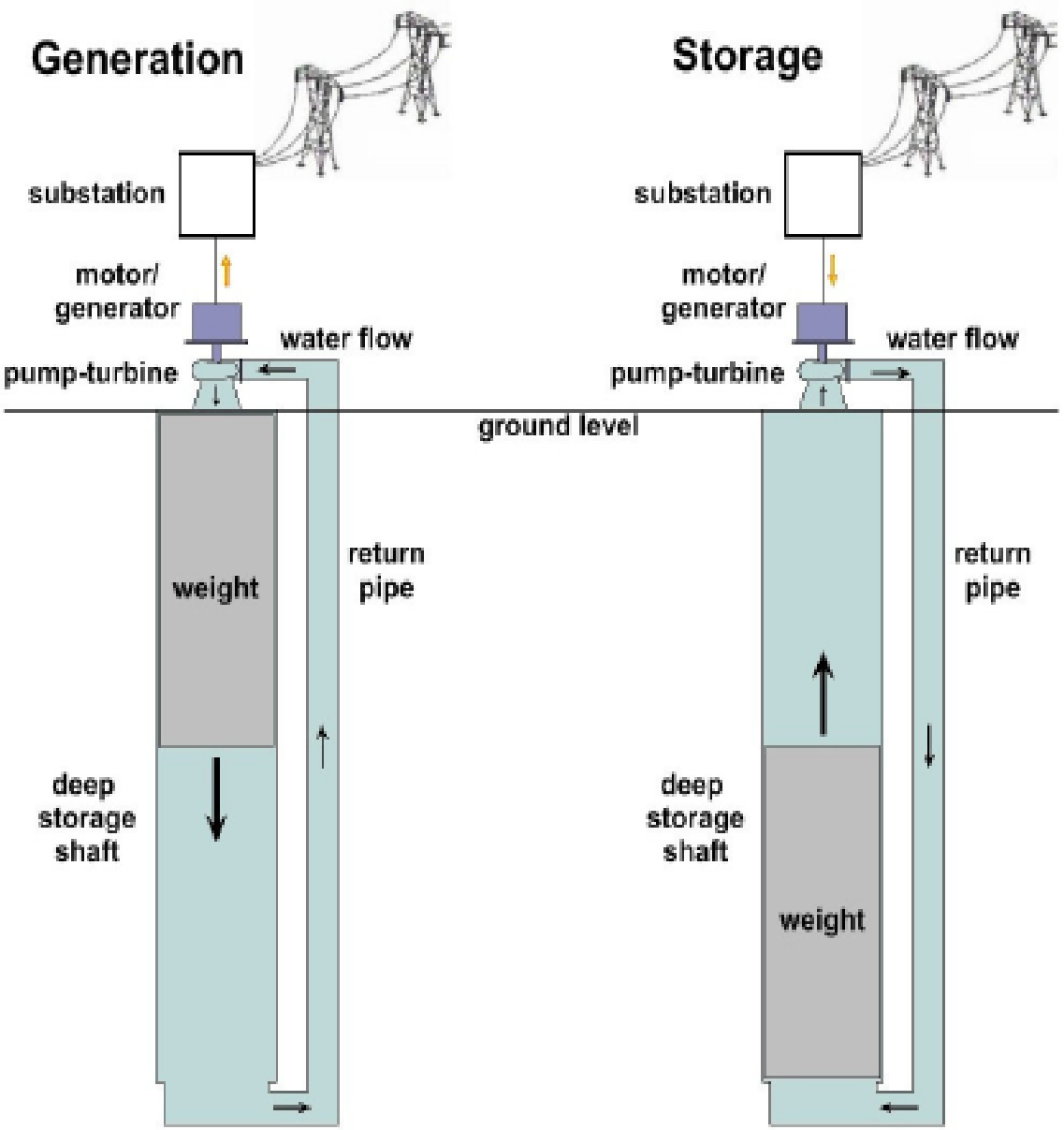
Copyright 2013 MIDATCO Group

Gravity Storage

Gravity Power, LLC, a spin-off of LaunchPoint Technologies, Inc., is developing a revolutionary grid-scale electricity storage system. The company's new Gravity Power Module(GPM)™ exploits the established principles of pumped storage hydropower, but extends the concept in a new direction

Copyright 2013 MIDATCO Group

Gravity Power



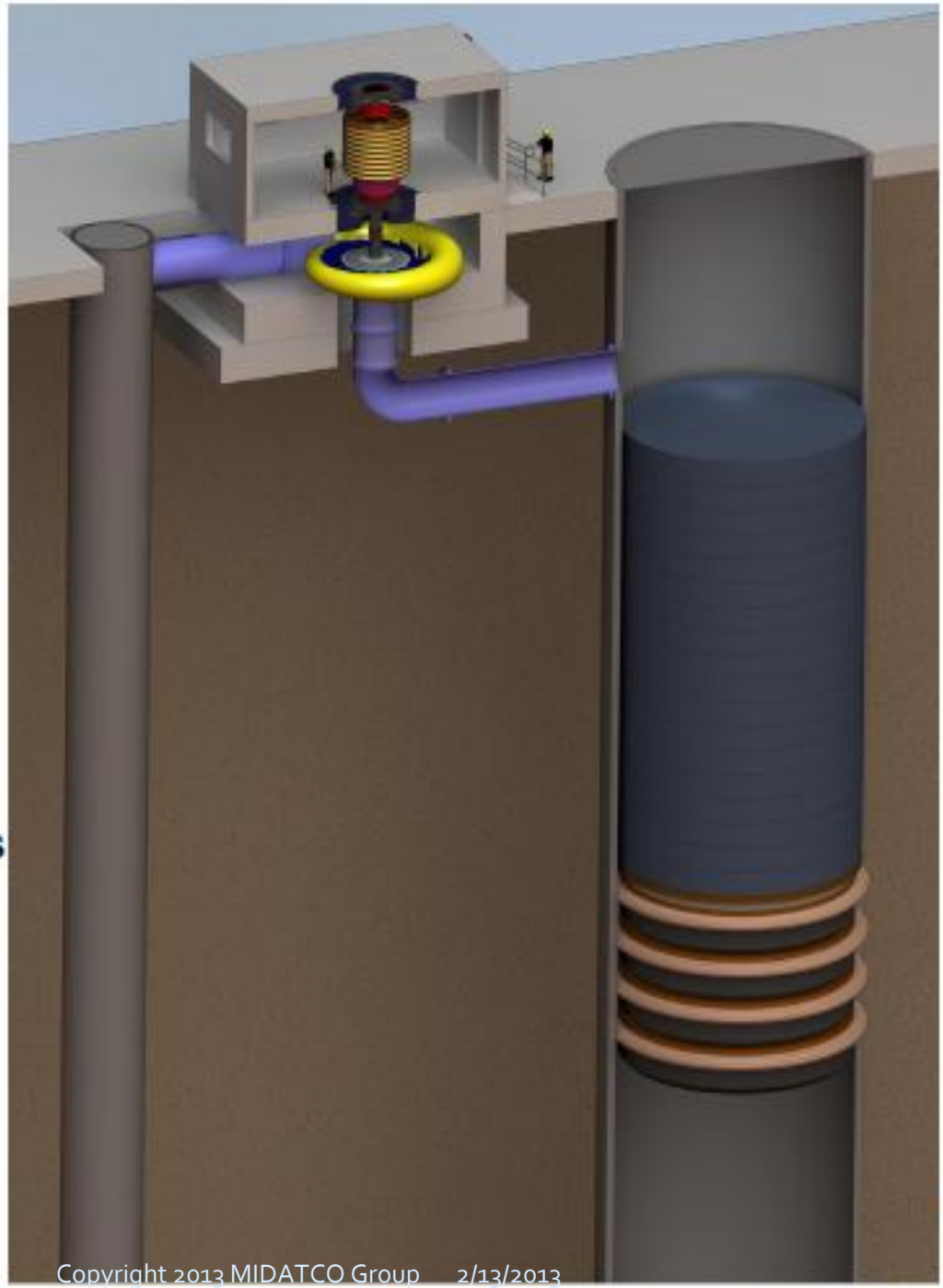
- Modular, underground pumped storage
- High efficiency (75-80%)
- Ramps far faster than gas turbines (peaking plants)
- Low cost materials (cement, iron ore, steel)
- Environmentally benign
- Flexible siting
- Fast permitting
- Rapid construction
- Expandable
- Short time to revenue
- Patents Pending

A-GPM Parameters

- 6m storage shaft, 2m return pipe
- 500m deep
- 8000-tonne storage mass
- ~25 MW with 8.5 MWh per module initially, more energy later

Market

- ~50 GW in U.S.
- ~2000 GPMs @ ~$25M each
- Performs better than thermal plants
- System payback time: ~5-10 years
- System lifetime: 30+ years



Copyright 2013 MIDATCO Group

Pumped Hydro Energy Storage

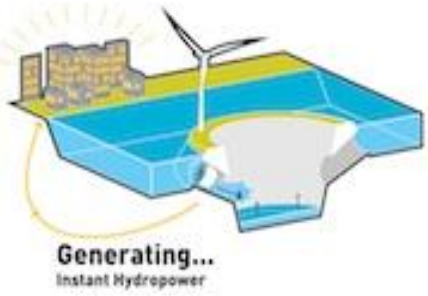


Copyright 2013 MIDATCO Group

Green Power Island
Pumped Storage (Denmark)







Green Power Island proposes using seawater pumped into a lagoon-like reservoir built into an artificial island. When demand is low, pumps driven by wind turbines empties the reservoir. At peak periods, water is allowed to flow back into the reservoir, through turbines generating electricity to meet the rising demand. Proposed by Copenhagen-based architectural firm Gottlieb Paludan

Copyright 2013 MIDATCO Group

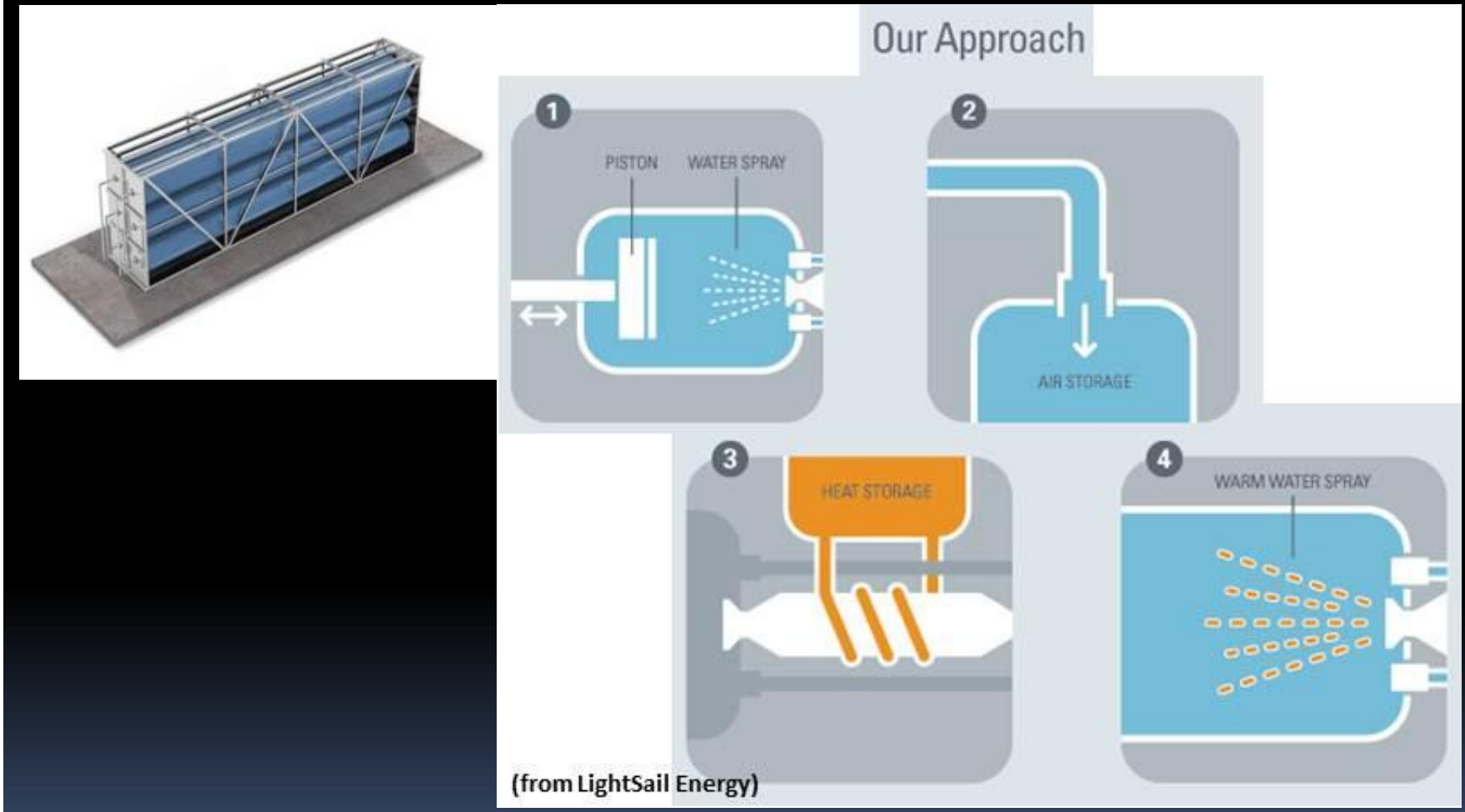
Compressed Air Energy Storage

There is a spate of new projects in development including: a 270 MW project in Iowa, a 300 MW project in California, a 150MW project in New York, and a new 200MW project in Germany. Together these projects will total almost one Gigawatt of compressed air storage capacity.

Compressed air has the advantage of using mature technology and in not relying on any new exotic technologies or materials. The gas turbines, air compressors, recuperators, injection and extraction wells, and other components used in CAES are all mature technologies that enjoy economies of scale and long design evolution built into them. The know how and the people with it are either ready right now or can be ramped quickly.

Copyright 2013 MIDATCO Group

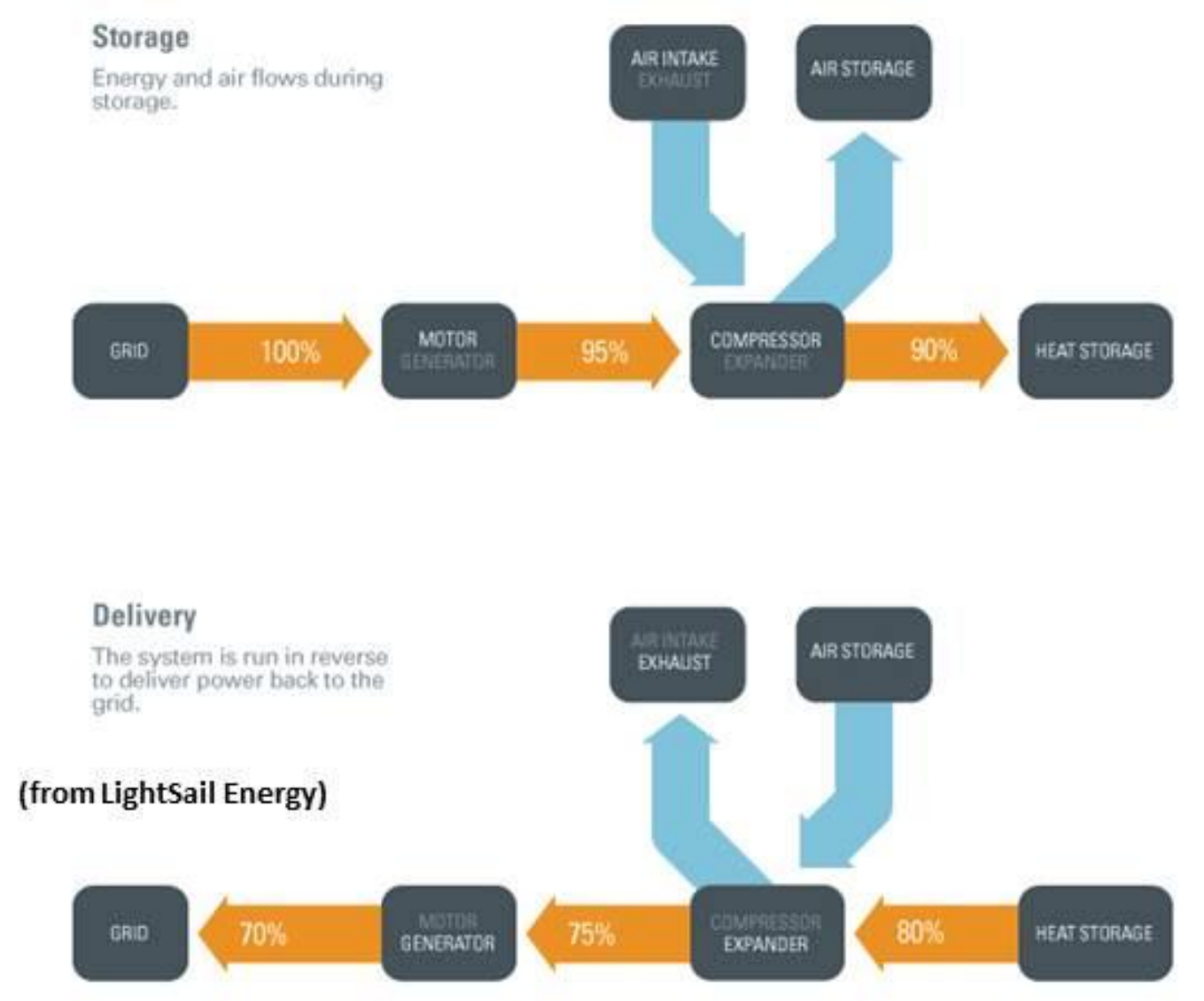
Compressed Air Energy Storage by LightSail Energy (USA)



CAES stores mechanical energy rather than electrochemical energy, which is what the more familiar battery holds

Copyright 2013 MIDATCO Group

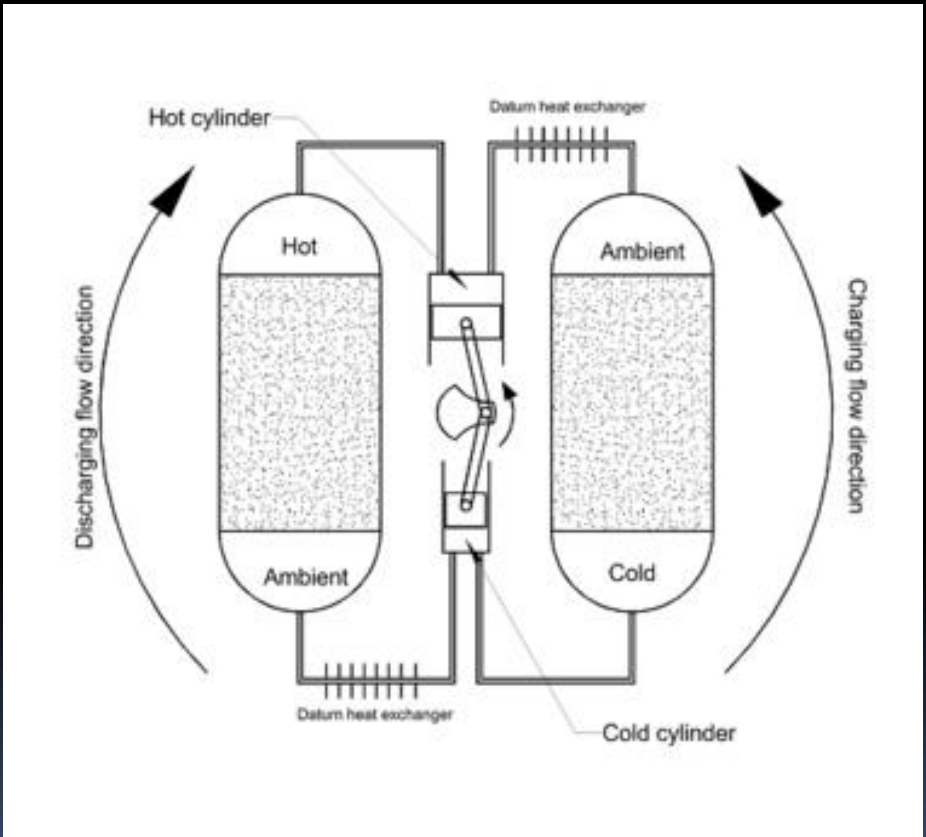
Compressed Air Energy Storage



(from LightSail Energy)

Copyright 2013 MIDATCO Group

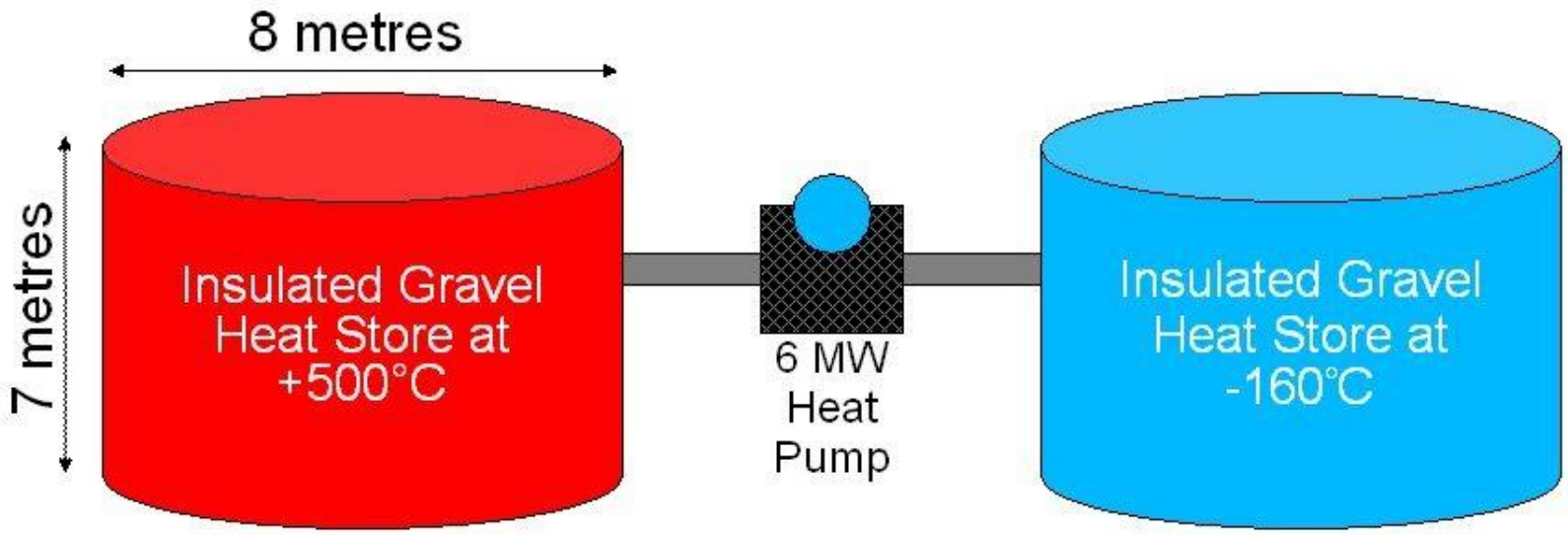
Isentropic (UK) Pumped Heat Electricity Storage



The storage system uses two large containers of mineral particulate. Electricity is used to pump heat from one vessel to the other resulting in the first container cooling to around -160°C and the second container warming to around 500°C. The specially designed heat pump machine can be thermodynamically reversed to operate as an engine and the electricity is recovered by passing the heat from the hot container back through the machine to the cold container, while the machine drives an electrical generator. During the process, the containers return close to their original temperatures.

Copyright 2013 MIDATCO Group

Isentropic's Pumped Heat Energy Storage – Gravel Pit!



Recoverable Electrical Energy 30 MWh

Copyright 2013 MIDATCO Group

Pumped Heat Energy Storage

Isentropic claims a round trip efficiency of over 72% – 80%. Because gravel is such a cheap and readily available material, the cost per kWh can be kept very low – $55/kWh – and $10/kWh at scale

Additional benefits:

- low cost compared to some other ideas;
- high efficiency;
- not constrained by geology (cf pumped hydro);
- environmentally benign;
- modular and scalable;
- can respond rapidly to load variations.

Copyright 2013 MIDATCO Group

Thank You!

Copyright 2013 MIDATCO Group