Small Modular Reactors (SMRs)

Increasing Demand for Electric Power

- **New Data Centers**

  (Microsoft and Constellation Energy re-opening Three-Mile Island nuclear facility that will generate 800 Mwe)

- **AI**

  (Goldman-Sachs estimates an increase of 100 TWh for AI. In 2023, total generation for the

  U.S. was 4.237 TWh)

- **Electric Vehicles**

- **Desalinization Facilities**

  (As increasing demand for potable water grows)

- **Crypto Mining**

Problems of National Electric Power Grid

Aging Infrastructure: Many grids around the world were built decades ago and are in need of significant upgrades and maintenance.

•**Capacity Issues:** Demand for electricity often exceeds the capacity of the grid, especially during peak hours or extreme weather conditions.

•**Reliability Concerns:** Grids can experience frequent outages or instability due to technical failures, weather events, or inadequate maintenance.

•**Cybersecurity Threats:** With increasing digitization, power grids are vulnerable to cyberattacks that can disrupt services or compromise data.

Problems of National Electric Power Grid

- **Transition to Renewable Energy:** Integrating renewable sources like wind and solar into the grid poses challenges due to their intermittent nature and varying energy outputs.

- **Environmental Impact:** Some grids rely heavily on fossil fuels, contributing to environmental concerns such as pollution and climate change.

- **Financial and Regulatory Issues:** Funding constraints and regulatory hurdles can hinder grid modernization efforts and investment in new technologies.

Largest Generating Facilities in the U.S.

Grand Coulee Dam (Washington)

Capacity: 6,809 MW Type: Hydroelectric

Bath County Pumped Storage Station (Virginia)

Capacity: 3,003 MW Type: Pumped Storage Hydroelectric

Palo Verde Nuclear Generating Station (Arizona)

Capacity: 3,937 MW Type: Nuclear

Browns Ferry Nuclear Plant (Alabama)

Capacity: 3,952 MW Type: Nuclear

Robert W. Scherer Power Plant (Georgia)

Capacity: 3,520 MW Type: Coal

Largest International Generating Facilities

Three Gorges Dam (China): Hydroelectric facility has an installed capacity of 22,500 MW, making it the largest in the world.

Itaipu Dam (Brazil/Paraguay): Hydroelectric power plant, Itaipu has a capacity of 14,000 MW.

Xiluodu Dam (China): Hydroelectric plant has a capacity of 13,860 MW.

Belo Monte Dam (Brazil): Hydroelectric facility, it has a capacity of 11,233 MW.

Guri Dam (Venezuela): Hydroelectric power plant has a capacity of 10,235 MW.

Sources of Electric Power in U.S. (2023)

- **Natural Gas**: 43%

- **Coal**: 16%

- **Nuclear**: 18%

- **Renewables**: 24% - This includes various sources such as wind, solar, hydroelectric, and biomass.
  - **Wind**: 10% - Wind energy has seen substantial growth over recent years.
  - **Solar**: 5% - Solar power continues to expand rapidly.
  - **Hydroelectric**: 6% - Hydropower remains a stable contributor, though its share fluctuates based on precipitation patterns.
  - **Other Renewables**: 3% - This includes biomass and geothermal energy.

- **Petroleum**: 0.4% - Petroleum is a minor source for electricity generation.

- **Other Sources**: 0.5% - Includes various other sources such as batteries, hydrogen, other.

Some Other Data

- A population of 100,000 requires, on average, 600,000 MWh per year (assuming 2 persons per household)
- At any given time, 68.5 MW is needed (600,000/365/24), on average
- 38% of electric consumption is by residences so an area with 100,000 population requires 180 MW (68.5/.38)
- The 2024 residential population of Phoenix is 1,662,607 so a rough estimate of electricity required at any given time is 1,141 MW (1.141 GW)

Bottom Line

- The demand for electric power is growing very rapidly
- To meet the increasing demand, reliance on all sources needs to be examined, with cleanliness as the key driver
- The National power grid is aging and has security concerns
- Nuclear generation is the most salient solution to the problem
- It is estimated that it takes up to 15 years to build a large-scale nuclear facility from start to finish

Small Modular Reactors (SMRs)

- SMRs typically have a capacity of less than 300 megawatts electric(MWe), which is significantly smaller than conventional nuclear reactors that can have capacities ranging from hundreds to over a thousand megawatts. They can be deployed in various settings, including remote communities, industrial sites, or as part of a larger power grid, providing energy for both electricity generation and other industrial applications.
- One of the key advantages of SMRs is their potential to be manufactured in factories and transported to site, reducing construction time and costs. Additionally, they often incorporate passive safety features that enhance their ability to shut down safely in case of emergencies.
- However, like any nuclear technology, SMRs also face challenges, including regulatory approval, public acceptance, and addressing concerns over nuclear waste management and proliferation risks.

SMRs

NuScale Power Corporation (NYSE: SMR) - Is recognized as the first and only publicly traded SMR technology provider. NuScale's flagship product is the NuScale Power Module, a compact pressurized water reactor with an electric capacity of about 60 megawatts per module. They focus on safety, scalability, and cost-effectiveness (Energy & Capital ,World Nuclear News).

The NuScale Power Module - a pressurized water reactor with all the components for steam generation and heat exchange incorporated into a single unit, generating 77 MWe - in September 2020 became the first SMR design to receive approval from the US Nuclear Regulatory Commission. NuScale offers the units as VOYGR plants which can be scaled to meet customer needs. Doosan Enerbility recently announced it is to begin manufacturing main equipment for the first commercial deployment of a NuScale VOYGR power plant for Utah Associated Municipal Power Systems' Carbon Free Power Project which is to be built at a site at the Idaho National Laboratory in the USA.

Meeting Electric Demands

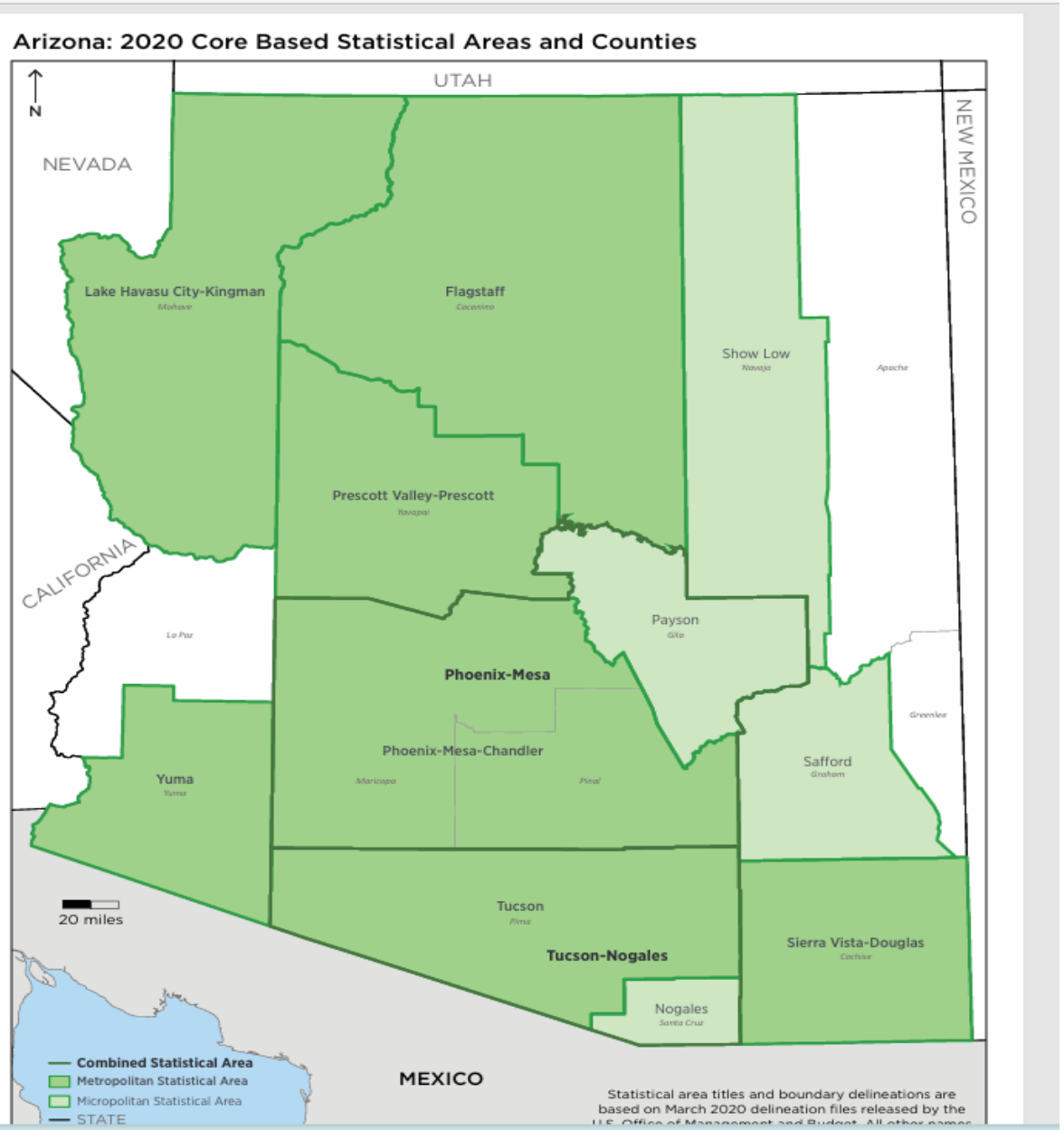
- NuScale Power Corporation (NPC) has developed a modularized nuclear generating system with the following characteristics:

Modules	Capacity (MW)
4	293
6	441
12	884

Since it takes approximately 68.5 MW to service a population of 100,000, a four-module NPC system would provide approximately twice that is needed for a population of 200,000. Estimated time from start to completion is approximately three (3) years.

Arizona Population by MSAs

- Picture of the Metropolitan Statistical Areas (MSAs) within Arizona.
- Phoenix-Mesa-Chandler has 5.1 million people
- Tucson has 1.08 million
- Prescott Valley-Prescott has 250,000 people
- Lake Havasu City-Kingman has 213,000
- Flagstaff has 213,000
- Yuma has 220,000



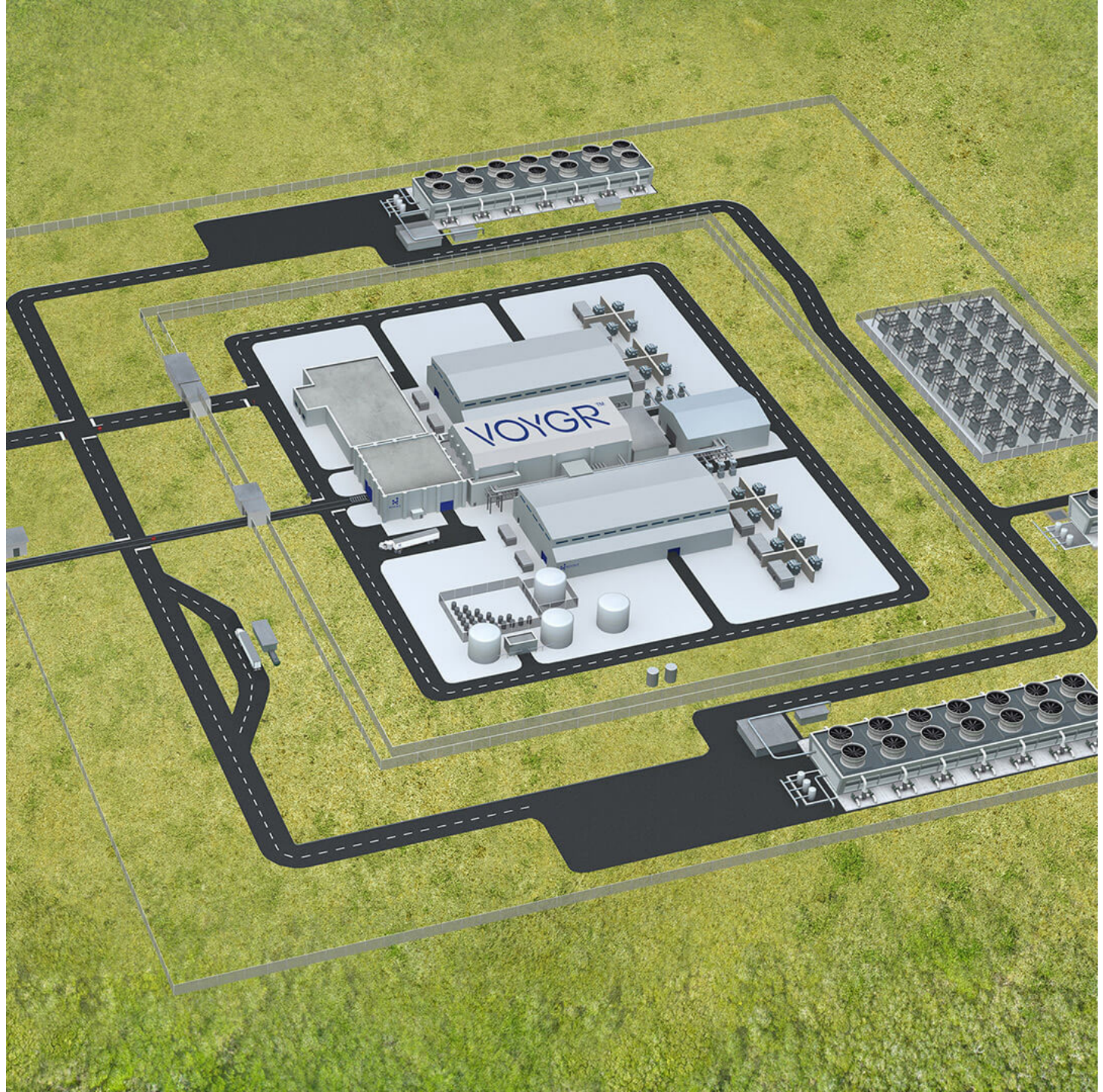
My Crazy(?) Idea

- Option # 1
  - Install a 4-module system in each of Flagstaff, Prescott, Lake Havasu, and Yuma MSAs (populations in the 200,000s).
  - Power needed is 171 MW for Prescott, 151 MW for Yuma, and 146 MW for each of Flagstaff and Lake Havasu. Each 4-module system can provide 293 MW.
  - Isolate each from the national grid with the capability of feeding the national grid in case of emergency.

My Crazy(?) Idea

- Option # 2
  - Install a 12-module system to service the Flagstaff, Prescott, and Lake Havasu MSAs (population of 676,000). This area would require 463 MW whereas the system can deliver 884 MW.
  - Create a separate ‘grid’ for this area, keeping it isolated from the national grid, with the capability of feeding the national grid in case of emergency.


VOYGR™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My Vision for Electric Power

- The Arizona model would be replicated throughout the U.S. where feasible.
- Major population centers will continue with existing suppliers while waiting for large scale technology to catch up with demand.
- The large number of SMRs throughout the U.S. will be independent of the national grid, each forming a micro-grid that will be capable of accessing the national grid.
- This will require a massive investment in infrastructure but provide security of electricity in the event of a massive grid failure that is increasingly susceptible to hacking and foreign influence.