WELCOME TO TECHNICAL TALK WITH RF

State Energy Policy Edition

November 13, 2023

TECHNICAL TALK WITH RF

FORWARD TOGETHER RELIABILITYFIRST

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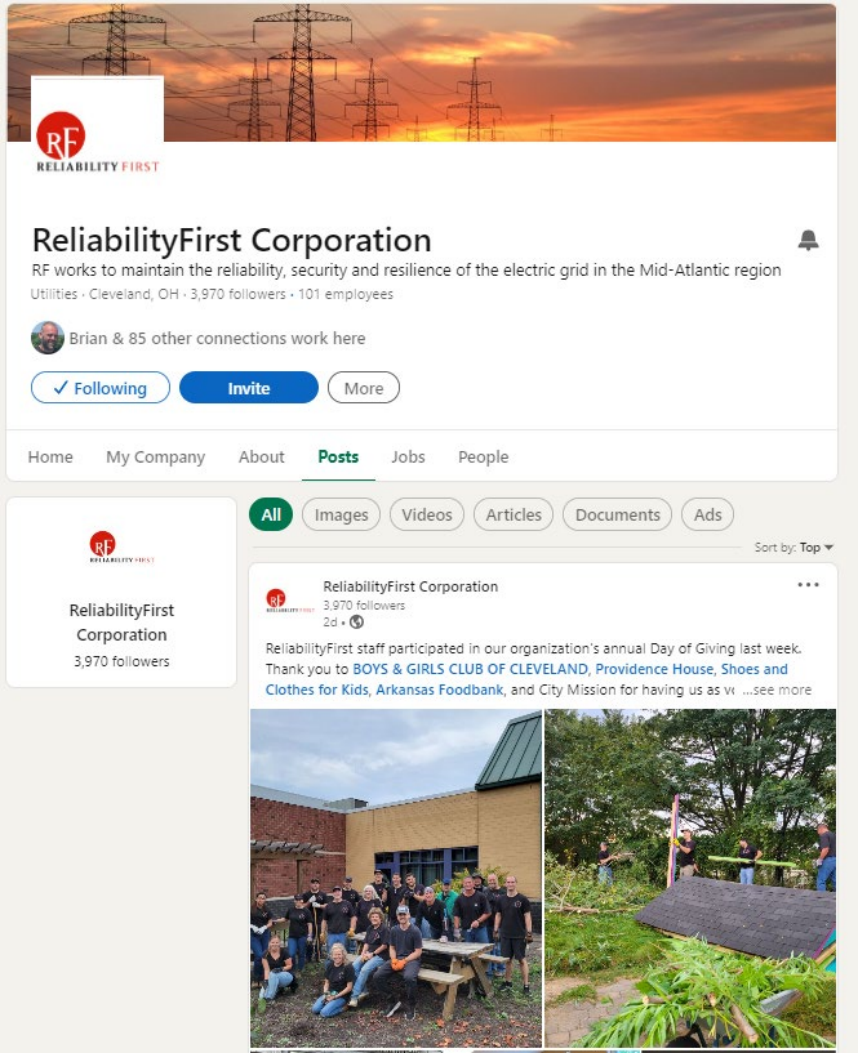

TECH TALK REMINDERS

Please keep your information up-to-date

- CORES, Generation Verification Forms, Entity Profile Questionnaires (quarterly)

Following an event, send EOP-004 or OE-417 forms to disturbance@rfirst.org

CIP-008-6 incident reports are sent to the E-ISAC and the DHS CISA

Check our monthly CMEP update and quarterly newsletter:

- 2023 ERO Periodic Data Submittal schedule
- Timing of Standard effectiveness

BES Cyber System Categorization (CIP-002-5.1a)

- Assess categorization (low, medium, or high) regularly and notify us of changes

CIP Evidence Request Tool V7.0 is online, see website

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2023-2024 WINTER RELIABILITY ASSESSMENT

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

2023 – 2024 Winter Reliability Assessment

NERC has released this year's winter reliability assessment examines potential risk factors across North America to better inform and prepare industry and policy makers to maintain grid reliability this winter. To read the full report click here

RISK FACTORS

Adequacy

Resource and Energy Adequacy

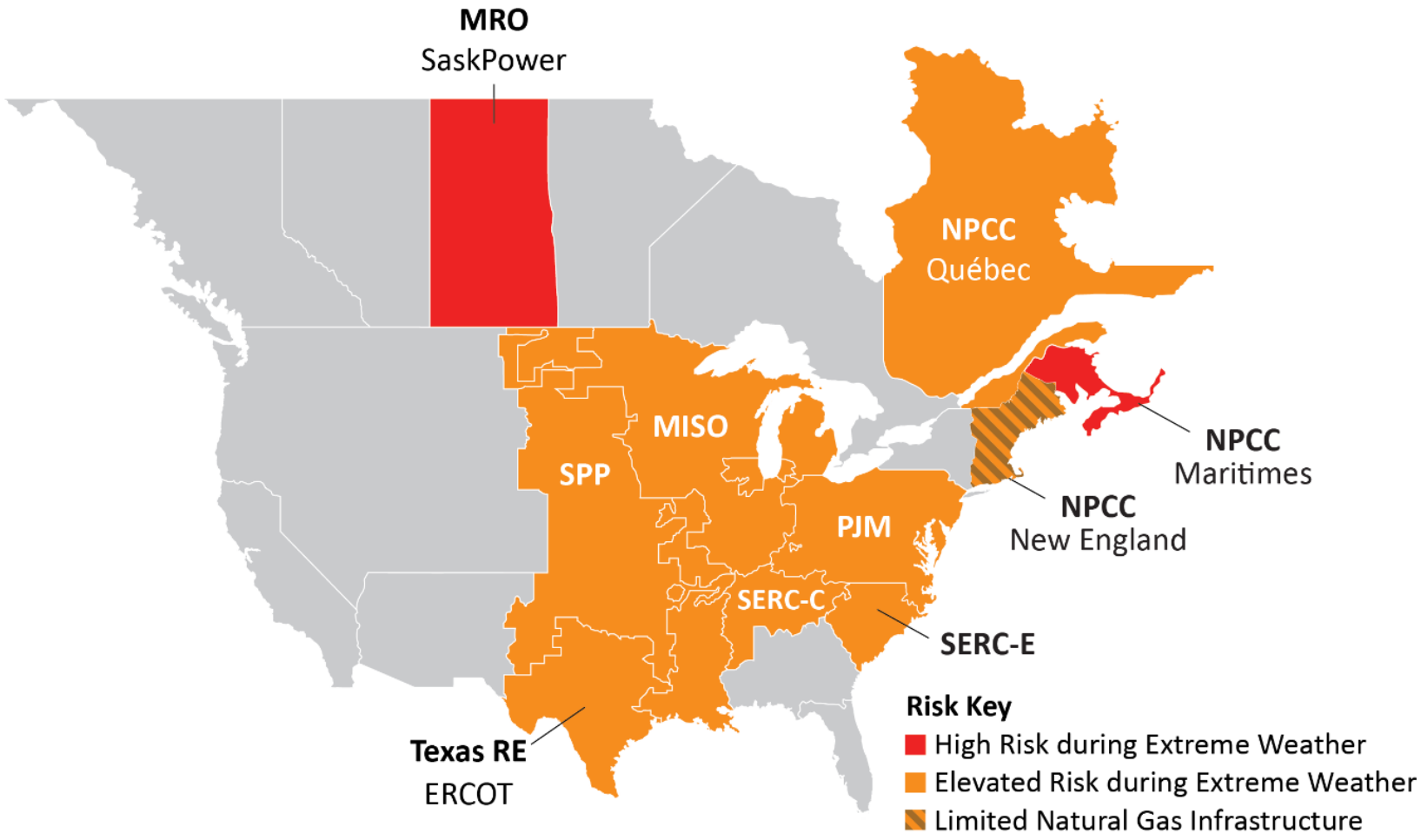
Fuel

Fuel Availability

Extreme Weather

Preparations for an extreme weather event

WINTER RELIABILITY RISK AREA



Seasonal Risk Assessment Summary	
High	Potential for insufficient operating reserves in normal peak conditions
Elevated	Potential for insufficient operating reserves in above-normal conditions
Low	Sufficient operating reserves expected

WINTER ASSESSMENT RECOMMENDATIONS

Review seasonal operating plans and protocols for communicating and resolving potential supply shortfalls

Implement the mitigations identified in the NERC Level 3 Alert, Cold Weather Preparations for Extreme Weather Events

Be cognizant of the potential for short-term load forecasts and be prepared to implement protocols for managing reserve deficiencies

Survey and monitor the adequacy of fuel supply

State regulators can assist grid owners by supporting environmental and transportation waivers for electric load and natural gas conservation

ANNOUNCEMENT

RF'S DIANE HOLDER TESTIMONY

RF's Vice President of Entity Engagement and Corporate Services testified in a joint public hearing with **The Ohio Public Utilities Committee and Pennsylvania Environmental Resources & Energy Committee**. Watch it here

RF'S NEW WEBSITE AT RFIRST.ORG

RELIABILITY FIRST

About | Contact | Careers | Calendar | Tools & Services | Resource Center | Search

Addressing Risks | Registration & Certification | Compliance | Enforcement | Data Requests | Get Involved

Forward Together

Ensuring a reliable and secure electric grid for today and tomorrow.

Explore risk areas | Explore resources

About Us

ReliabilityFirst is one of six regional organizations responsible for ensuring the reliability and security of the North American Bulk Electric System. Under the authority of the Federal Energy Regulatory Commission (FERC), we audit utility companies on mandated standards related to cybersecurity, vegetation management near vital power lines, preparation for extreme weather and more. We also promote the reliability and security of the electric grid through outreach, training and analysis. We are based out of Cleveland, Ohio, and our footprint includes the Great Lakes and Mid-Atlantic areas of the United States.

ADDITIONAL RESOURCES

December 14th Publication

- NERC Long-Term Reliability Assessment – Annually assesses the adequacy of the Bulk Electric System over a 10-year period.
- Set up a meeting with RF to provide a debrief to you and your staff. Contact Michelle Cross at michelle.cross@rfirst.org

RF is an independent resource for reliability questions and discussions including the grid transformation, cyber and physical security, emerging technologies and extreme weather.

Upcoming testimony – December 11th

- West Virginia Senate/House Joint Energy Committee Hearing

TECHNICAL TALK WITH RF

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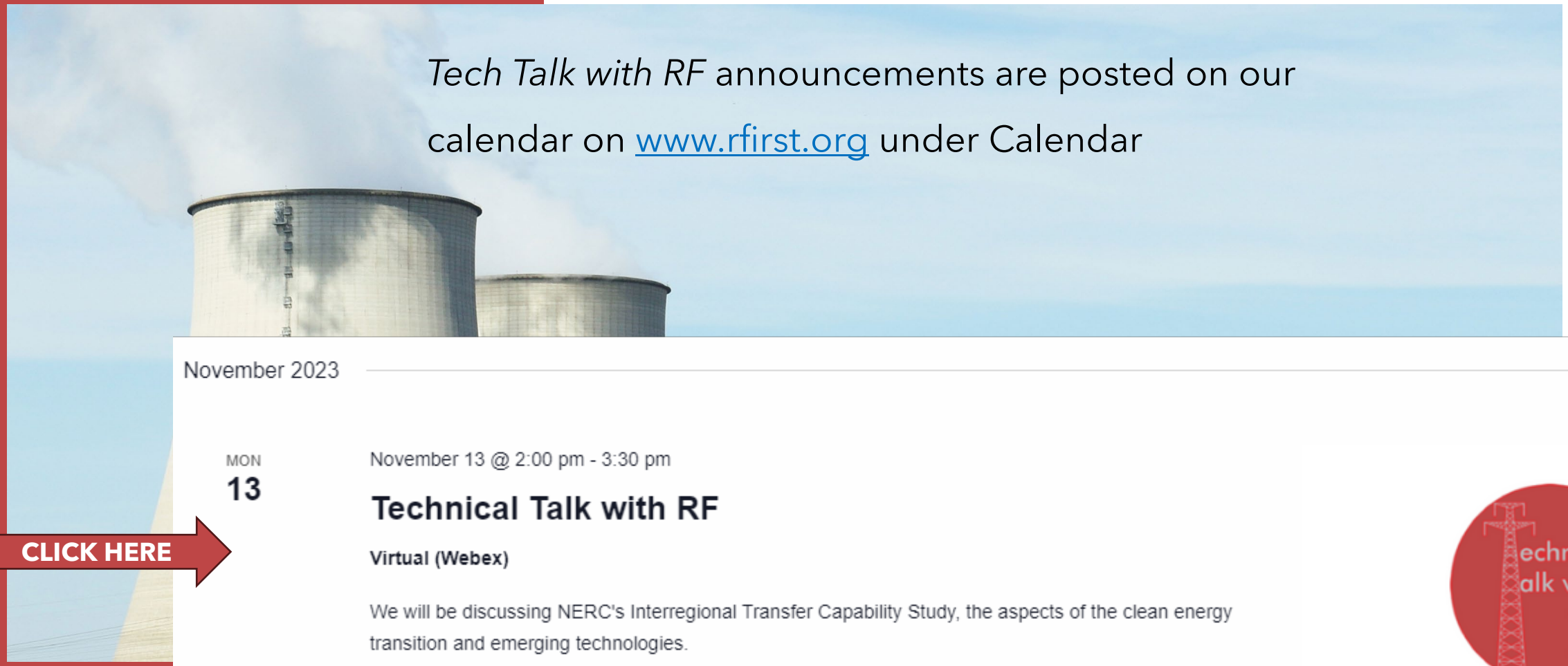
TECH TALK REMINDER

FORWARD TOGETHER RELIABILITYFIRST

Tech Talk with RF announcements are posted on our calendar on www.rfirst.org under Calendar



November 2023

MON
13

November 13 @ 2:00 pm - 3:30 pm

Technical Talk with RF

Virtual (Webex)

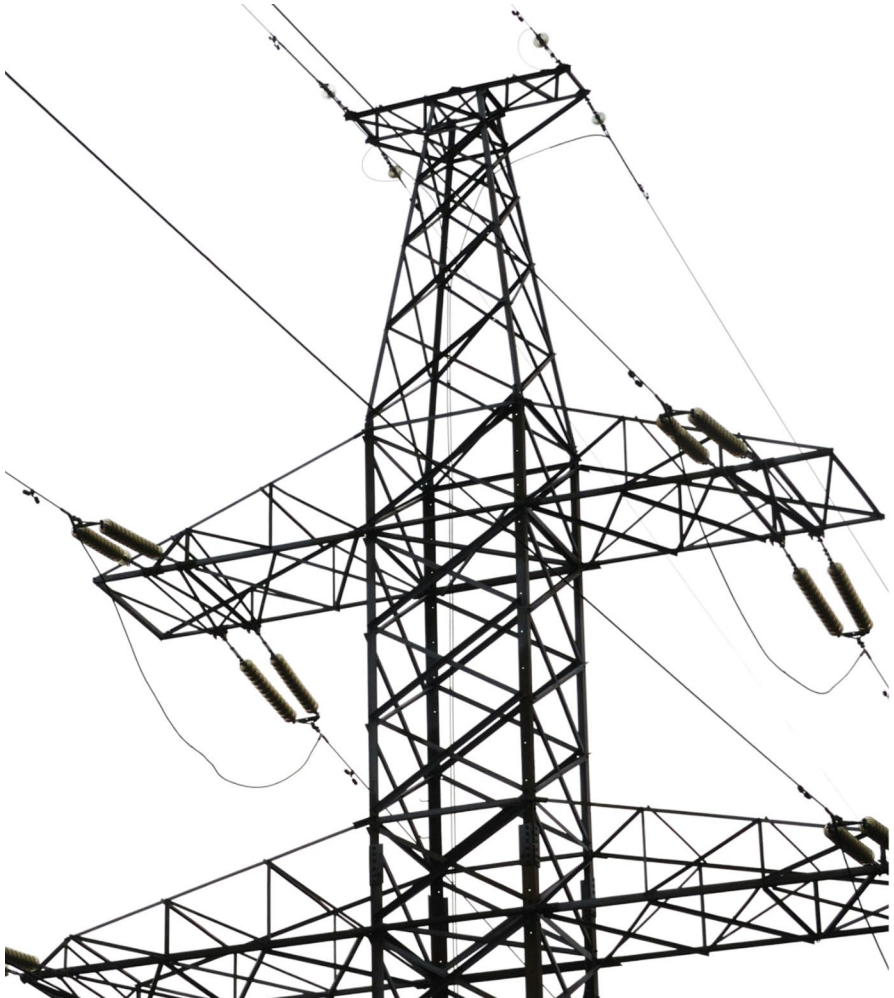
We will be discussing NERC's Interregional Transfer Capability Study, the aspects of the clean energy transition and emerging technologies.

CLICK HERE

Anti-Trust Statement

It is ReliabilityFirst's policy and practice to obey the antitrust laws and to avoid all conduct that unreasonably restrains competition. This policy requires the avoidance of any conduct which violates, or which might appear to violate, the antitrust laws. Among other things, the antitrust laws forbid any agreement between or among competitors regarding prices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that unreasonably restrains competition.

It is the responsibility of every ReliabilityFirst participant and employee who may in any way affect ReliabilityFirst's compliance with the antitrust laws to carry out this policy.



AGENDA

STATE ENERGY POLICY EDITION

NORTH AMERICAN ELECTRIC RELIABILITY CORP – INTERREGIONAL TRANSFER CAPABILITY STUDY UPDATE

- JOHN MOURA- DIRECTOR, RELIABILITY ASSESSMENT AND PERFORMANCE ANALYSIS, NERC

EMERGING TECHNOLOGIES

- SHANE WATTS– SR. LEAD TRAINER, PJM INTERCONNECTION

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

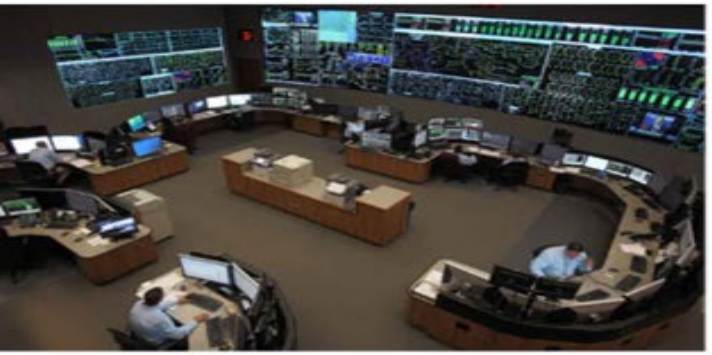
A Grid in Transition and the Interregional Transfer Capability Study

Technical Talk with RF: State Policy Edition

November 13, 2023

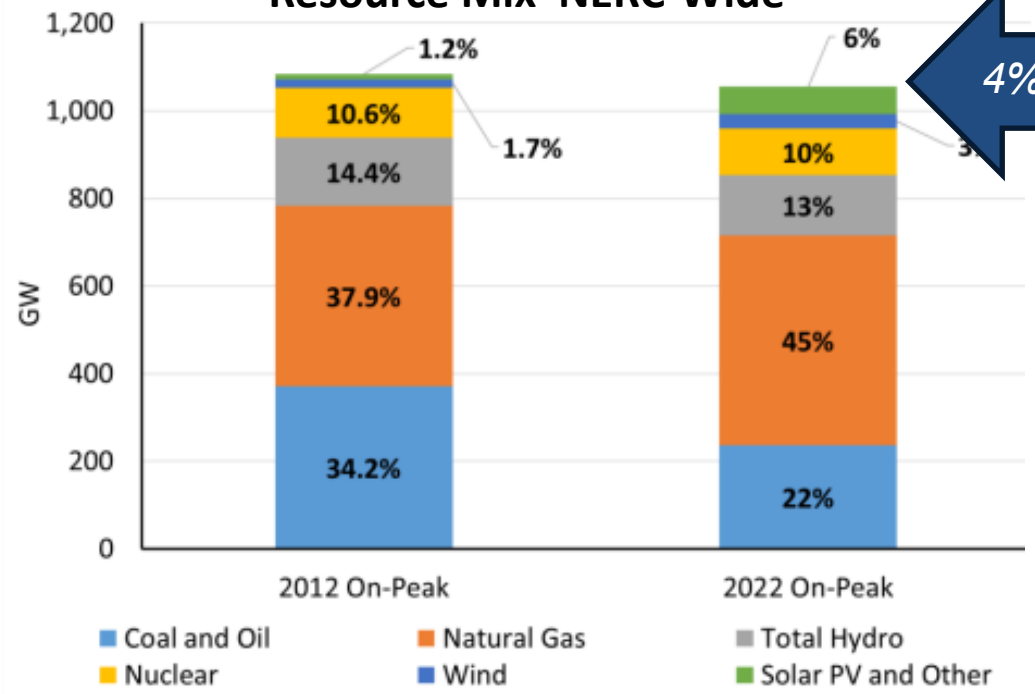
John Moura, Director, Reliability Assessment and Performance Analysis

RELIABILITY | RESILIENCE | SECURITY



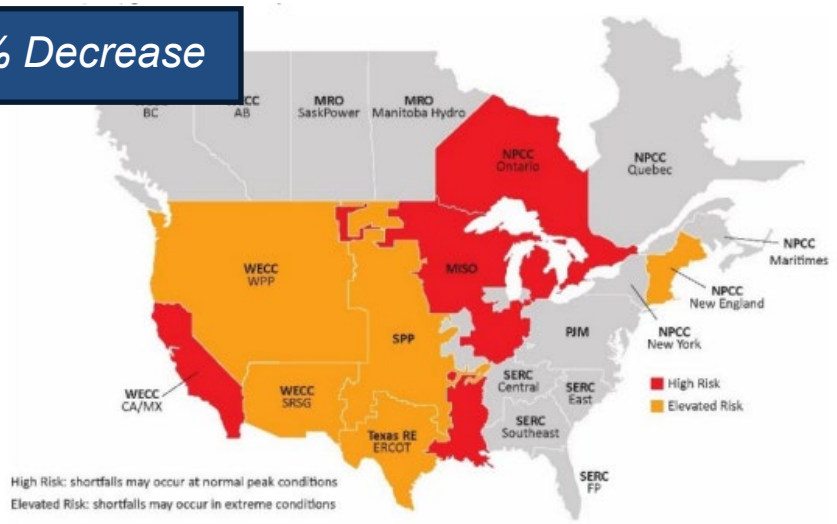

Across an Interconnected System: Less Resources, More Reliance on Neighbors

2012 and 2022 Peak Capacity Resource Mix NERC-Wide

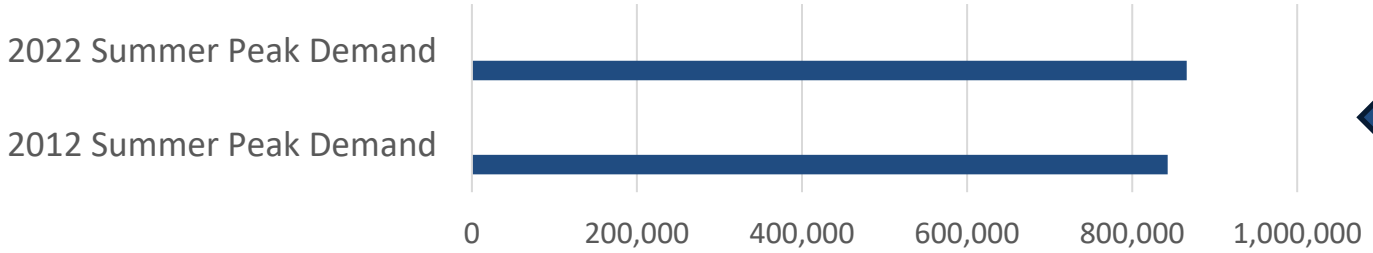


4% Decrease

2025 Risk Areas



NERC-Wide Summer Peak Demand Changes 2012 and 2022



3% Increase

Hyper Complex Risk Environment

Rapidly Changing Resource Mix

- Retirements of traditional generation
- Natural gas interdependencies
- Inverter-Based Resource (IBR) integration
- DER performance and visibility

Extreme Weather Complexities

- Extreme not infrequent
- Broader deeper longer

Energy & Environmental Policy

- Electrification
- Emissions
- Transmission

Rapidly Evolving Threat Landscape

- S/W vulnerabilities
- Supply chain
- Ransomware
- Physical attacks

Hyper Complex Risk Environment Results in Increased BPS Reliability Risk

Rapidly Changing Resource Mix

- Retirements of traditional generation
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Energy & Environmental Policy

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Rapidly Evolving Threat Landscape

- S/W vulnerabilities
- Supply chain
- Ransomware
- Physical attacks

Fuel assurance/uncertainties

- Natural gas
- Renewables
- Correlated outages
- Water and drought

Loss of key "essential reliability services" with retirements

- Inertia/frequency response
- Reactive Power/voltage support
- Dispatchability

Appropriate level of investment in infrastructure for hardening & resilience

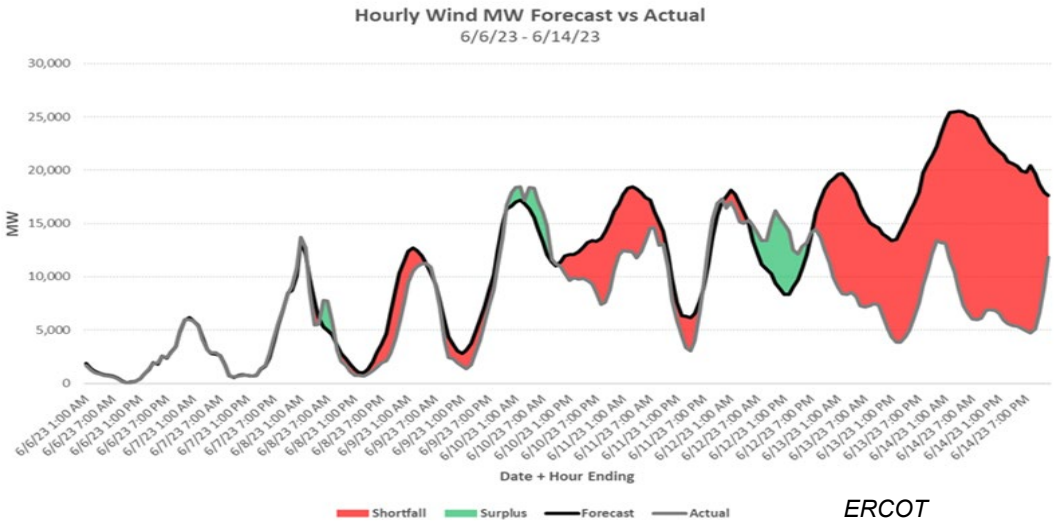
- Extreme weather
- Coordinated Physical attack
- Insufficient transfers

Expanding cyber attack surface, Physical Security

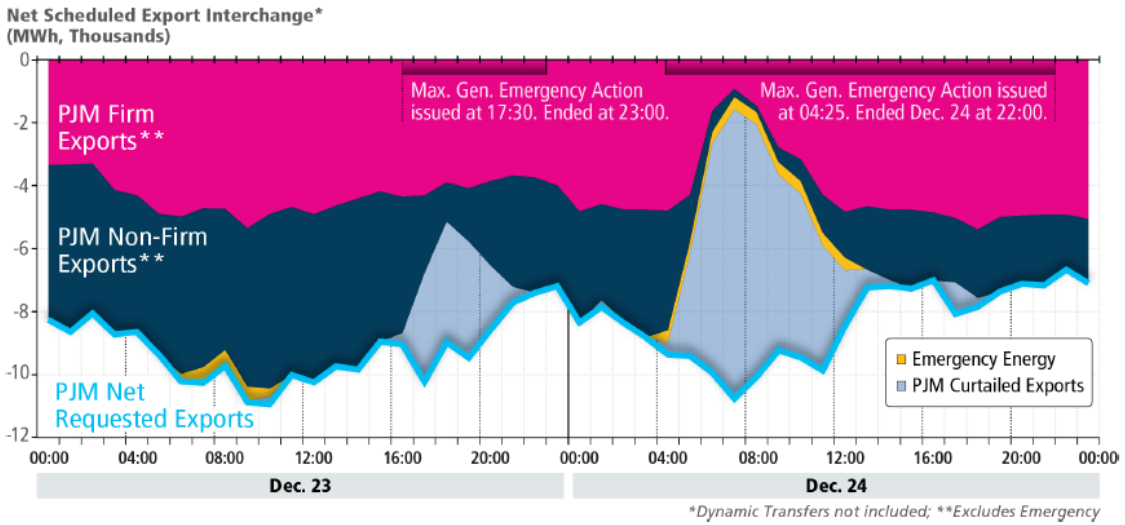
- Industry Control Systems (ICSs)
- IBRs/DERs/EV Charging

Recent Examples Highlight Need for Wide-Area Energy Assessments

ERCOT, SPP, MISO: *A "wind drought" caused 60 GW of installed wind capacity to generate 300 MW*

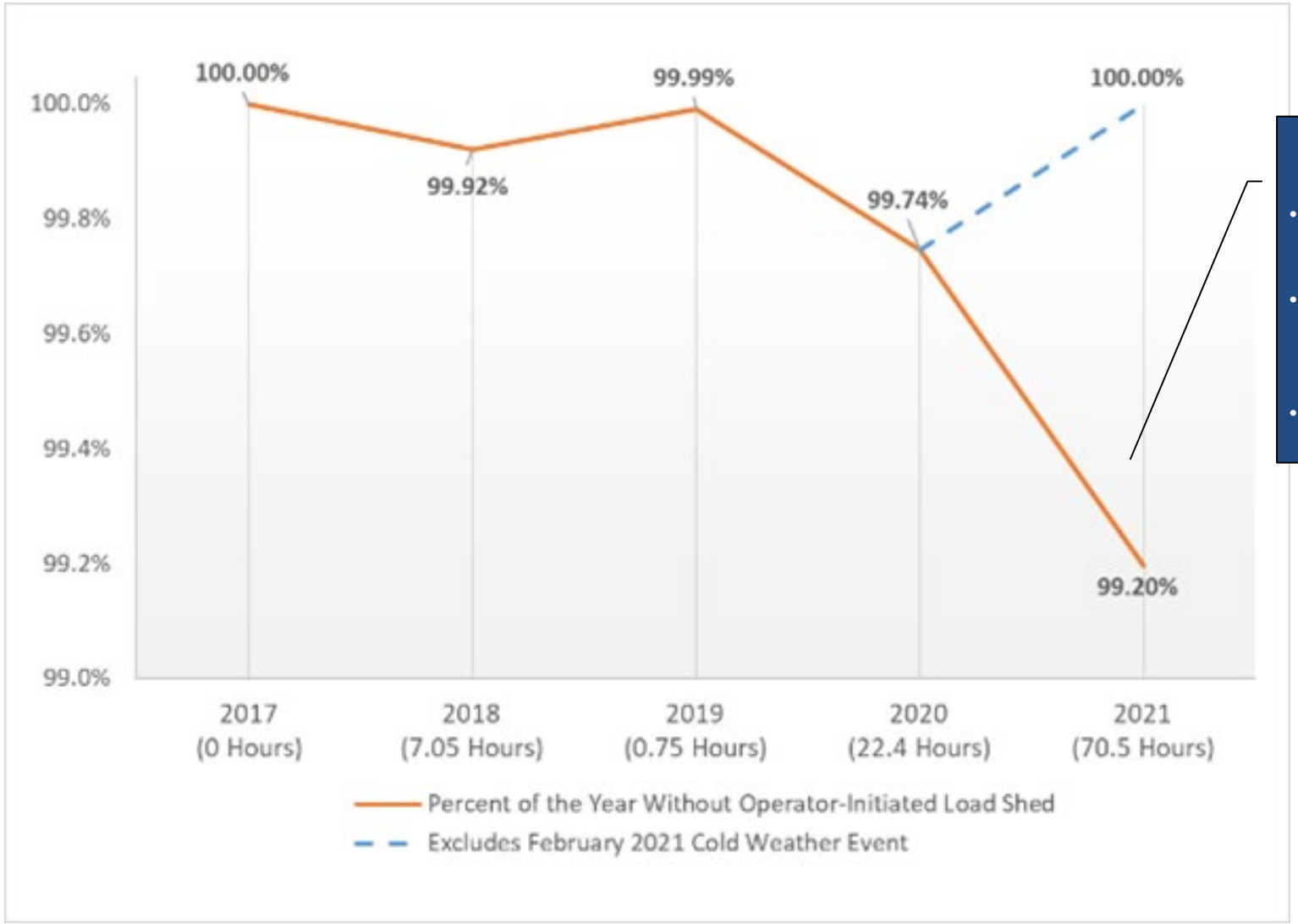


ERCOT



PJM: *Transmission system during extreme cold weather limited the ability to export to support southern neighbors*

Hours Without Operator-Initiated Firm Load Shed (%/year)



2021

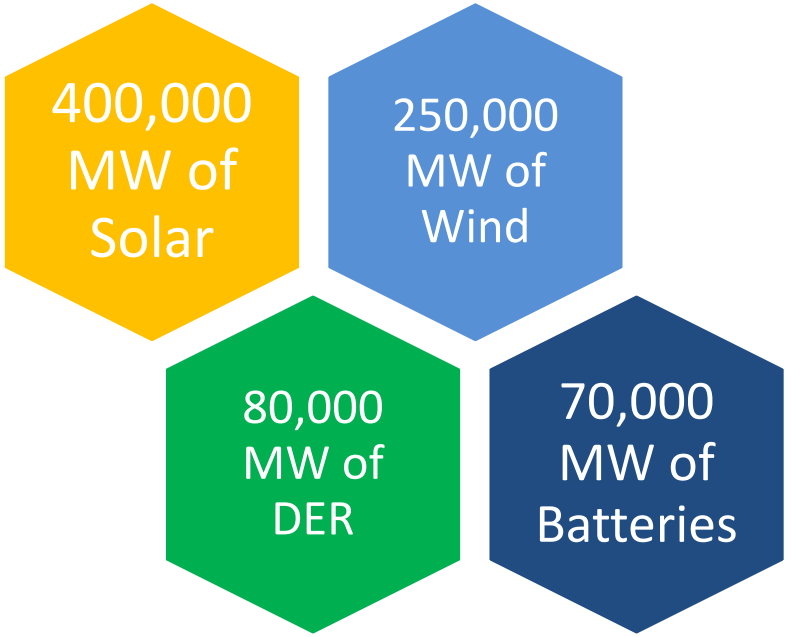
- *10 EEA-3 Alerts*
- *1,015 GWh unserved energy*
- *Occurred February*

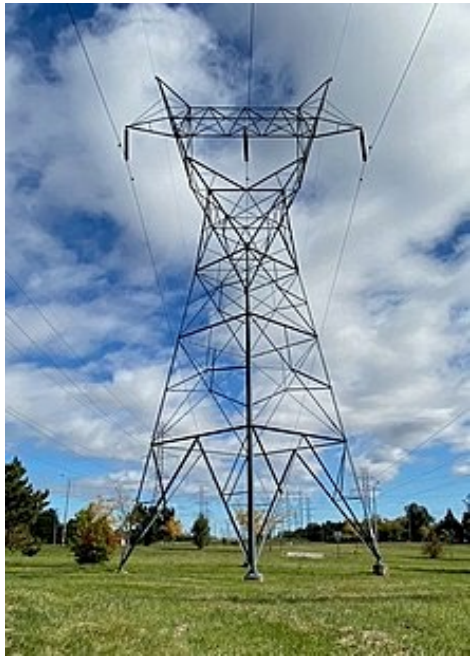
Similarities to Past Extreme Cold Weather Events

	2011 Event	2014 Event	2018 Event	2021 Event	2022 Event
Significant levels of incremental unplanned electric generating unit losses with top causes found to be mechanical/electrical, freezing, and fuel issues.	✓	✓	✓	✓	✓
Significant natural gas production decreases occurred, with some areas of the country more severely affected.	✓			✓	✓
Short-range forecasts of peak electricity demands were less than actual demands for some BAs in event area	✓		✓	✓	✓

Long-Term Challenges Emerge

How are we going to integrate…

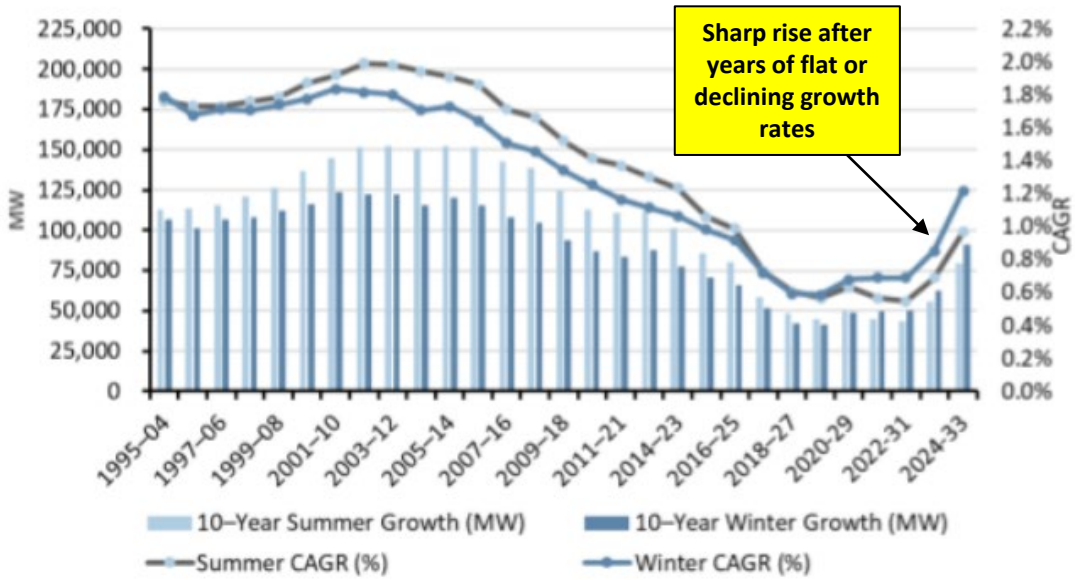


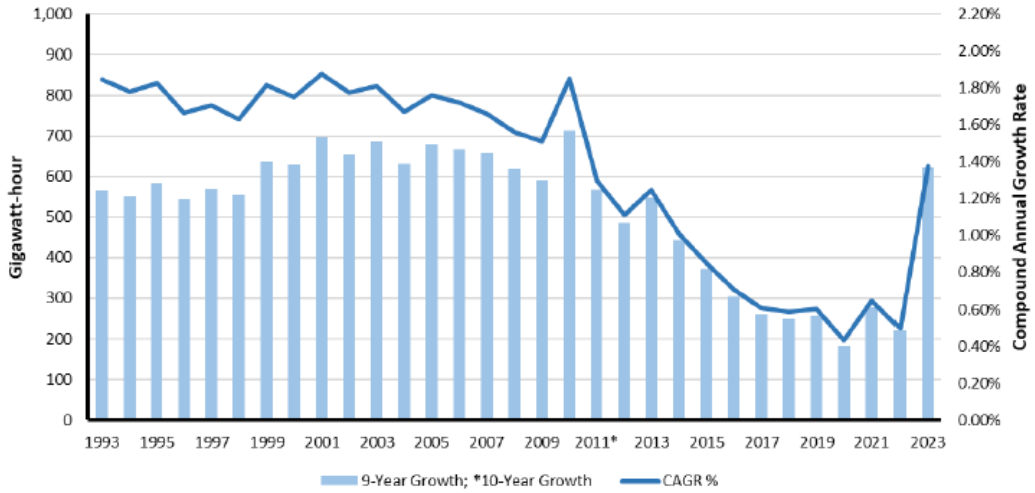


without more of this….

Peak Demand and Energy: Electrification Growth Across North America

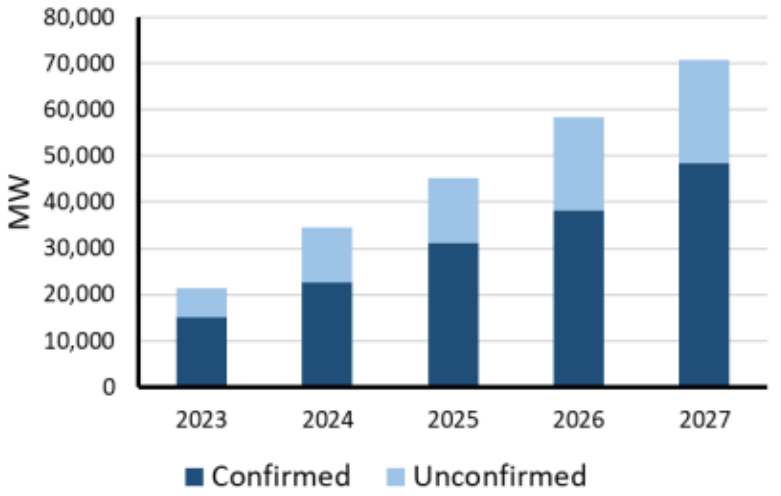
- 10-year Peak Demand and Energy growth showed largest increases in years
  - Further increases from electrification and EV adoption are anticipated
- Peak demand growth is accelerating – Growth rate nearly doubled in last two years
- **Growth in some areas is affecting adequacy of reserves and seasonal energy risks**



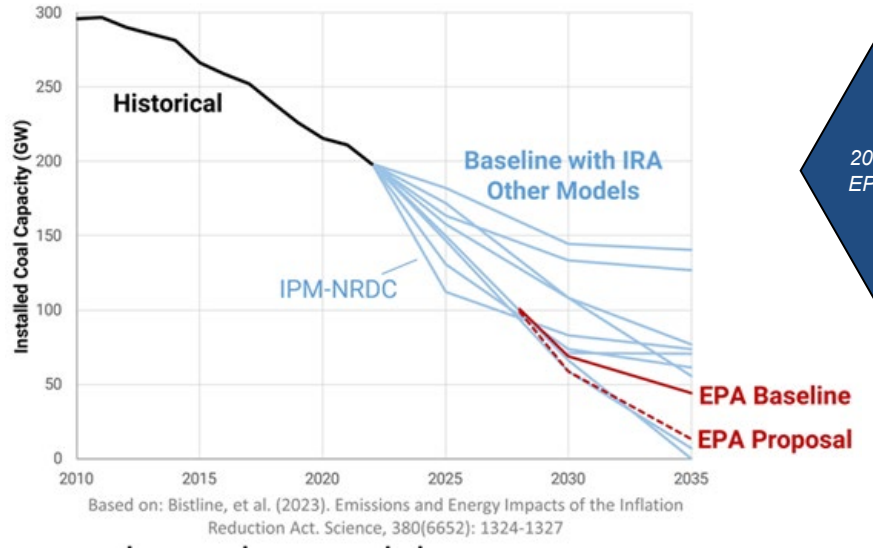


Managing the Pace of Generator Retirements

- Known generator retirements totaling over 110 GW
- New and proposed U.S. EPA regulations are expected to further accelerate retirements
- Replacement capacity to meet growing demand urgently needed!
- **2023 Long-Term Reliability Assessment will consider updated retirement information and scenarios for assessing future resource adequacy and reliability risks**



2022 NERC LTRA



2023 EPRI

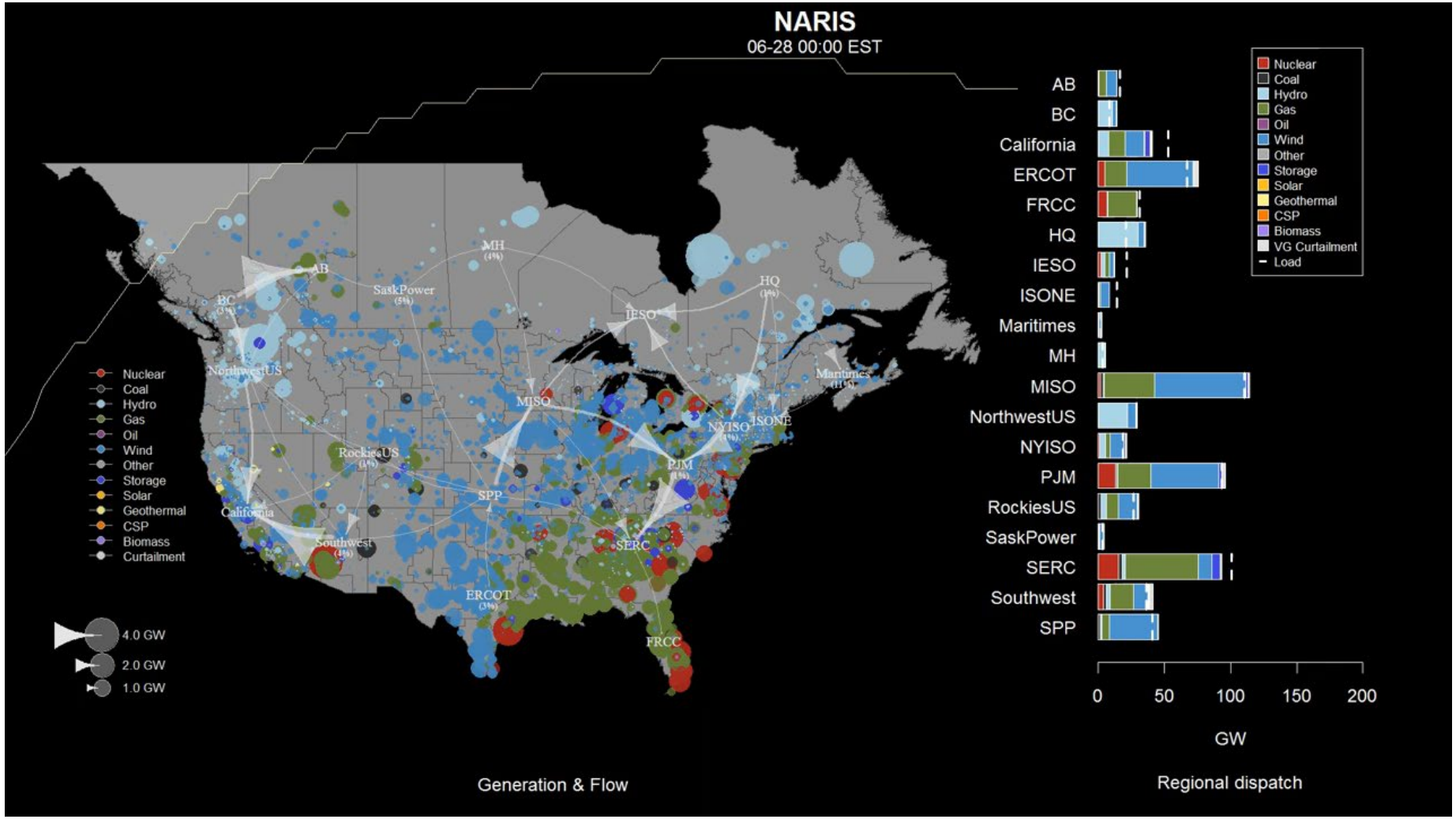
FRA of 2023: Required Study Elements

Fiscal Responsibility Act, Section 322

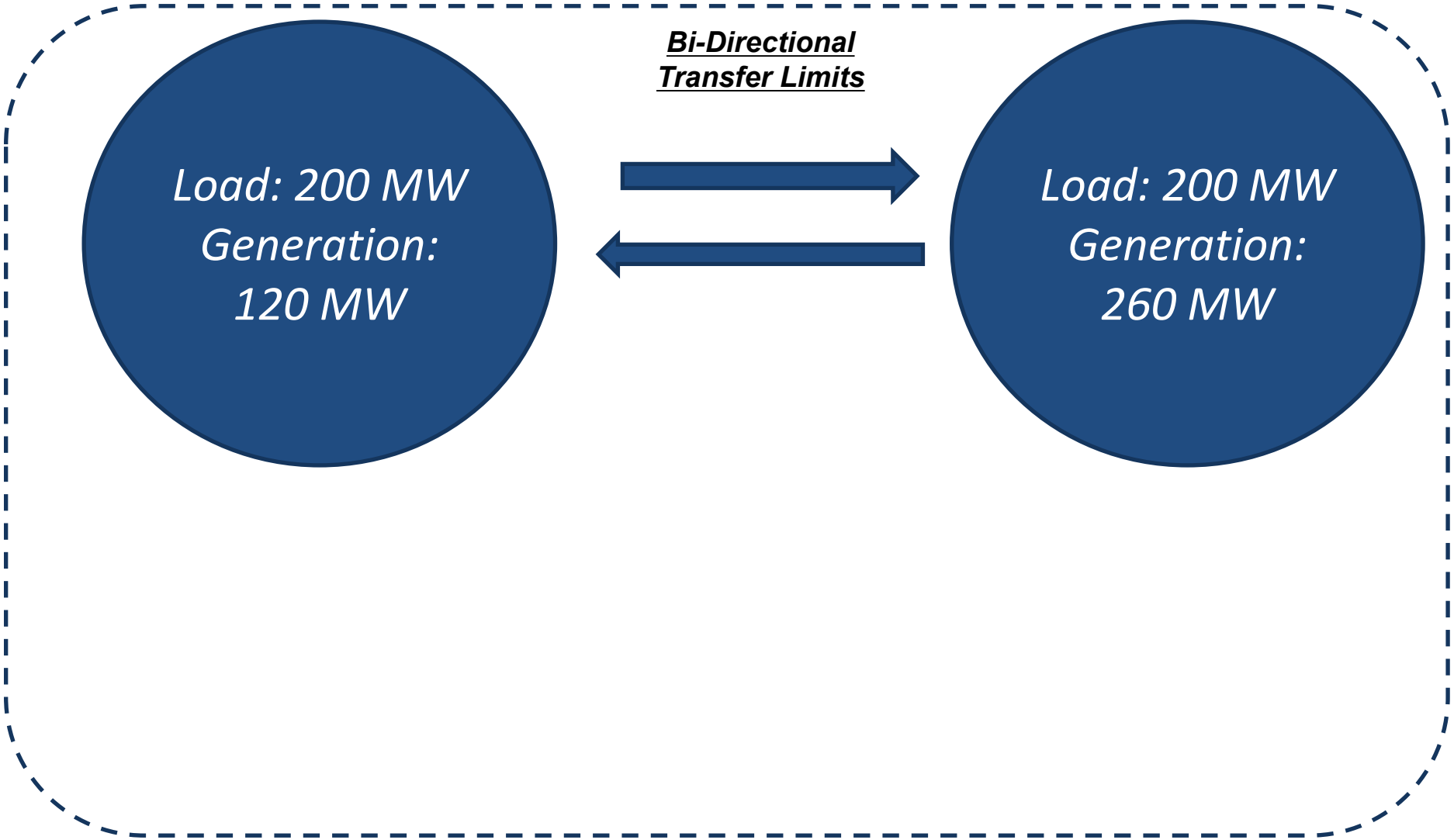
In consultation with the Regional Entities and transmitting utilities, NERC shall conduct a study containing three elements:

1. **Current total transfer capability,** between each pair of neighboring transmission planning regions.
2. A recommendation of **prudent additions to total transfer capability** between each pair of neighboring transmission planning regions that would demonstrably strengthen reliability within and among such neighboring transmission planning regions.
3. Recommendations on **how to meet and maintain the identified total transfer capability**, together with the prudent recommended additions in #2.

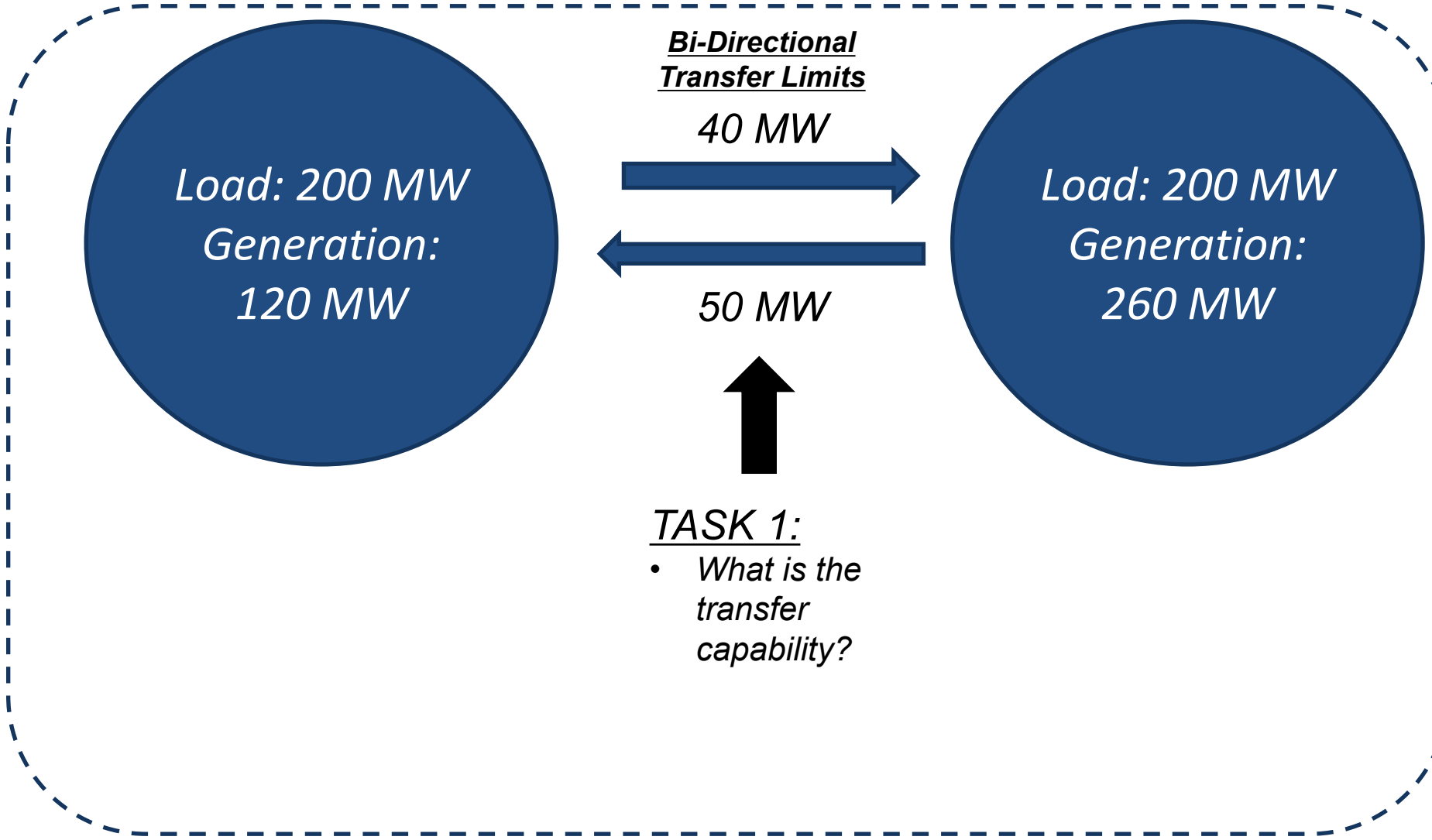
A "Macro Grid" To Enable Continent-Wide Resource Sharing



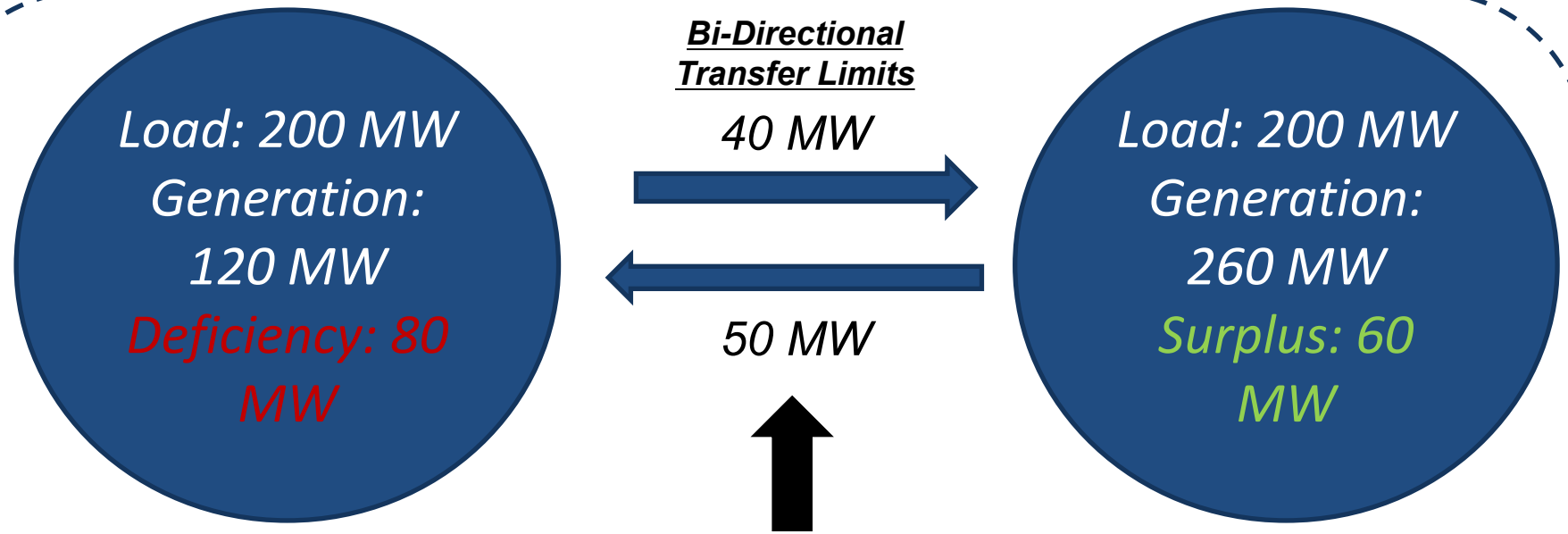
ITCS Summary



ITCS Summary



ITCS Summary



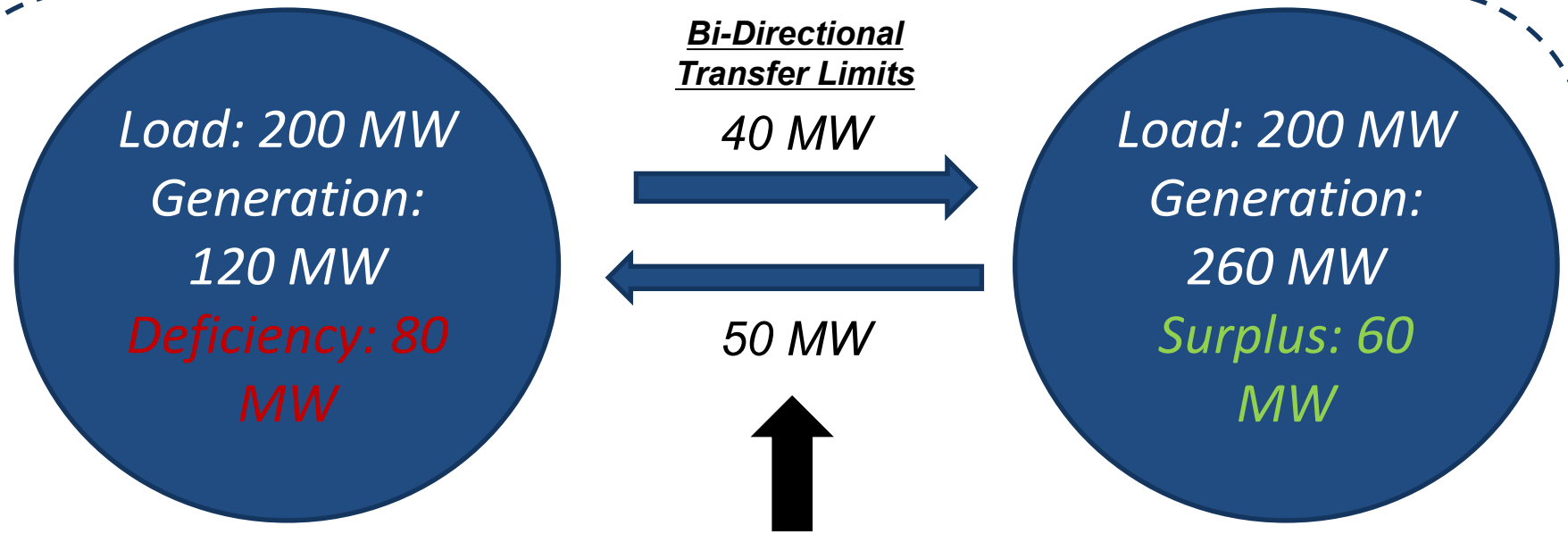
TASK 1:

- What is the transfer capability?

TASK 2:

- What is the deficiency?
- Is there sufficient capability?
- If not, how much is needed to maintain reliability?

ITCS Summary



TASK 1:

- What is the transfer capability?

TASK 2:

- What is the deficiency?
- Is there sufficient capability?
- If not, how much is needed to maintain reliability?

TASK 3:

- What is needed to meet and maintain these transfer limits
- Does the increase require other reliability reinforcements or considerations?

What This Study is NOT

- Planning Study
- Replacement for Transmission Expansion Analysis and Interregional Planning Groups
- No recommendations for specific projections (generation, transmission, etc)
- Will focus on WHAT…not HOW
- A complete solution

ITCS Advisory Group

ITCS Advisory Group Role

- Stakeholder membership advises and provides input to the ERO Project Team
- Collaborate with the ERO and stakeholders on the study scope, approach, results, and recommendations

Key Input Needed

- Study Scope
- Scenario Selection
- Major Assumptions – Capacity/Transfer Expansion
- Criteria Development
- Results and Recommendations

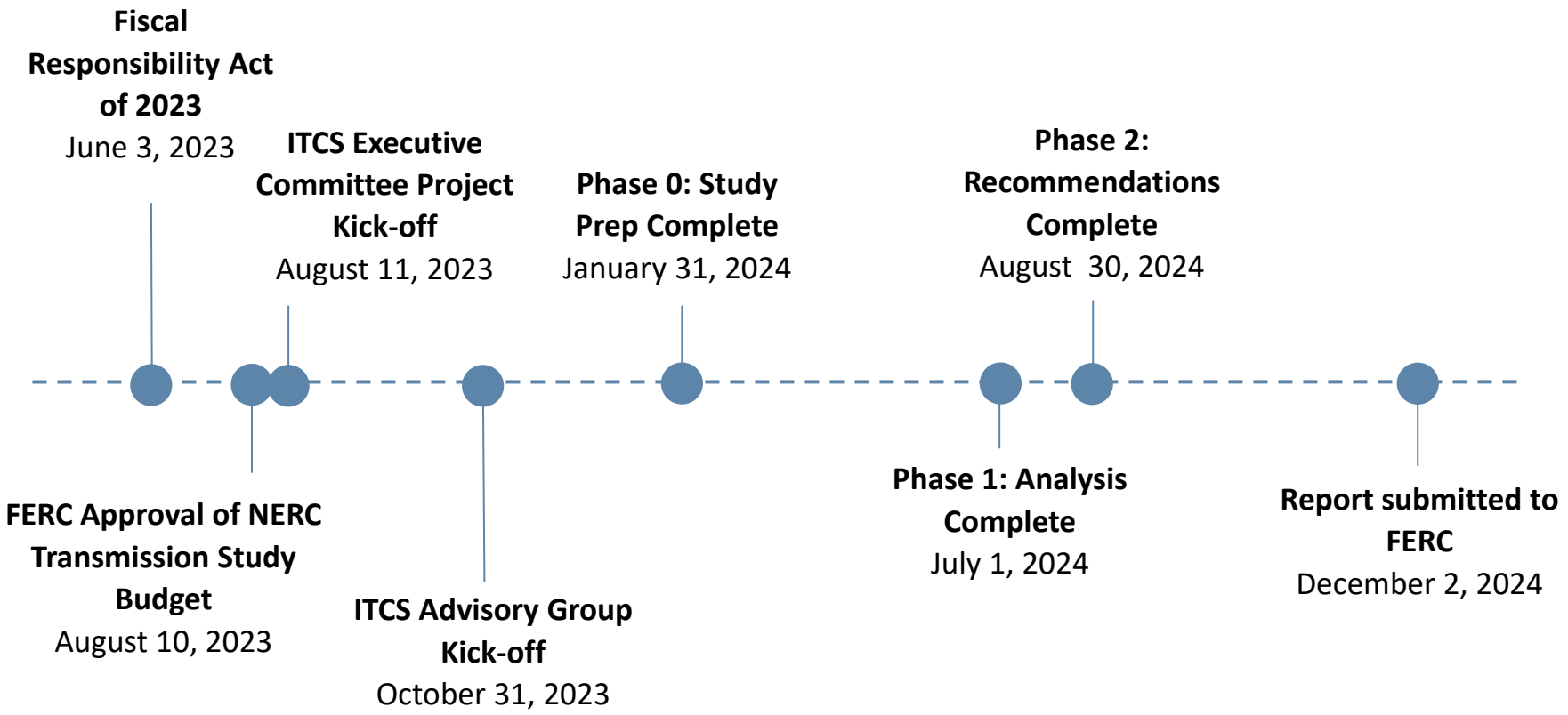
Study Group and Project Management

- **ERO Executive Leadership Group:** Serves as the executive project sponsor
- **ERO Project Team:** ERO Staff Team (NERC and Regional Entity Staff) will oversee, coordinate, and conduct the required studies
- **ITCS Advisory Group**: Stakeholder advisory group provides advice and input on the study scope, approach, results, and recommendations.

NERC Staff	Regional Entity Staff	Industry
• Study design and oversight • Identify common assumptions, scenarios, and case creation parameters • Compile study results for cross-interconnection wide study	• Leverage technical study groups and data collection processes • Run power flow simulations	• Support scenario development • Support capacity and transmission expansion assumptions • Coordinate with study groups and Regional Entity staff

ITCS Timeline Overview

The following is a timeline of upcoming key activities:

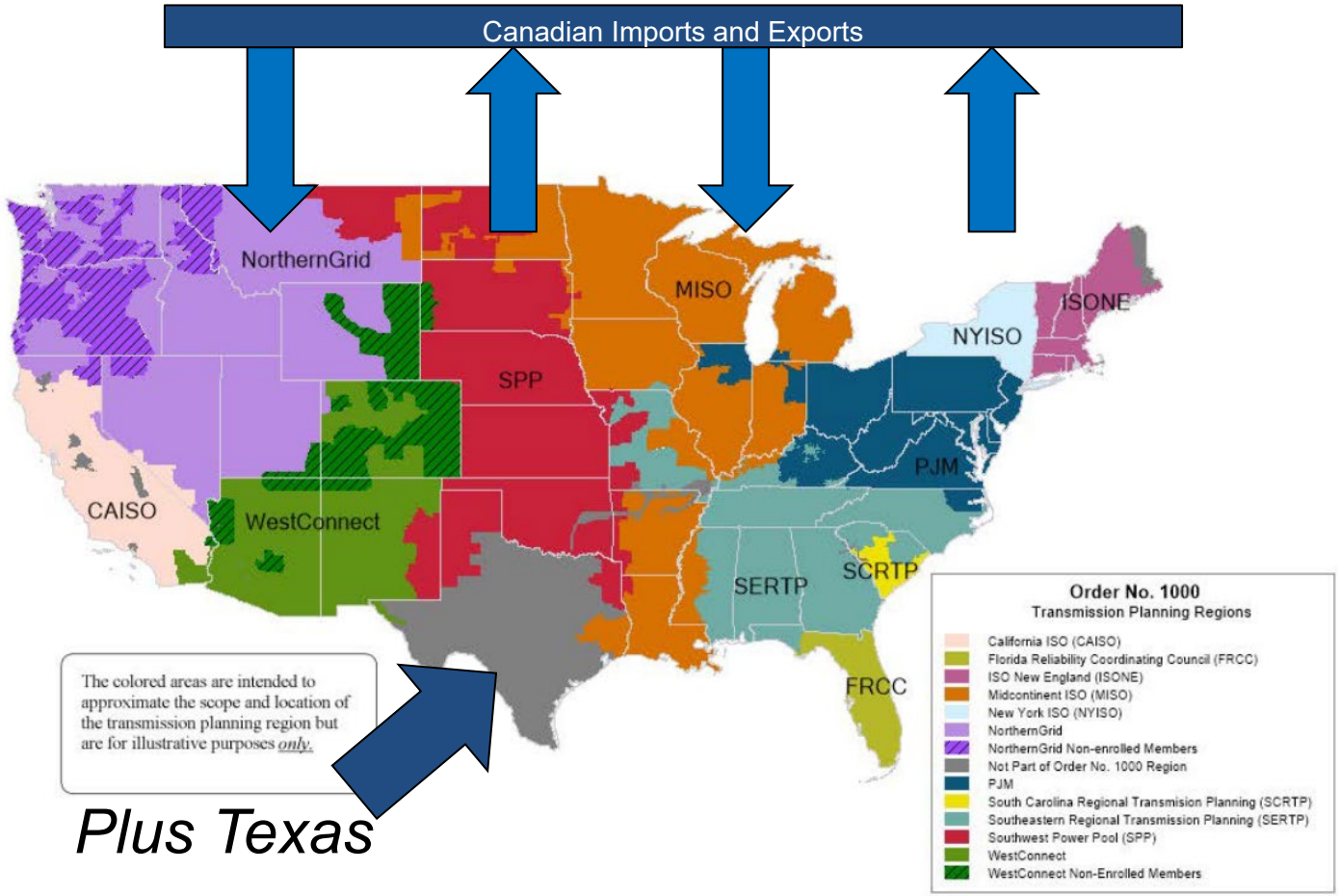


Communication and Engagement

- Engagement and Communications Plan includes:
  - **Communication and Engagement Milestones:** High-level tracking of key activities with a defined target audience
  - **Tactical Communication Plan:** Dynamic document drills down to key communication dates, audiences, activities and communication materials/methods.
    - Drafting Stakeholder Analysis and Engagement plan to be shared with ERO State Outreach Group and ERO Communications Group

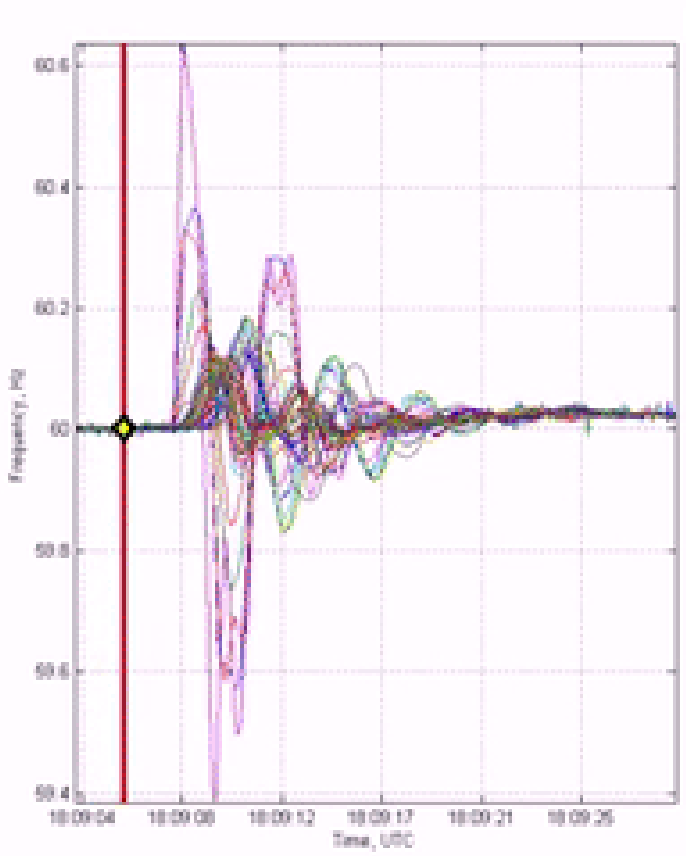
- Communications initiatives include:
  - Updates at key project milestones
    - **Website (NERC.com):** launched on October 24th, 2023
    - **Announcements / Updates**
    - **Media interviews**
    - **Videos/ Social Media**

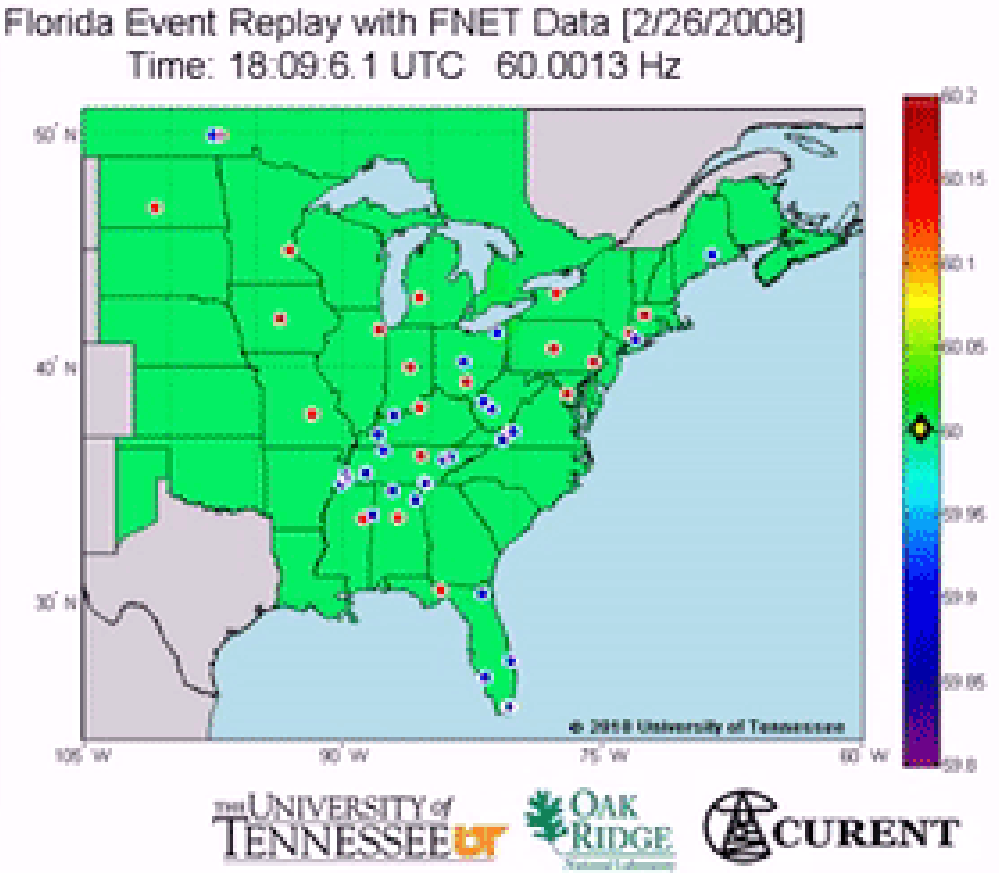
ITCS - Areas of Study



- Legislation identified "Transmission Planning Regions" as identified in FERC Order 1000
- Texas Interconnection DC Ties included
- Canadian transfer capability and possible increases also assessed

Frequency Excursion – Interconnection-wide Phenomena





Onward!

- NERC's role as the independent voice for reliability
- Critical assignment supporting the ERO's Reliability Assessment mandate
- Strong transmission system is crucial to a reliable supply and the delivery of electricity
- Rapidly changing resource mix requires greater access and deliverability of resources
- On-going assessment critical to maintaining BPS reliability

Looking Forward to Your Questions

Emerging Technologies

PJM State & Member Training Dept.

Objectives

At the completion of this training, the learner will be able to:

- Identify the various emerging technology tools being developed and used to maintain reliable operation of the electric system

Agenda

- Fusion Reaction – ….. Recent Activity
- BtMG Wind Technologies
- Geothermal Technologies

Fusion Reaction

& Recent Advancements

Fusion

- Fusion: the process of combining two light nuclei to form a single heavier nucleus which releases a large amount of energy
- Uncontrolled v **Controlled Fusion**
- Benefits & Disadvantages

DT (Deuterium Tritium) are a favored fuel because:

- They produce large amounts of energy
- This fuel reaches fusion conditions at lower temperatures compared to other fusion reactions
- Deuterium and tritium are isotopes of hydrogen, the most abundant element in the universe

Fusion

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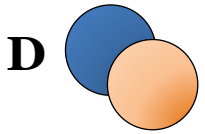

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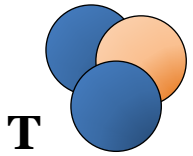

D = Deuterium **T = Tritium**

Fusion

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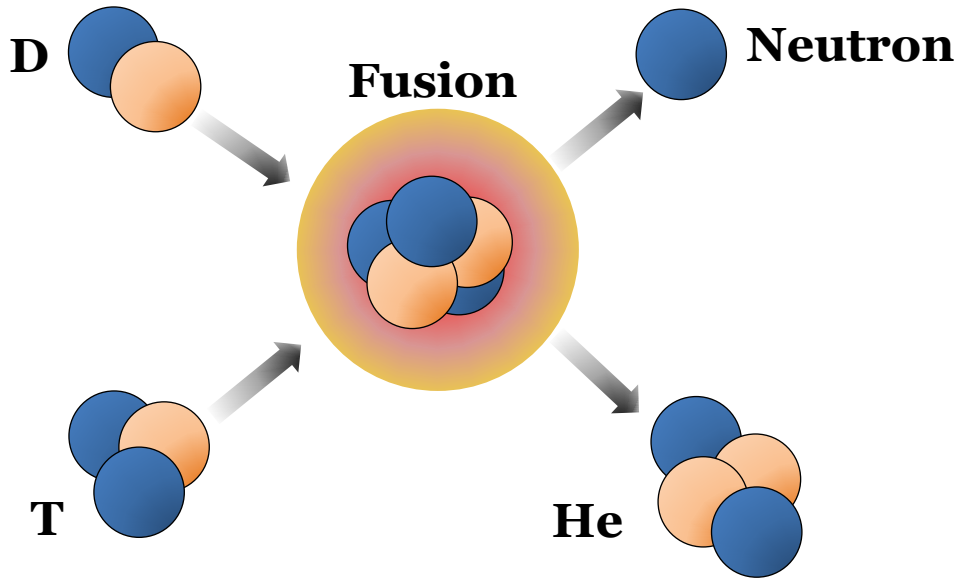

D = Deuterium **T = Tritium** **He = Helium**
Neutron = a subatomic particle which has a neutral charge

DT fusion produces a neutron and a helium nucleus

Fusion

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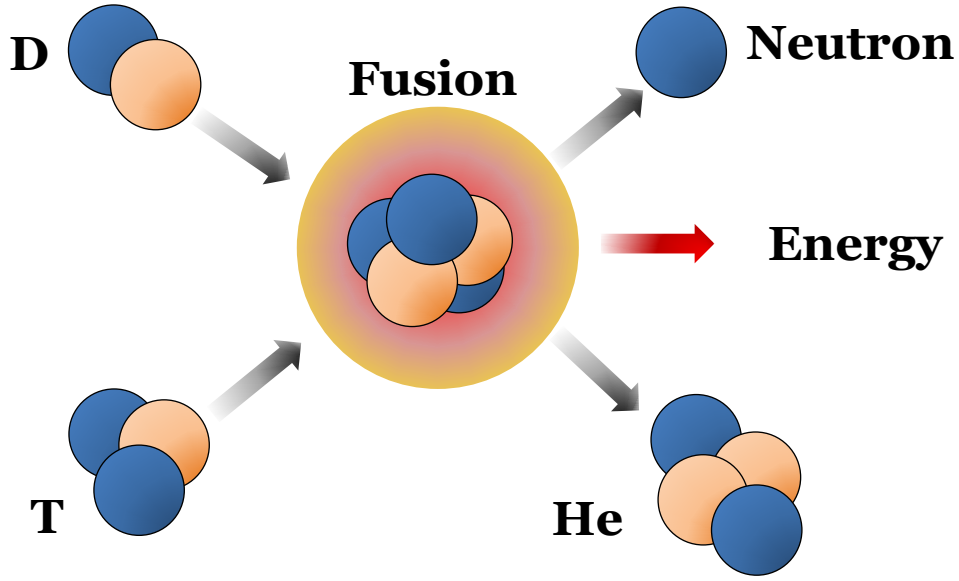


D = Deuterium **T = Tritium** **He = Helium**
Neutron = a subatomic particle which has a neutral charge

DT fusion produces a neutron and a helium nucleus
In most cases, it also releases much more energy
than most fusion reactions itself

Fusion

- Fusion: the process of combining two light nuclei to form a single heavier nucleus which releases a large amount of energy
- Uncontrolled v Controlled
- Benefits & Disadvantages

Benefits

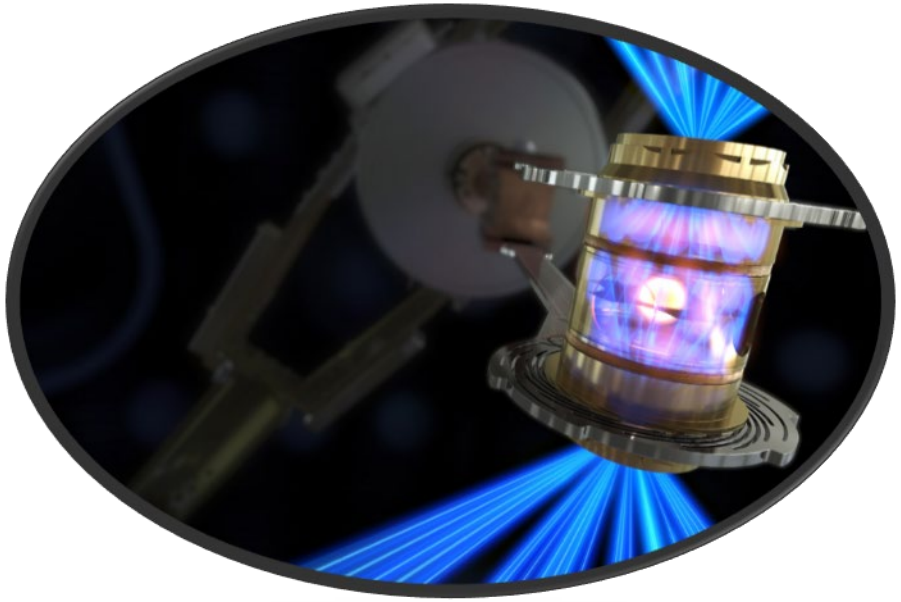
- No carbon emissions
- Abundant fuels
- Energy efficiency
- Fusion releases 4 million times the energy of coal, gas, or oil
- Fusion releases 4 times as nuclear fission
- No long-lived waste
- No meltdown risk

Disadvantages

- Neutron radiation damage to exposed materials, causing swelling, embrittlement and fatigue
- Very expensive in research stage
- For practical use, will Require scientific break-even, engineering break-even, commercial break-even

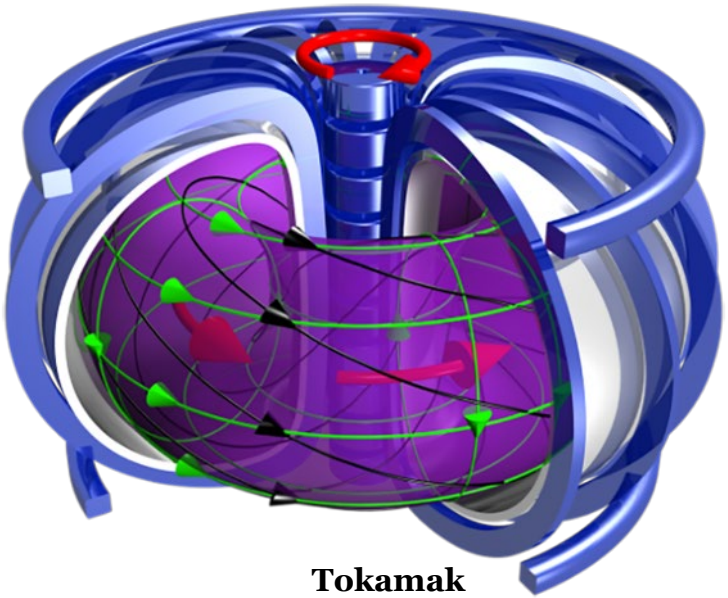
Laser Ignition v Magnetic Confinement

Basic Inertial Concept



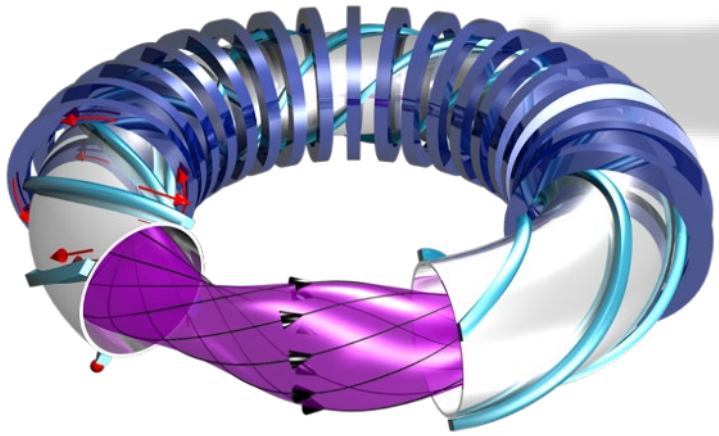
Source: DOE, Lawrence Livermore National Laboratory

Basic Magnetic Concept



Tokamak

Image: Max Planck Institute for Plasma Physics, Germany



Stellarator

Image: Max Planck Institute for Plasma Physics, Germany

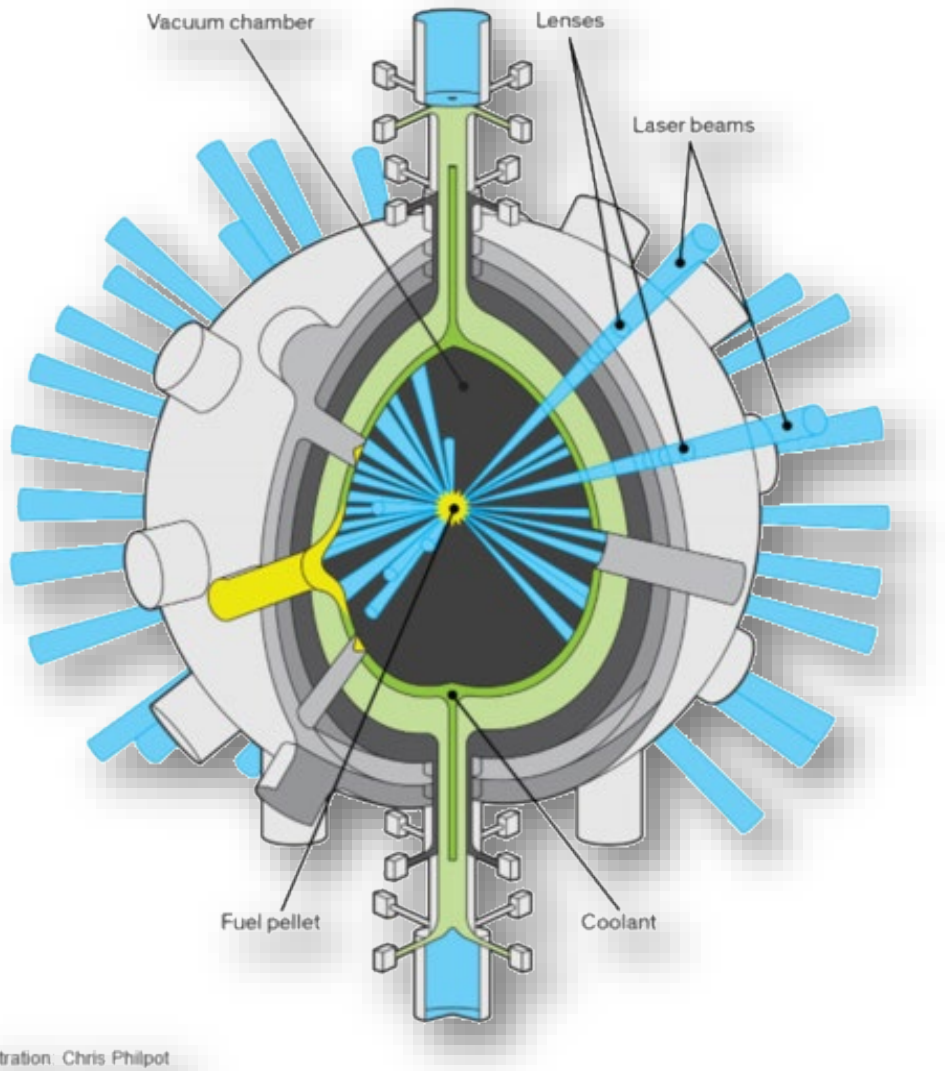
Inertial-Confinement Fusion (ICF)

How it works:

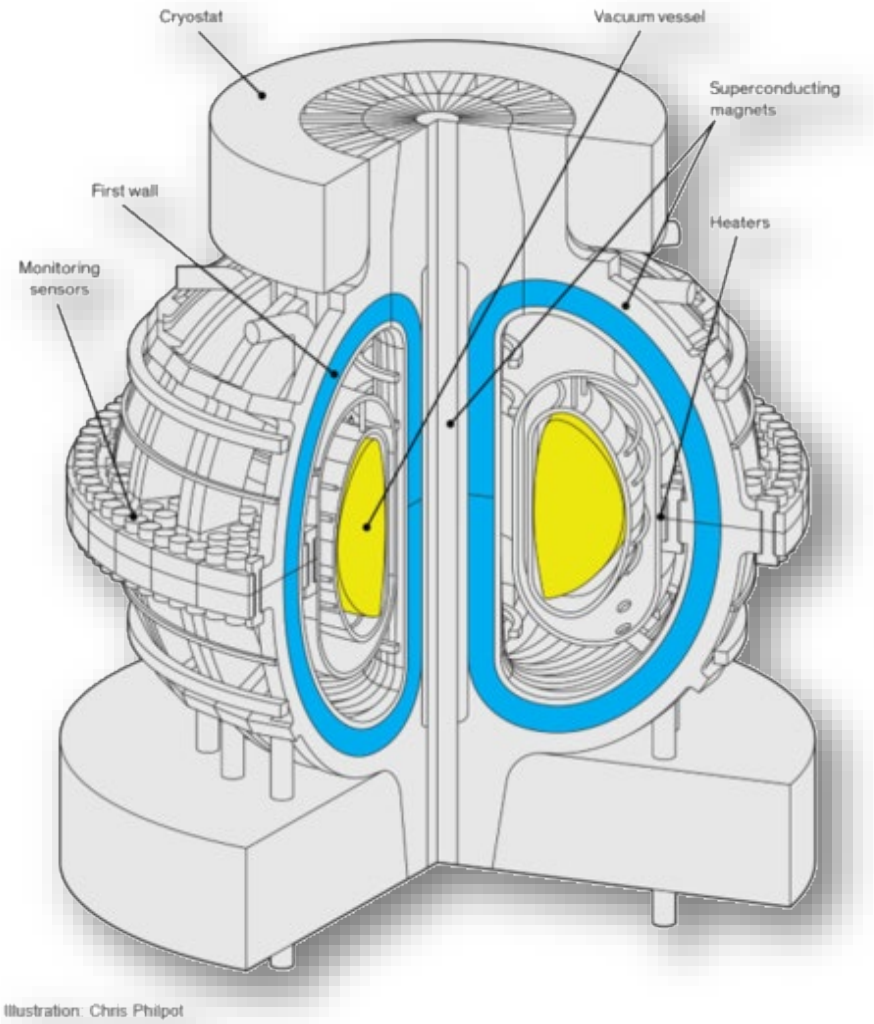
- Powerful pulsed laser(s) or ion beams compress a small fuel pellet to extremely high densities
- Produces a shock wave that compresses and heats the plasma before (plasma) dissipating
- Powerful enough shock waves enable fusion

Issues:

- Pressures on the fuel pellets contribute to laser-plasma instabilities causing the fuel to heat and scatter before it can fuse
- High cost and complexity of laser drivers



Magnetized Confinement Fusion (MCF)



How it works:

- Powerful electromagnetic fields confine and heat plasma inside a doughnut-shaped reactor
- Magnetic field prevents the particles from coming into contact with the reactor walls, which dissipates heat and slows down its movement
- Commonly referred to as a Tokamak

Issues:

- Difficulty in maintaining the integrity of the walls within the reactor

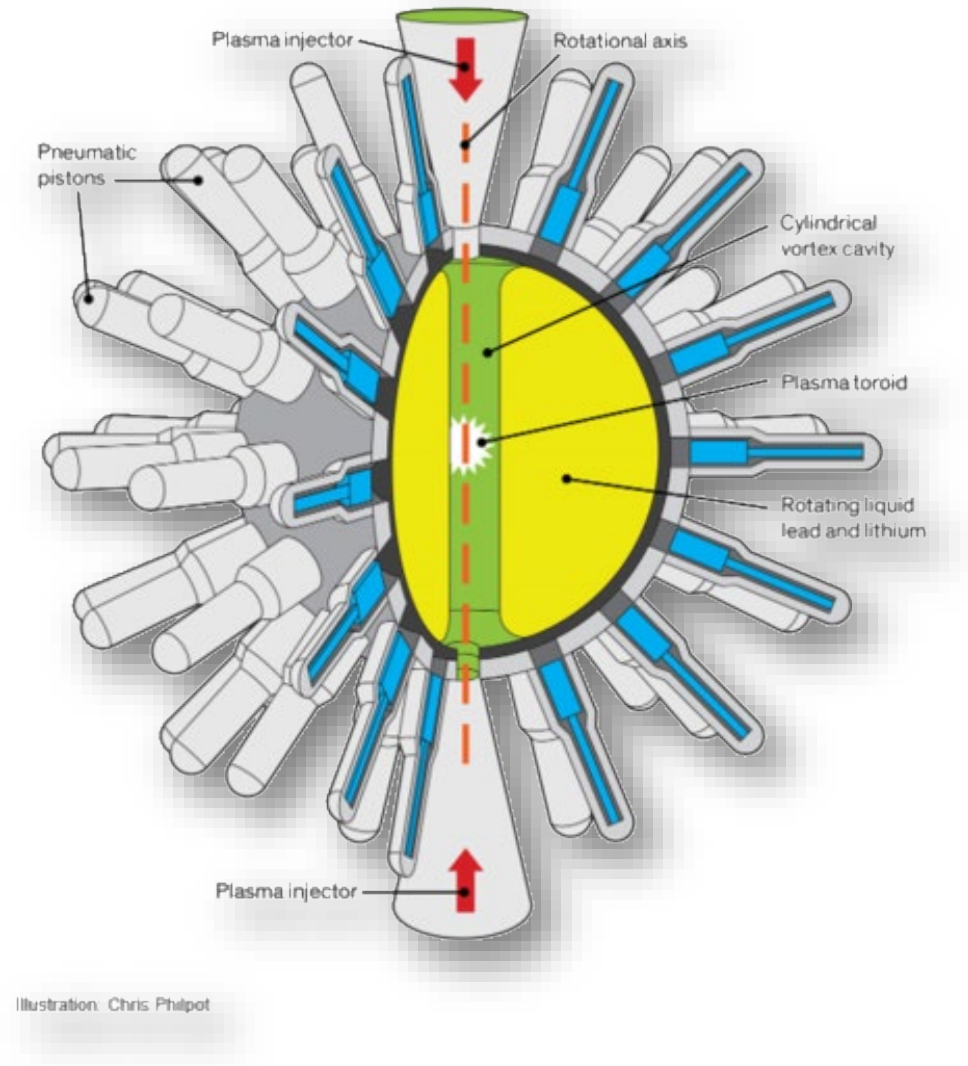
Magnetized Target Fusion (MTF)

How it works:

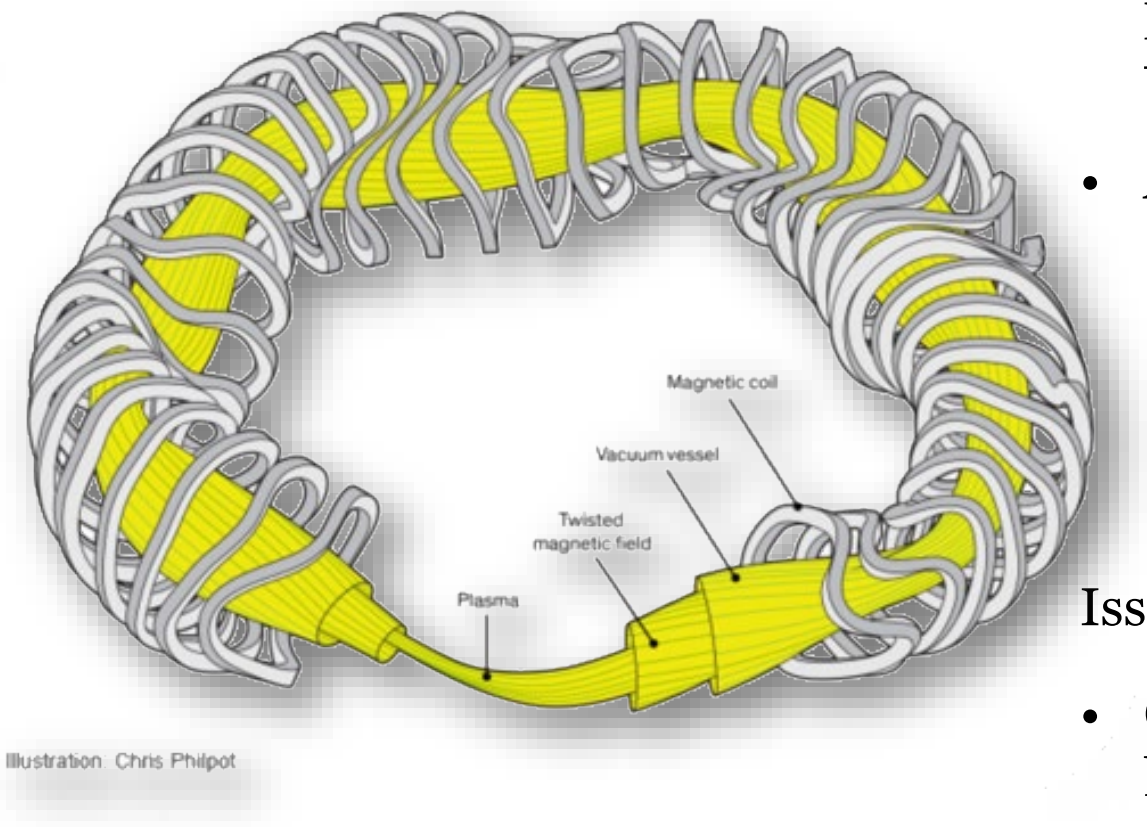
- Hybrid Approach
- Uses magnetic fields to confine a lower-density plasma
- Then, heated and compressed using an inertial-confinement method (lasers or ion beams)

Issues:

- So far, scientists have been unable to increase the plasma density to a suitable “working” level, or maintain its integrity long enough to fuse



Stellarator



How it works:

- The Spiraling ribbon shape produces high-density plasma that is symmetrical and more stable than a tokamak
- Advantages over Tokamak
  - Requires less injected power to sustain the plasma
  - Uses external coils to generate a twisting magnetic field instead of inducing electric currents inside the plasma like a tokamak

Issues:

- Challenging geometry makes it difficult to build and highly susceptible to imperfections

Field-Reversed Configuration (FRC)

How it works:

- Reactor contains plasma in its own magnetic field by inducing a doughnut-shaped electric current inside a cylindrical plasma
- Uses plasma guns to accelerate two plasmas into each other, then heats them with particle beams
- Less prone to instabilities

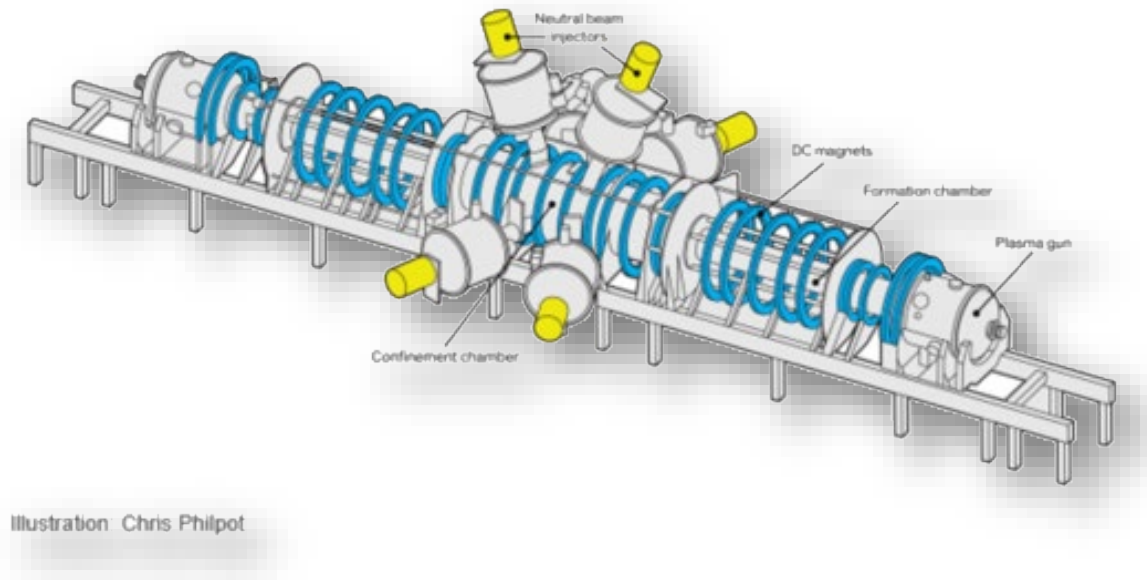


Illustration: Chris Philpot

Issues:

- So far, scientists have been unable to maintain/create sufficiently dense enough and stable plasma

Lawrence Livermore National Laboratory

- Energy Gain!
  - December 5, 2022 First Time Ever
    - 2nd Success July 30, 2023 (Higher Output)
  - Huge laser v thimble sized target
  - Lasted a few billionths of a second
  - More energy came out of the target than went in = “Energy Gain”
  - What does this experimental achievement mean for energy production?

The National Ignition Facility (NIF) - Primary function is to create miniature thermonuclear explosions and provide data to ensure the U.S. arsenal of nuclear weapons is safe and reliable. Images Source: https://lasers.llnl.gov/

The Details

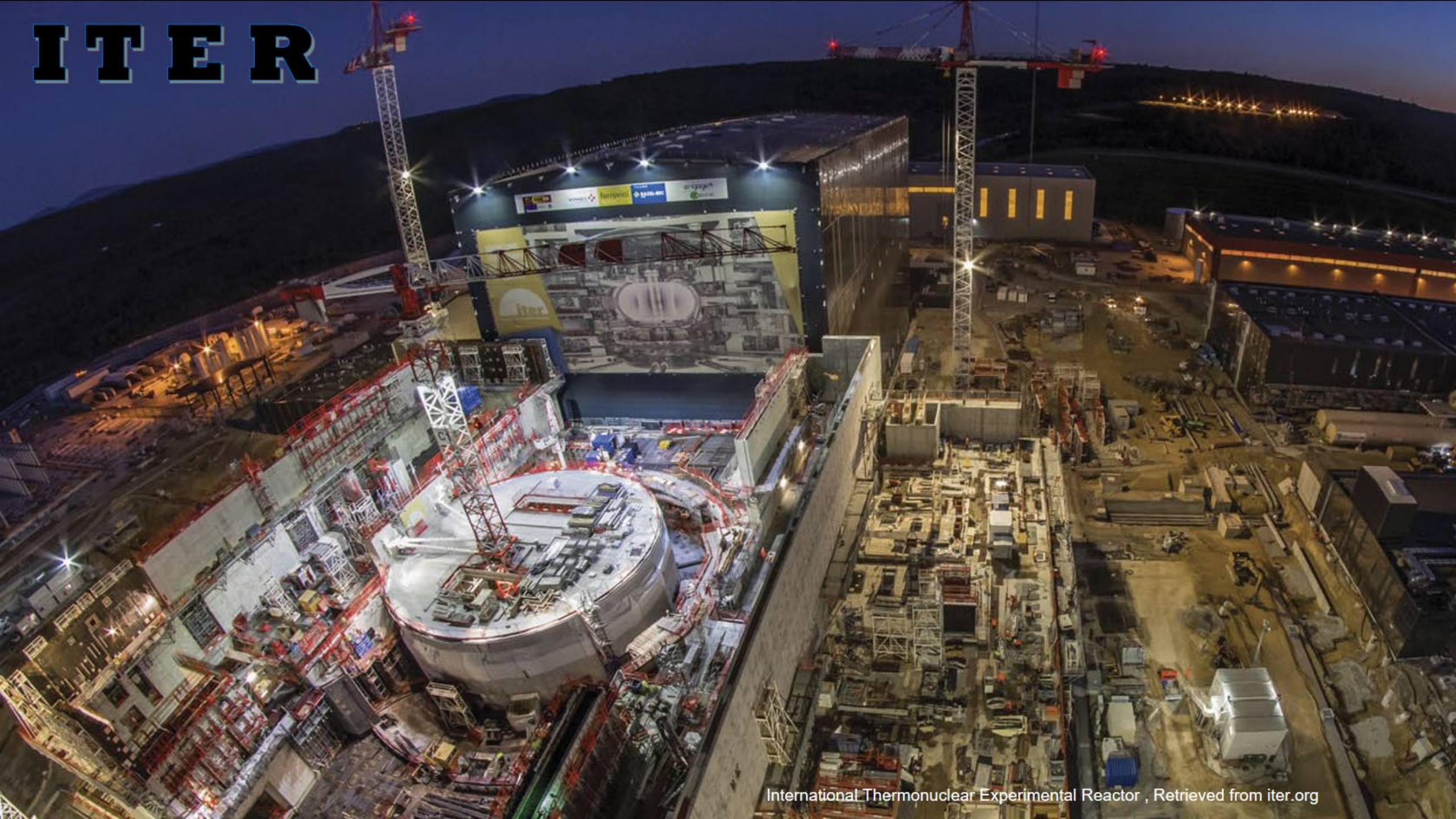
What Did Happen?

1. Focused 2.05 mega joules of laser light onto a tiny capsule of fusion fuel, Sparking an explosion that produced 3.15 MJ of energy
   - Equivalent of about three sticks of dynamite
2. Explosion at the capsule was hotter than the sun
   - Hottest point in the entire solar system
3. Current capability
   - One shot per day
   - Energy Gain 3 for 2 (1 shot)
   - 1 perfect diamond shell per day
   - Laser efficiency (Indirect Drive) 1%

What Didn't Happen?

1. This artificial Energy Gain did not account for power needed to run the equipment used in the experiment
   - Total energy consumed ~ 300 v Total energy produced ~ 3
2. Yep, it was hot!
3. For Commercial power plant purposes,
   - 10 "shots" (explosions) per second
   - Energy Gain increases by a factor of 100
   - 900,000 perfect diamond shells per day
   - Laser efficiency (Direct Drive) 5%

ITER



International Thermonuclear Experimental Reactor , Retrieved from iter.org

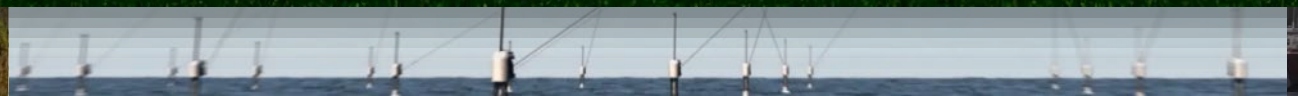
Fusion Energy – Practical Use

- For practical use, will Require scientific break-even, engineering break-even, commercial break-even
- Scientific break-even ✓
  - Lawrence Livermore National Lab
- Engineering break-even
  - Inefficient lasers, perfectly symmetrical diamond pellets (900,000 / day), loading, extracting, calibrating, etc
- Commercial break-even
  - Huge project costs, supplies, etc = higher cost per kWh
  - Will need be competitive with other fuels to gain higher use

Emerging Wind Tech

Wind

- PJM ~ 3.9%, US 10%
- Currently, Wind produces about twice that of solar
- Issues: Efficiency, Sound, Height, Vibrations, Ascetics, Danger to wildlife
  - include Small Wind Turbines (SWTs) (back yard turbines)
- Current Wind Generation uses “air foils” (wings), more lift than drag increases lift and turns the turbine
  - The turbine rotates a shaft, that runs a generator…..



Wind Efficiency Limit

Can we achieve 100% Wind Turbine Efficiency?

Betz's Law (1919) defines the maximum power that can be extracted from the wind, in that no turbine can capture more than 59.3% of the kinetic energy in wind

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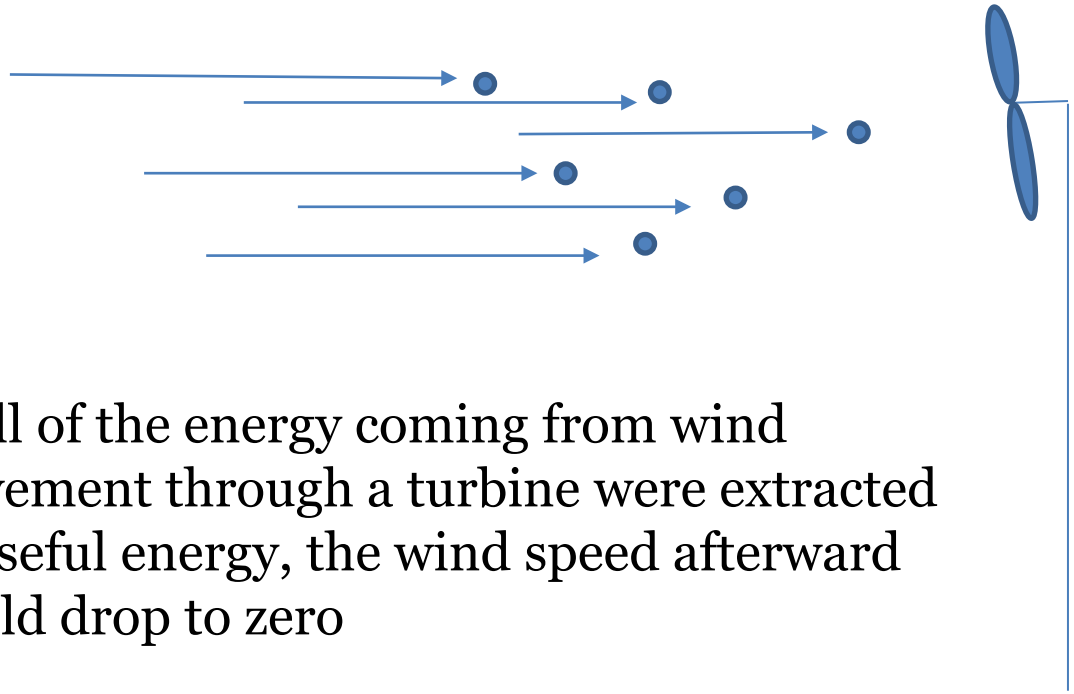
Nope! Here's Why



If all of the energy coming from wind movement through a turbine were extracted as useful energy, the wind speed afterward would drop to zero

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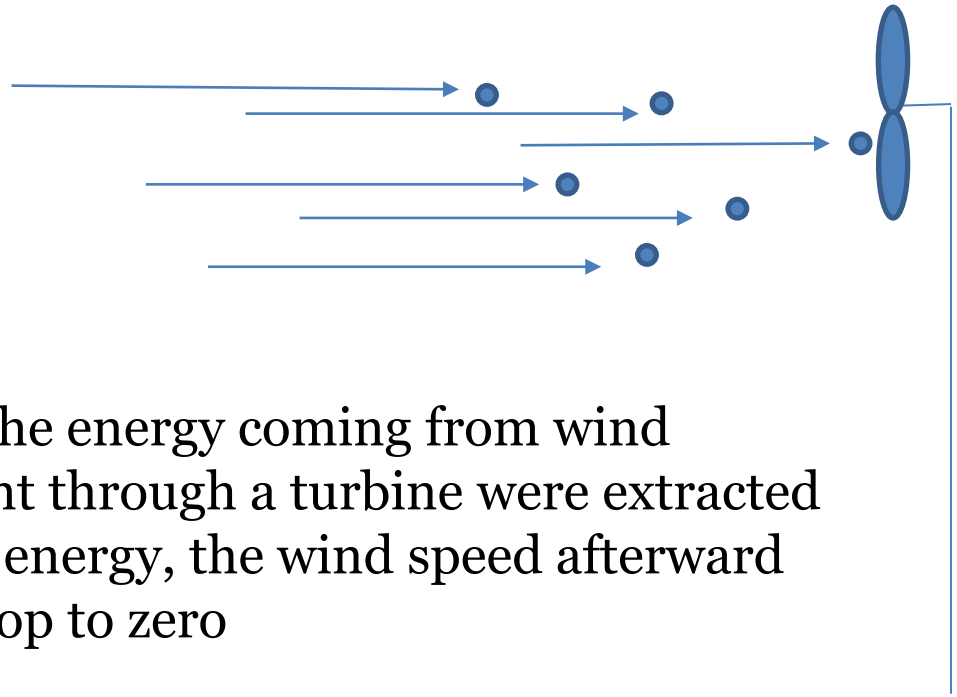

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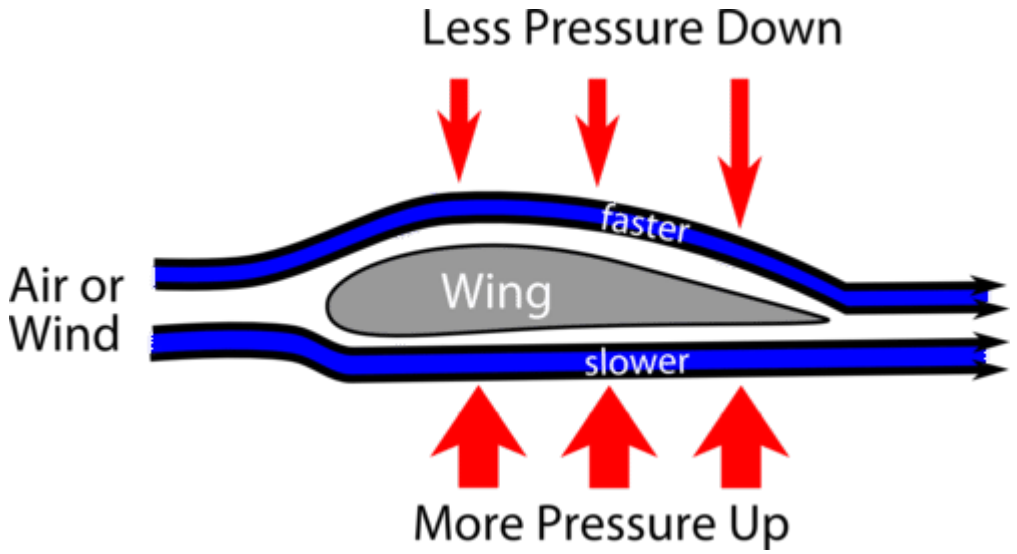
Emerging Wind Tech

- Bernoulli – along a streamline, the sum of static pressure, + dynamic Pressure + the hydrostatic remains the same (individual values can change)
  - Static Pressure = fluid pressure of wind
  - Dynamic Pressure = density and velocity of wind
  - Hydrostatic Pressure = pressure of wind due to gravity
- So, for horizontal flow, a decrease in pressure must be accompanied by an increase in velocity
- Streamline – the path a single particle takes



Commercial Rooftop BtMG Wind

Commercial Rooftop Wind

- New Tech - Aeromines
- Reimagining Energy For the DOD Appendix
- Performance Metrics Vs Solar
  - 50% More Energy @ 10% of the Space
  - Power Output for 1 Aeromine unit = 16 solar panels *
  - Each unit output 14.5 MWh/year, v 4.5 MWh/year
  - Installation: $2400/kW v $1655/kW
- Requires less wind to operate (5 mph)
- Enclosed parts (silent, Wx protected, less maintenance, no risk to humans or animals)
- Pilot program @ BASF Corporation manufacturing plant in Wyandotte, Michigan

Source: Aeromine Technologies

Aeromine Rooftop Wind – How it works

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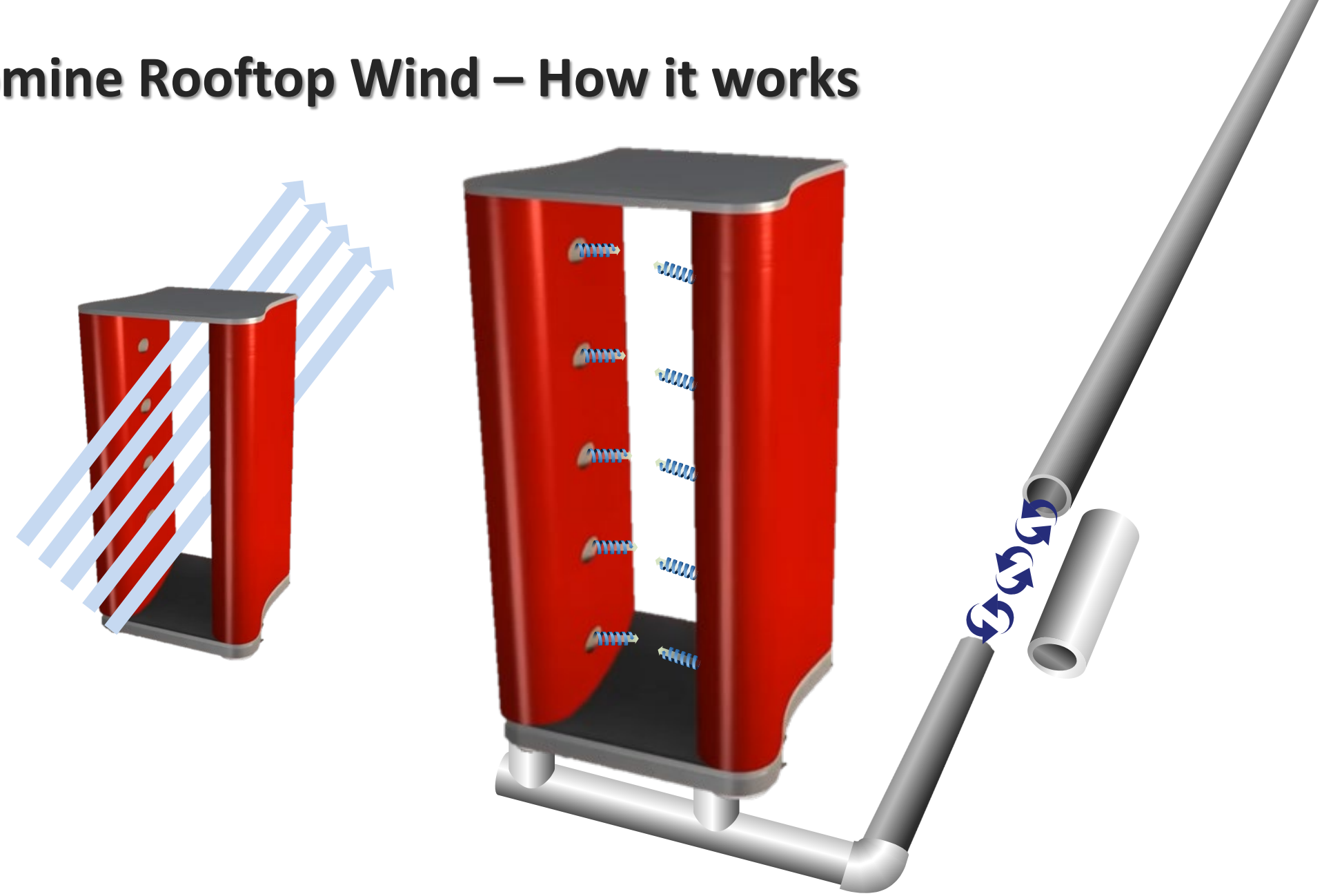
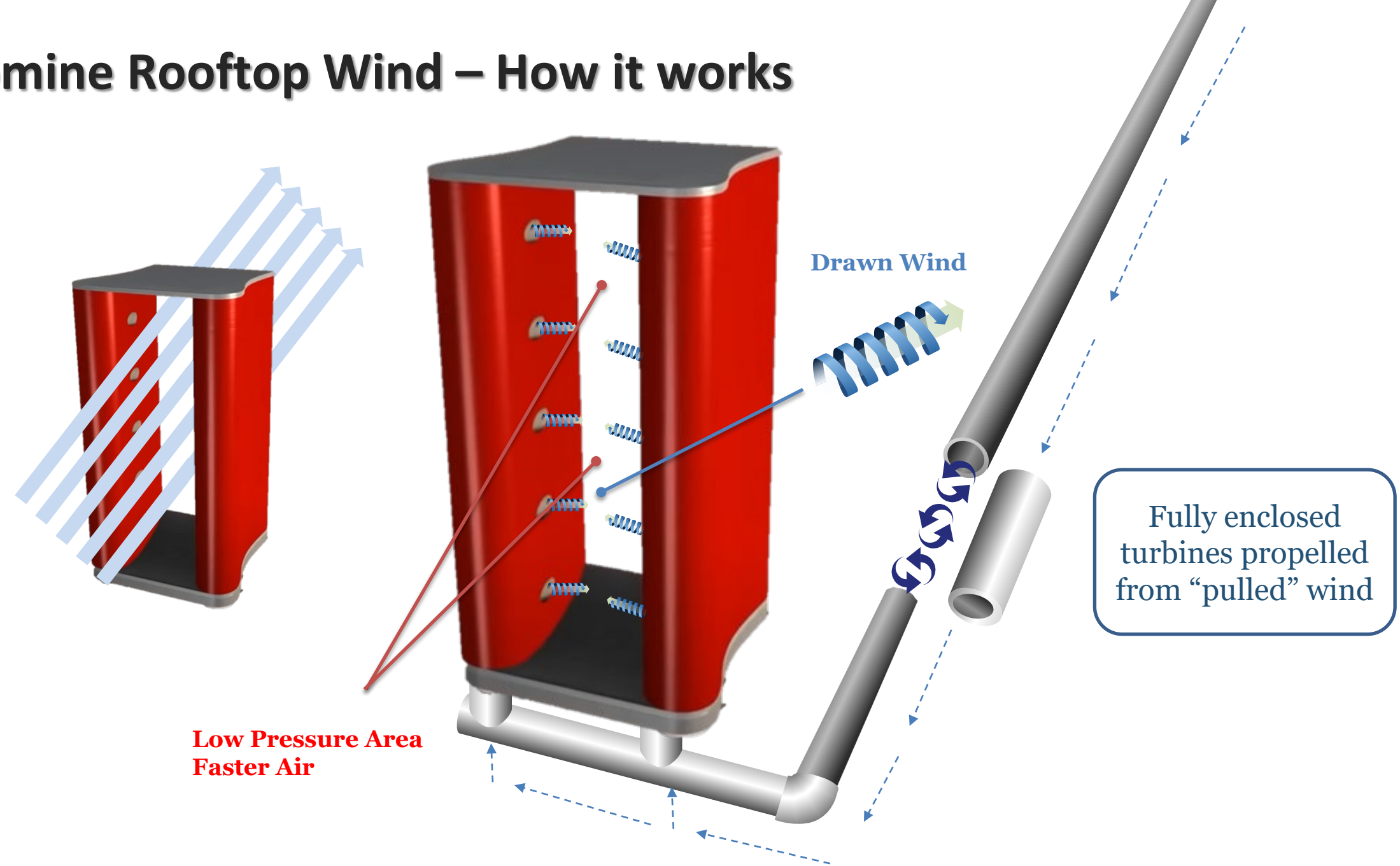
Aeromine Rooftop Wind – How it works



Aeromine Rooftop Wind – How it works



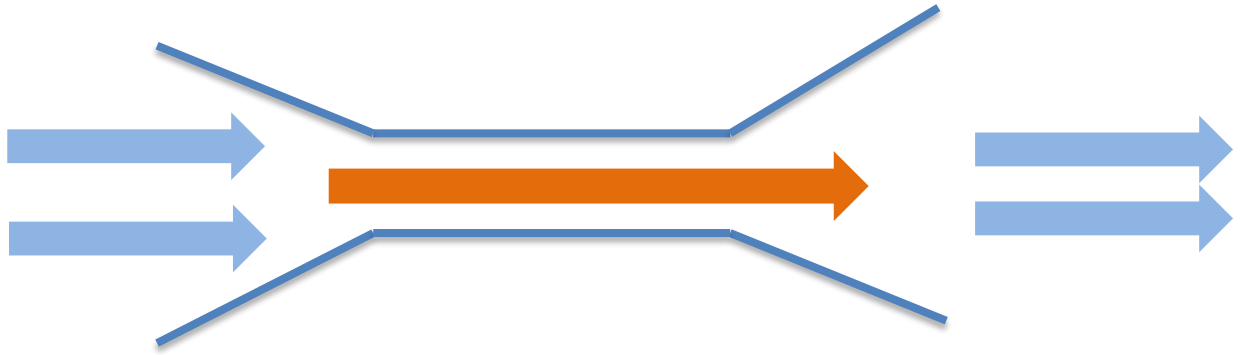
Fully enclosed turbines propelled from “pulled” wind

Theoretical image of Aeromine Wind Turbines on a Warehouse

Ibis PowerNEST

IBIS PowerNEST

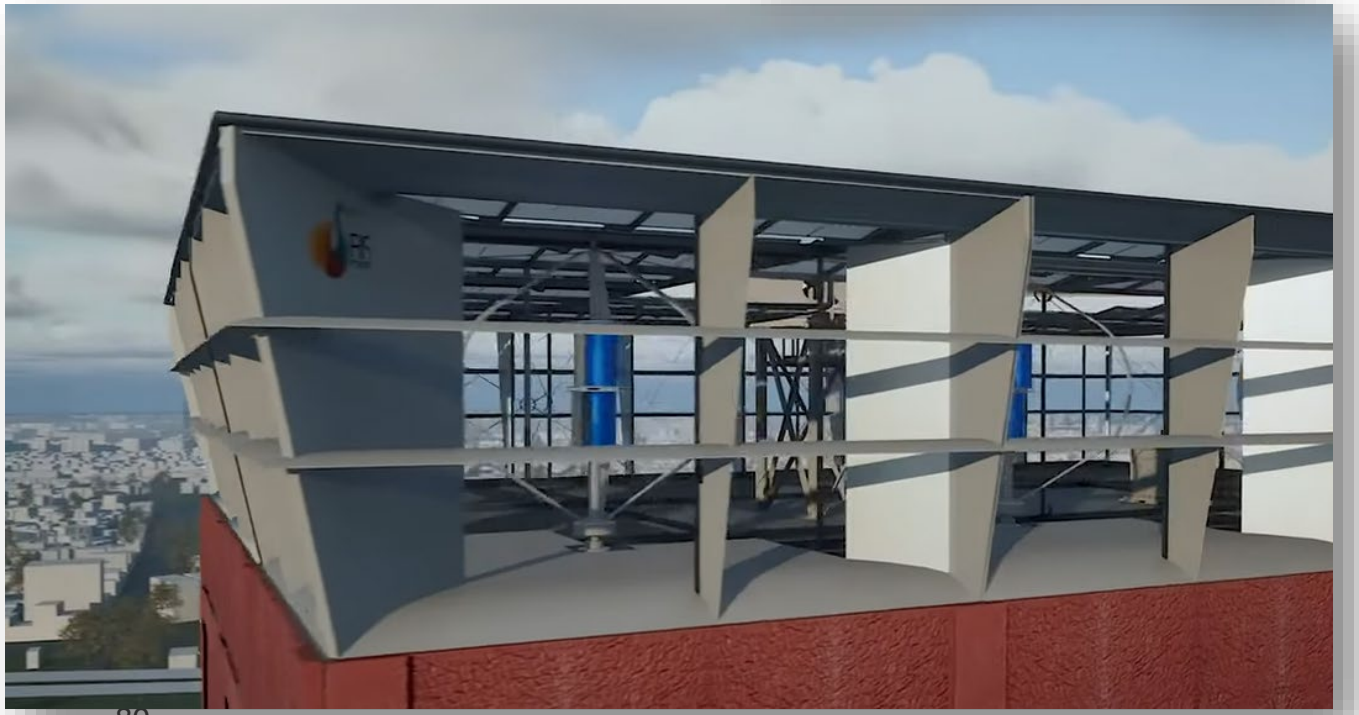
- Incorporates rooftop wind, funnels, and solar panels into “kinetic sculpture”
  - Designed specifically to blend in with the existing architecture of a city
  - Requires a flat roof on a building with a minimum of five floors
- Expands on the Bernoulli Principle using Venturi Effect which allows us to predict results within constricted spaces
  - Allows use of wind energy within metropolitan area
- Each PowerNEST:
  - Solar panels top level
  - VAWT wind turbines and funnels lower level



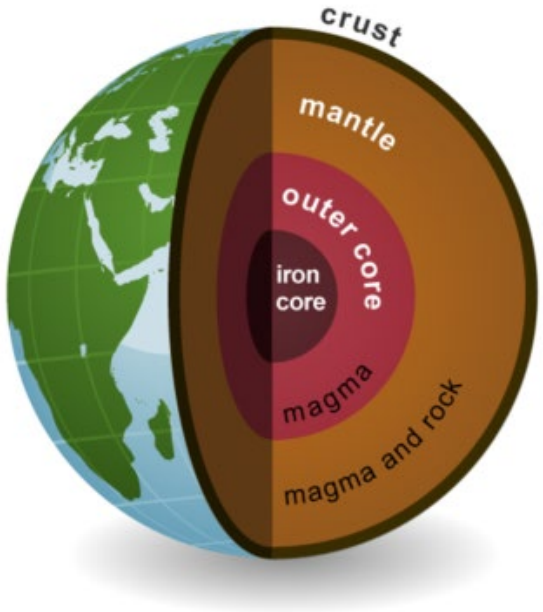
IBIS PowerNEST

Operational Data (2019 – Present)

- Venturi Effect accelerating wind speed up to 160%; creates “useable” wind @ 4.5 mph
- Wind induced cooling of solar roof cools; 10% – 25% efficiency boost
- Nest slopes outward over rooftop, allowing use of entire roof for solar panels
- Bi-facial Solar Panel use
- Zero vibration
- Zero noise
- Meets 80-105% of buildings annual energy demand

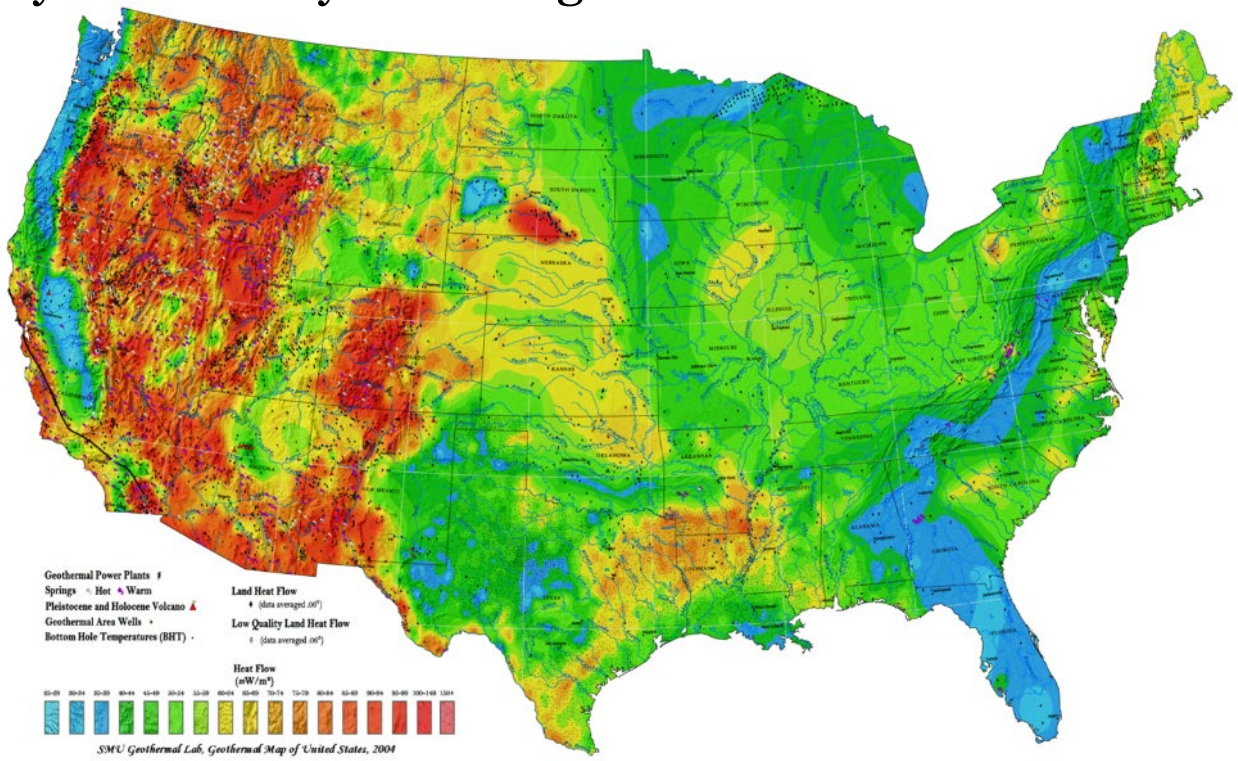


Geothermal Tech



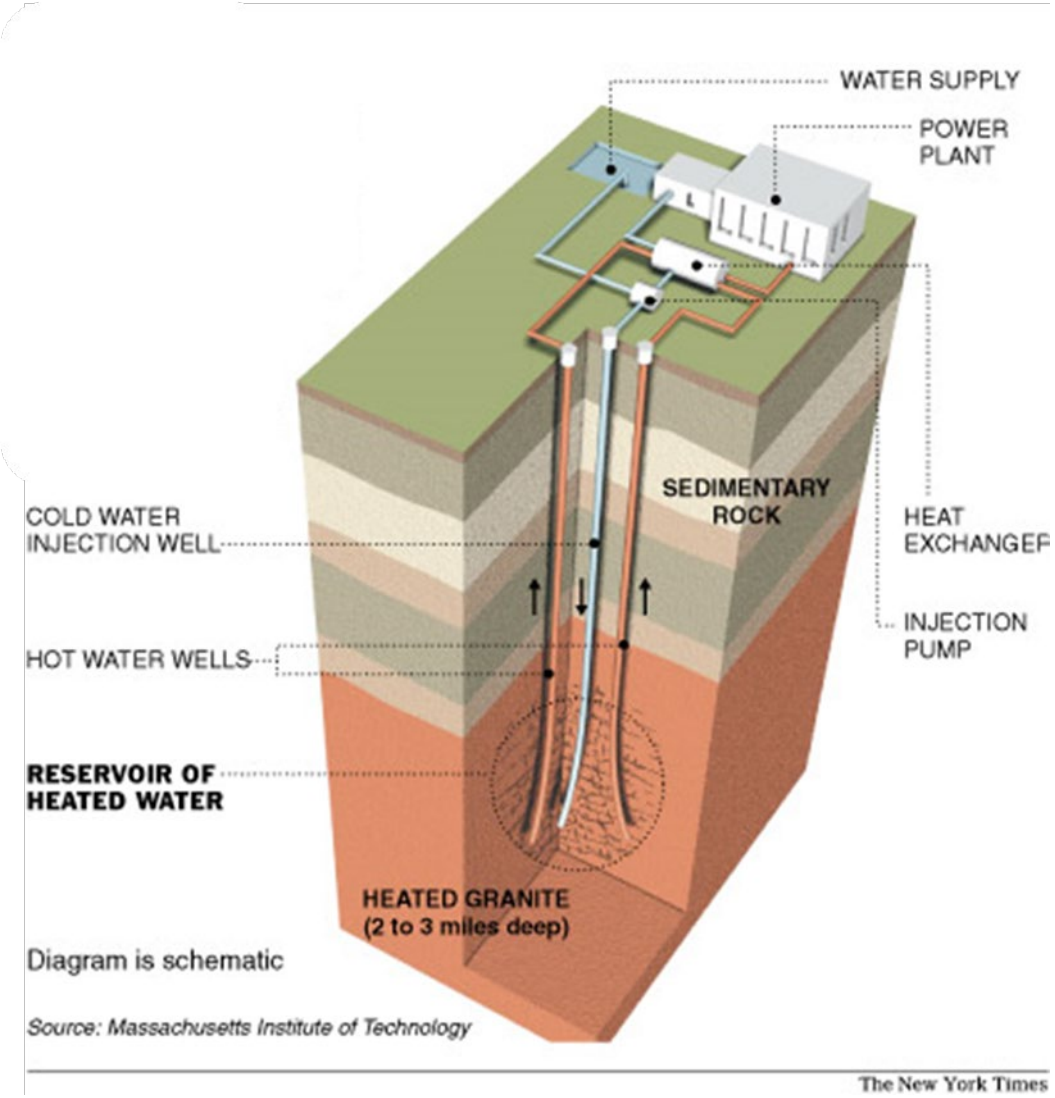
Geothermal Tech

- Geothermal energy is heat that flows continuously from the Earth's interior to the surface
- The temperature at the center of the Earth is about the same as the surface of the sun (nearly 6,000°C, or about 10,800°F)
- This heat is continually replenished by the decay of naturally occurring radioactive elements beneath the subsurface
  - Will remain available for billions of years
- In the US, primarily in the western states, Alaska, and Hawaii
  - Direct use and district heating systems
  - Geothermal power plants
  - Geothermal heat pumps
  - Enhanced geothermal systems (EGS), New + more locations



- Currently not included as part of Renewable Portfolio Standards (RPS)

Geo Thermal Plants



Dry Steam Power Plant

- Use hydrothermal fluids that are already mostly steam
- Steam is drawn directly to a turbine, driving a generator
- After the steam condenses, reinjected into the reservoir

Flash Steam Power Plant (Most Common Type)

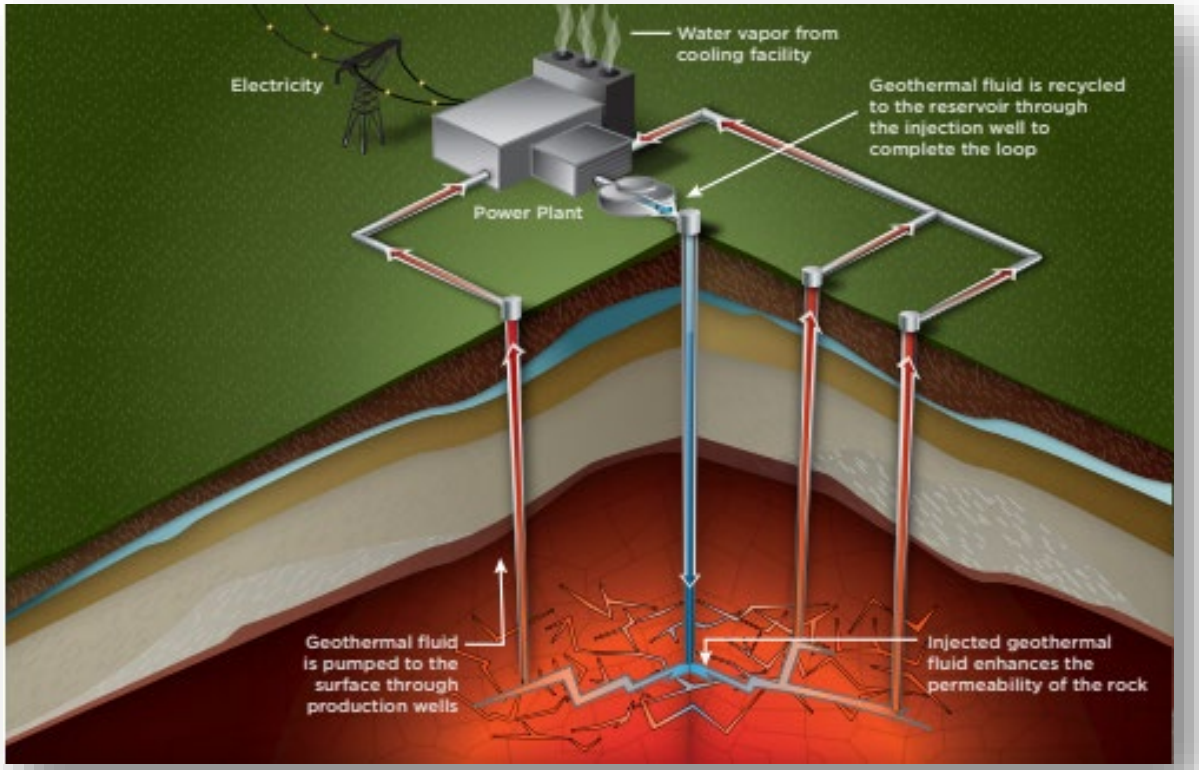
- Fluids at temps > 182°C/360°F, pumped from deep underground,
- High pressures to a low-pressure tank change causes “flashing”
- Vapor then drives a turbine, which drives a generator
- Any liquid remains in the low-pressure tank can be “flashed” again

Binary-Cycle Power Plant

- Uses lower temperature geothermal resources
- Low-temperature (below 182°C/360°F) geothermal fluids pass through a heat exchanger with a secondary, or "binary," fluid
- This binary fluid has a much lower boiling point than water, causes it to flash to vapor, which then drives the turbines, spins the generators

Enhanced Geothermal Energy Plant

- Drill injection wells into hot rock with limited fluid permeability
- Inject water at sufficient pressure to create a fractures
- Drill a production well into the fracture network, intersecting the created flow paths
- Circulation loop allows water to flow through the enhanced reservoir, picking up heat
- Hot water is then pumped to the surface through the production well
- At the surface, the water flashes to steam



- Or, heats a working fluid that produces vapor, turns a turbine
- The original geothermal water is recycled into the reservoir through the injection well to complete the circulation loop

Questions?

PJM Client Management & Services

Telephone: (610) 666-8980

Toll Free Telephone: (866) 400-8980

Website: www.pjm.com

The Member Community is PJM's self-service portal for members to search for answers to their questions or to track and/or open cases with Client Management & Services

Resources & References

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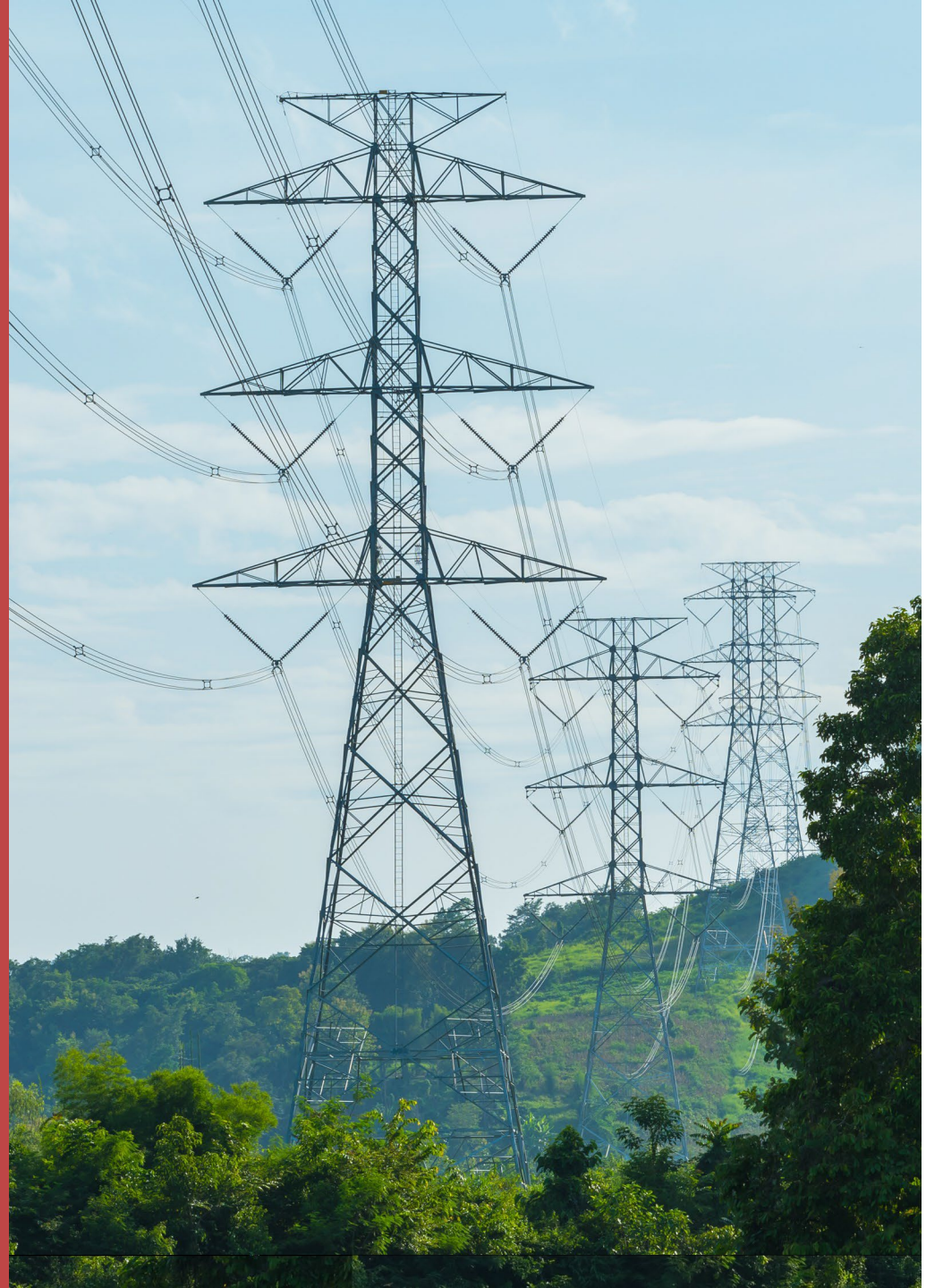
Appendix

Reimagining Energy for the DOD

- The Reimagining Energy for the DOD Challenge, seeking solutions to create the future of resilient energy production, transmission, use and storage
- The Department of Defense (DOD) is currently the largest energy consumer globally. By reducing demand and reliance on petroleum and modernizing the energy infrastructure, the Air Force can improve the way they consume energy, increase sustainability and remain adaptable to future impacts of climate change and reduction in fossil fuels
- An open crowdsourcing program that aims to reduce the U.S. military's reliance on fossil fuels and accelerate it's shift toward renewable and resilient energy sources



THANK YOU

Join us for our next Tech Talk – December 18th

Beth Rettig, RF - EOP-011 walk downs