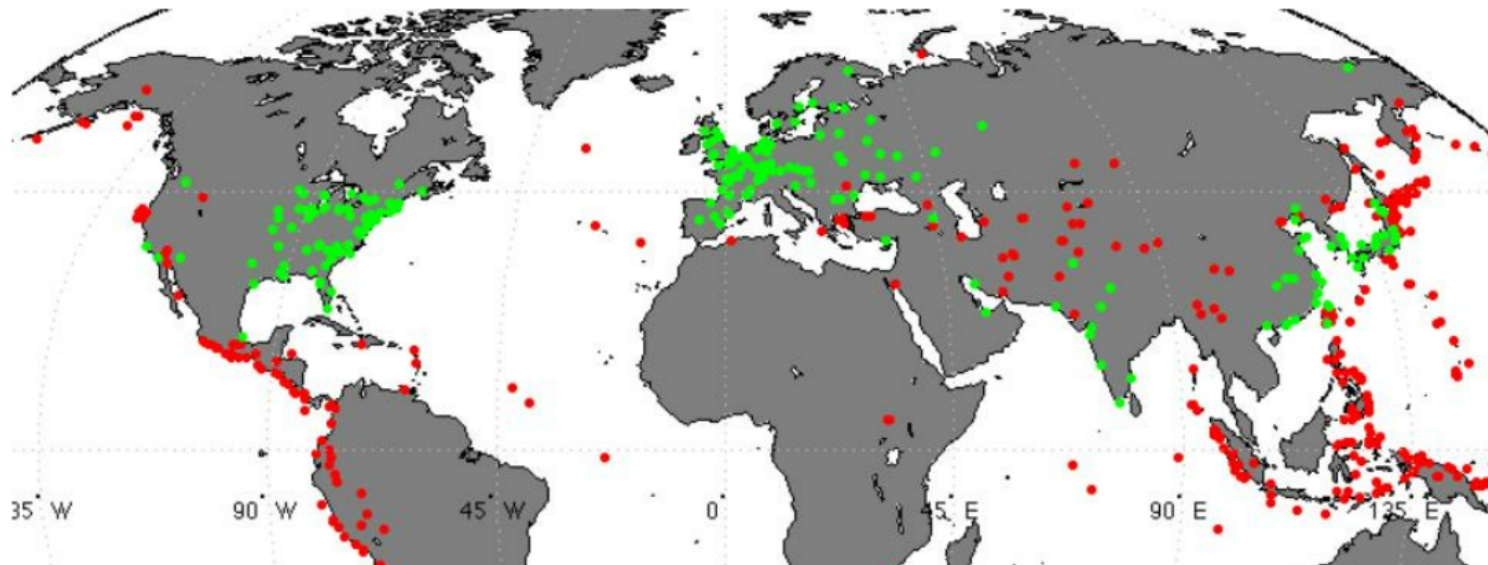


Redundancy: Backup Power Generation Solutions

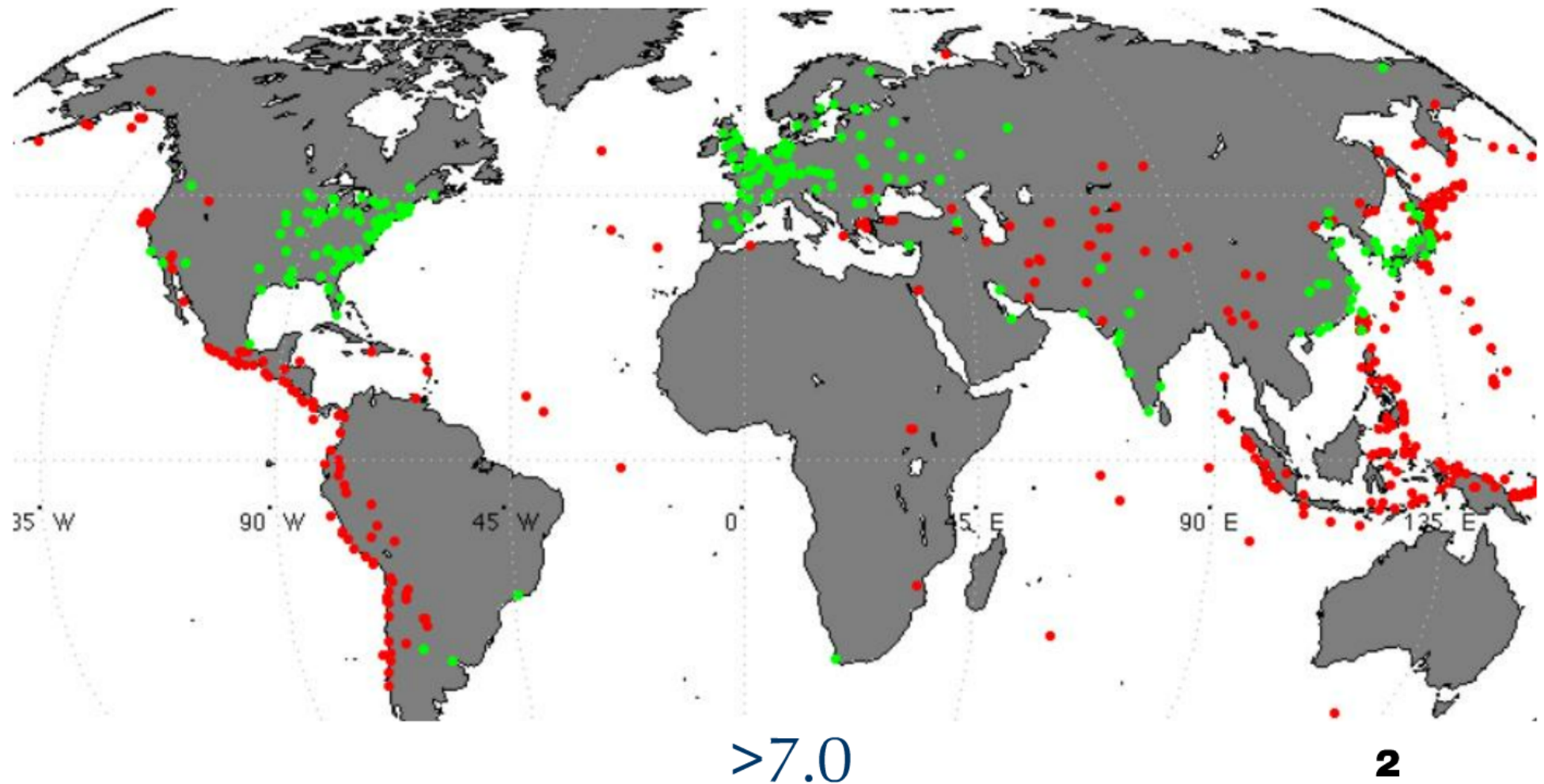
Group 19
Jordan Berke
Dustin McRae
Khristofer Thomas

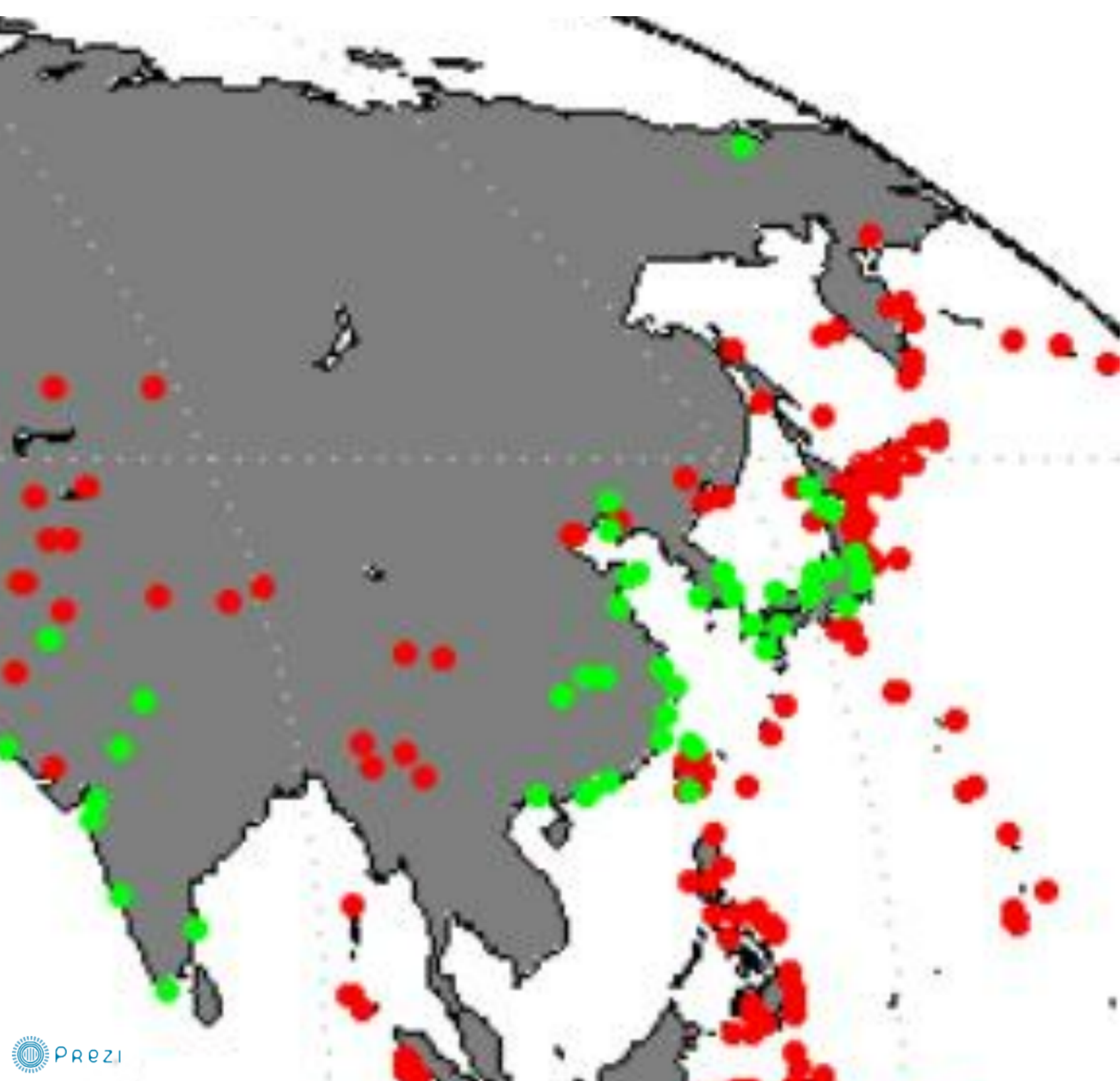
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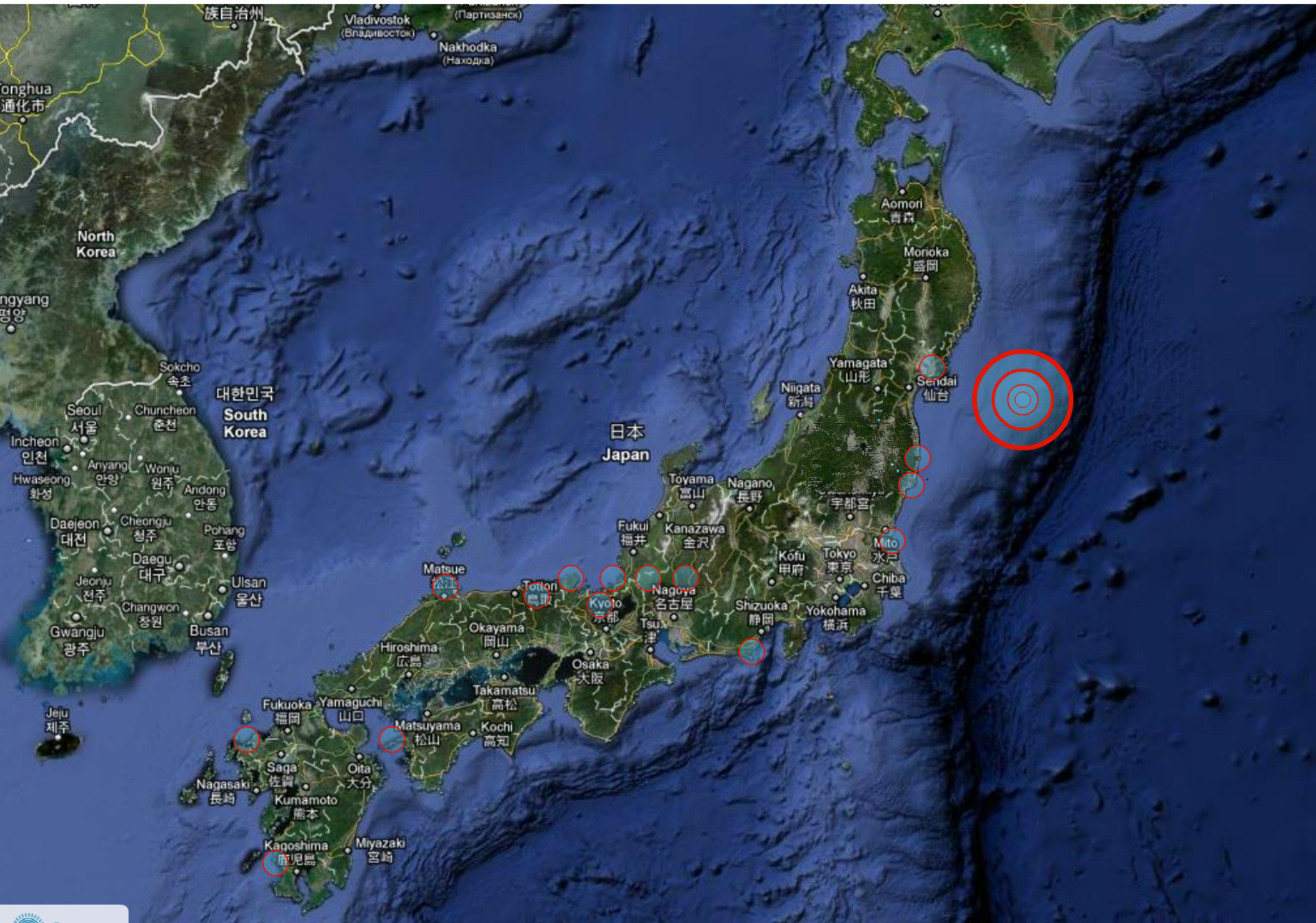
What Is The Problem?



What is the Problem



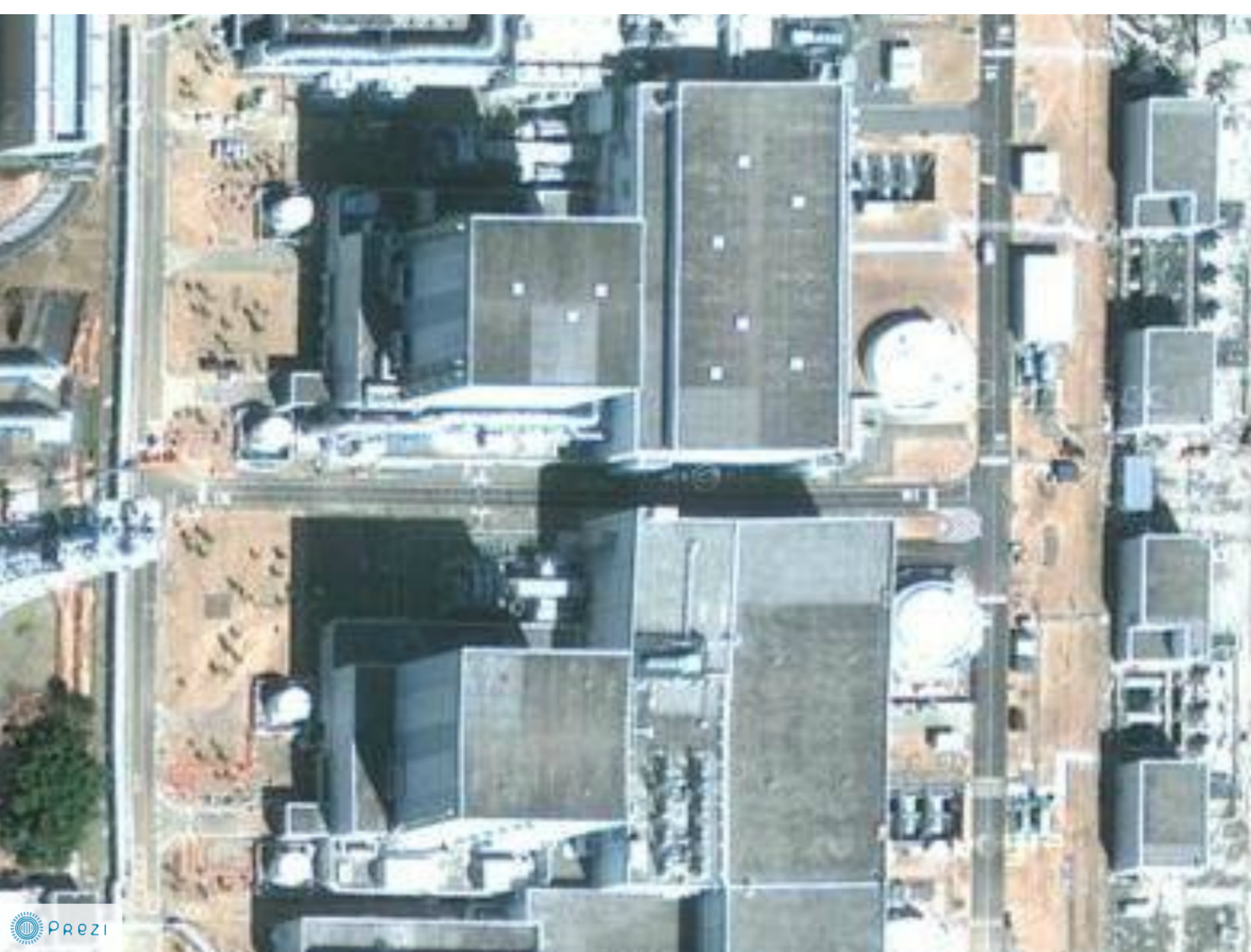










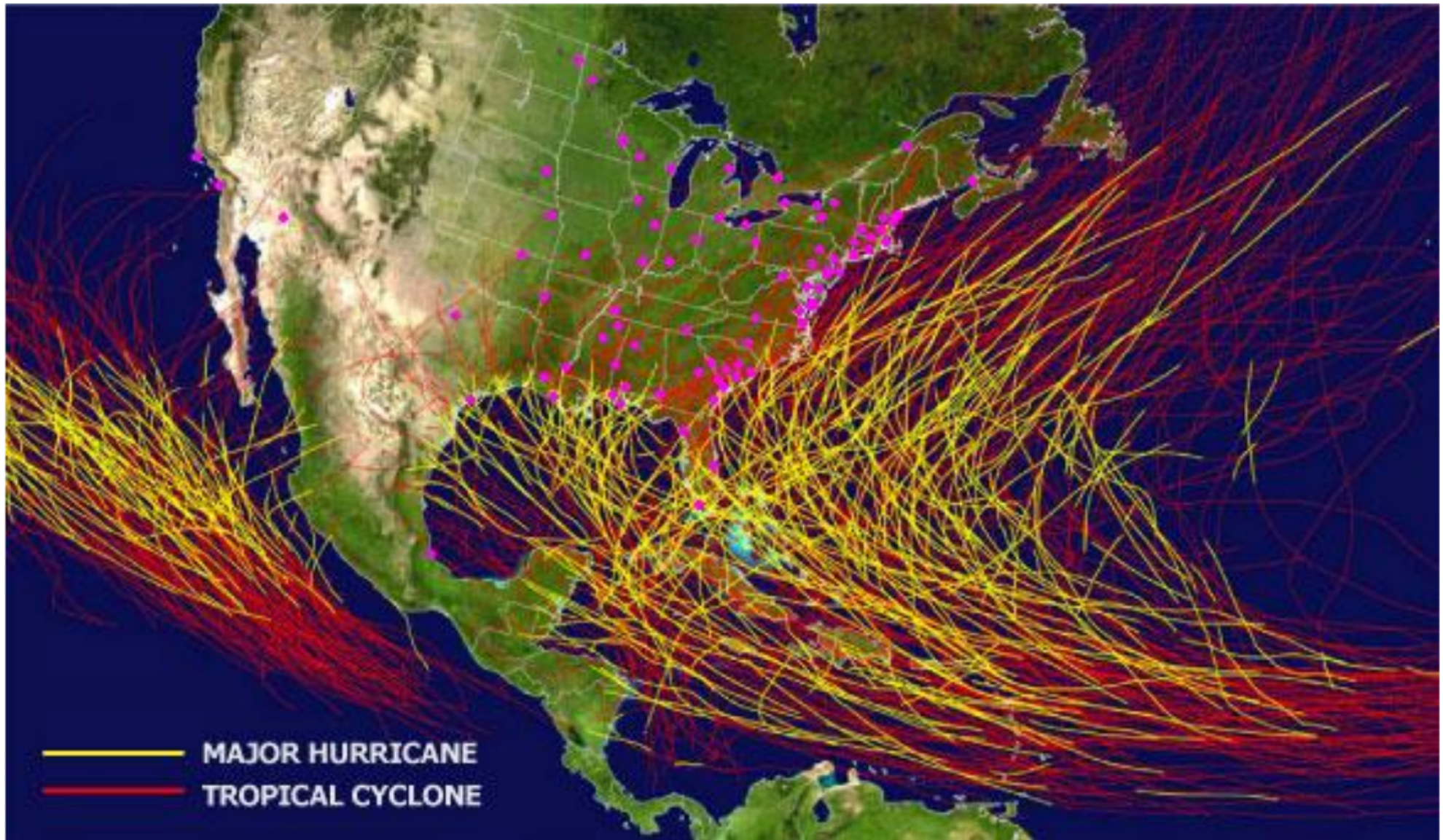




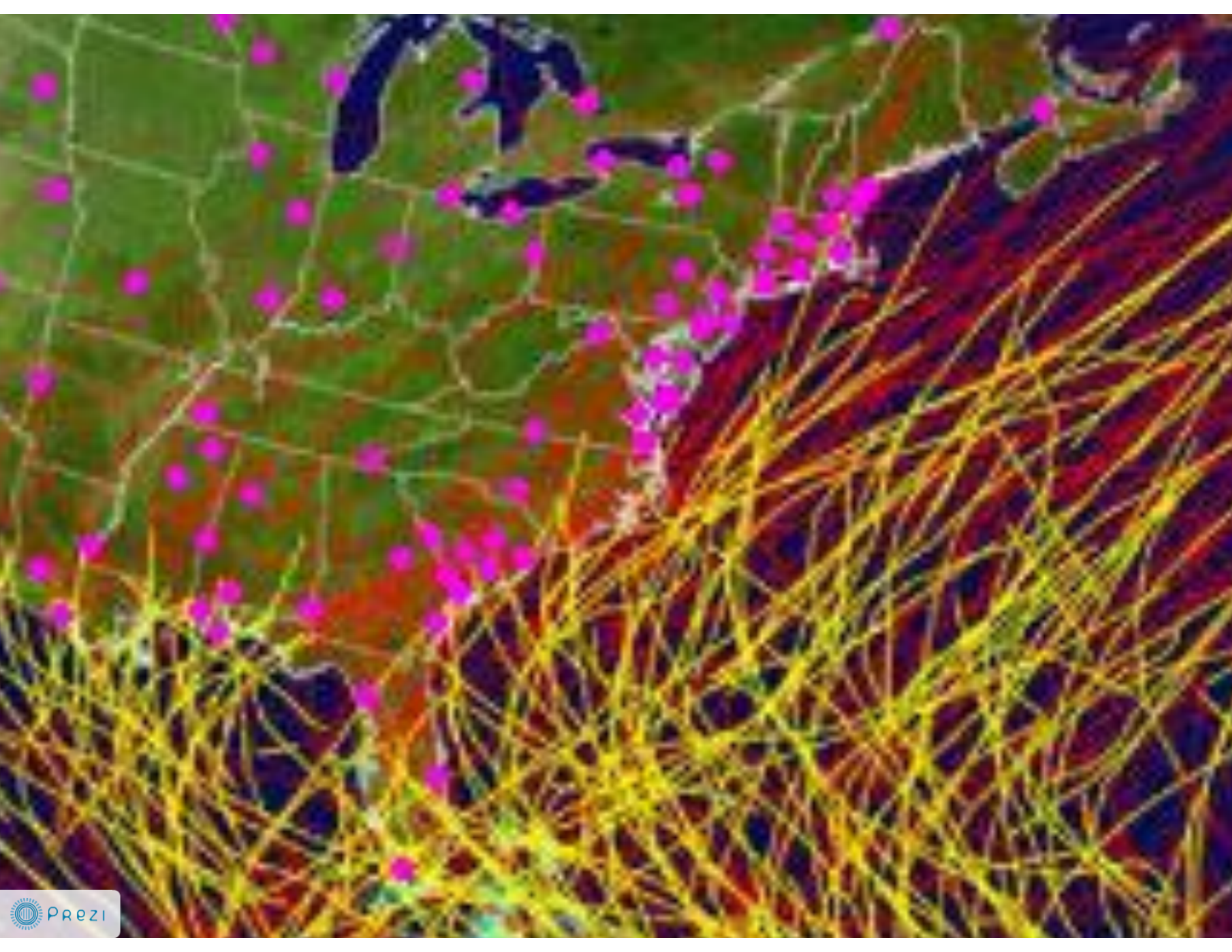
Why does this affect us?

6

Here's An Example



Since 1851

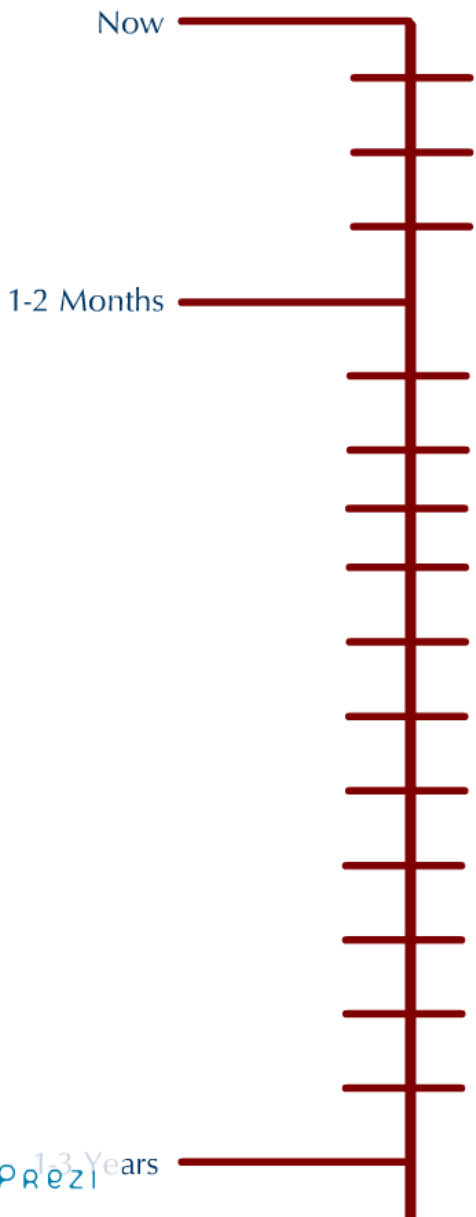


What Is The Solution?

Phase 1 Pt. 1

Mobile Diesel Generators

Phase 1 Pt. 2



1-3 Years

Phase 1 Pt. 2

Regulatory Changes

"Under the pressure of the public and the media, the government may be compelled to push for sweeping policy and regulatory changes, which may ultimately prove to be unnecessarily onerous on existing and future plants."

**-MIT
Center for Advanced
Nuclear Energy Systems**

Humans react in an emotional manner.

Humans react in an emotional manner.

Smaller regulatory alterations may be a better solution.

"Does an accident like Fukushima, which is so far beyond design basis, really warrant a major overhaul of current nuclear safety regulations and practices? The answer is country-dependent..."

**-MIT
Center for Advanced
Nuclear Energy Systems**

Discussion ?

3-10 Years

Phase 2

Relocation of Diesel Generators

External power was lost in Fukushima.

Along with diesel generator redundancy.

Installation of Redundant Diesel Generators & Adaptation of Voltage Switching Yards

11

10-30 Years

Phase 3

Recombinant Hydrogen Fuel Cell Generators



Redundant Diesel Generators

Four Diesel Generators

One Diesel Generator Failed

First of Two Redundant Diesel Generators Replaced it



Reactor Building No. 1
Reactor Building No. 2

A
North Anna
Nuclear
Info Center

State Route 700

Installation of Redundant Diesel Generators & Adaptation of Voltage Switching Yards

11

Phase 3

Recombinant Hydrogen Fuel Cell Generators

Capture Hydrogen in case of Zircaloy oxidation reaction

No moving parts - 99% reliability, low maintenance

Initial cost comparable to diesel generators for similar power output and capacity

Solar-powered Hydrolyzers have been used to create and store Hydrogen (Stewart Island Energy Initiative)

13

10-30 Years



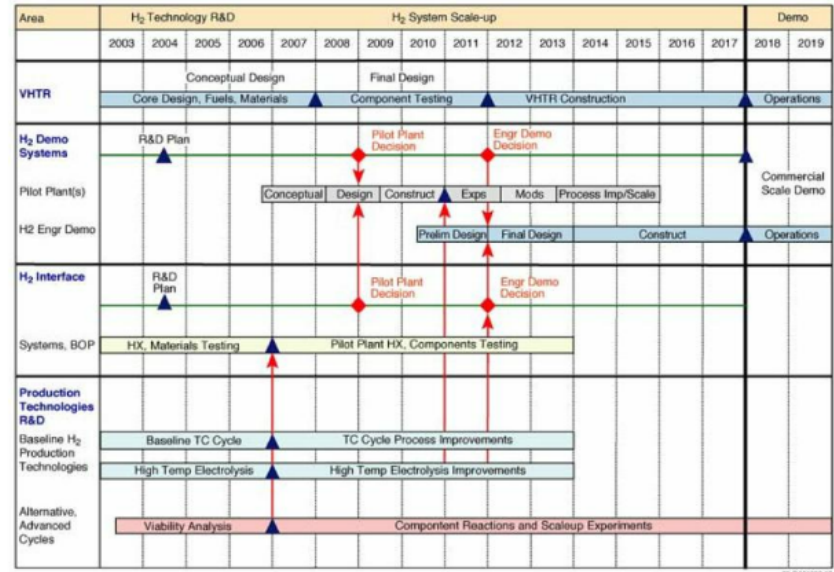
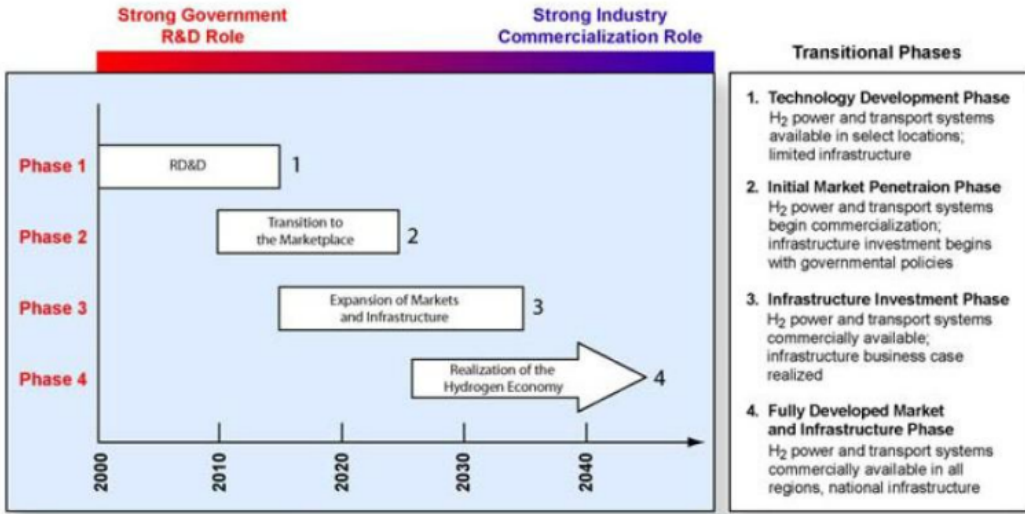


Figure 6-1. Summary of NHI R&D plan for the development and demonstration of a nuclear hydrogen production capability by 2017.

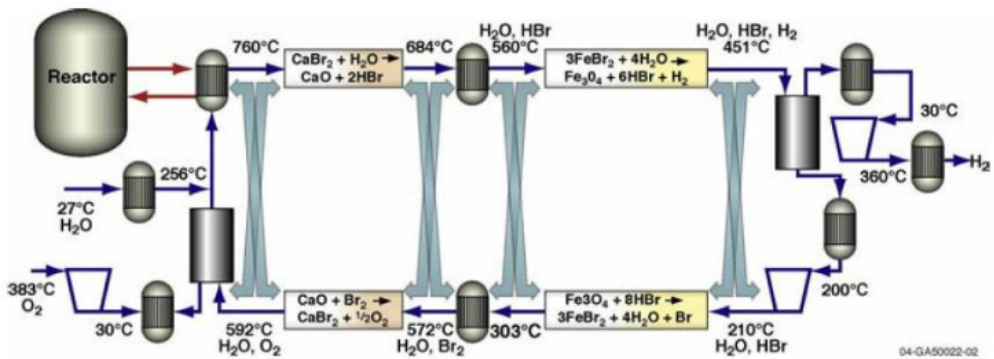
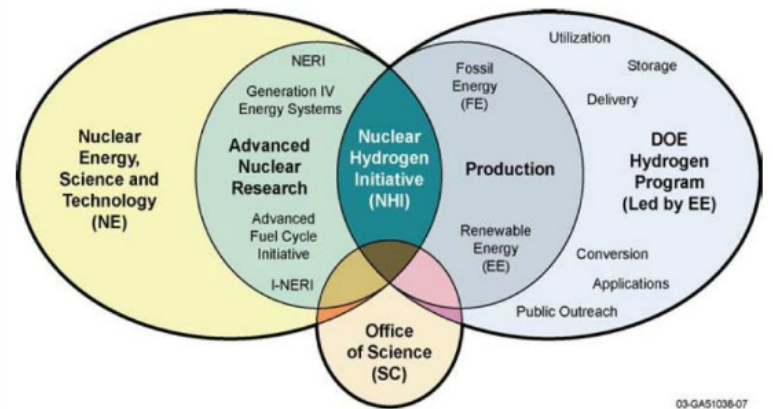


Figure 3-3. Schematic of Ca-Br thermochemical cycle (UT-3).



03-GA51038-07



Decision Matrix	Initial Cost	Cost of Maintenance and Operation	Reliability	Safety	Energy Capacity	Ease of Implementation	Total
Generators	7	7	7	8	10	9	48
Fuel Cells	7	8	9	7	8	6	45
Flywheel Energy Storage	5	7	7	5	2	4	30
Backup Batteries	8	6	7	7	2	8	38

Flywheel and Battery options only feasible for very short time frames

Generators and Hydrogen Fuel Cells are the only option for sustained operation

Summary

Triple Modular Redundancy

- **Maintenance procedures & mobile diesel generators in reactor housing**
- **Permanent redundant diesel generators in reactor housing**
- **Permanent Recombinant Hydrogen Fuel Cells in reactor housing**

Lifespan = 40yrs											
No Change			Phase 1			Phase 2			Phase 3		
Item	Rate	Total	Item	Rate	Total	Item	Rate	Total	Item	Rate	Total
Regular Maintenance	\$15000/yr	\$600,000	Portable Generators Initial Cost	\$25000/unit	\$75,000	Construction and Permanent Installation	\$25000/unit (additional)	\$75,000	Hydrogen Fuel Cell System Installation	\$100000/unit	\$300,000
Environmental Cleanup		\$1 billion to \$59 billion	Generator Maintenance	4x Frequency of Regular Maintenance	\$2,400,000	Generator Maintenance	4x Frequency 2x Generators	\$4,800,000	Hydrogen Capture System Maintenance and Inspections		up to \$5,000,000 (est)
Decommissioning Cost		\$300 million								\$15000/yr	\$600,000
Totals	No Change	1.3 Billion-59.3 Billion	All Phases		13.3 Million						

Although it costs more than the backup system implemented today, the redundant generator plan will cost more than one hundred times less than the conceivable event of a loss of backup power

Questions?

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Sources

Decommissioning:

<http://nuclearinfo.net/Nuclearpower/WebHomeCostOfNuclearPower>

Cost of generators and fuel cells:

http://www1.eere.energy.gov/hydrogenandfuelcells/education/pdfs/early_markets_backup_power.pdf

Cost of batteries/flywheels:

<http://www.touchstoneenergy.com/efficiency/bea/Documents/BackupPowerSolutions.pdf>

Fuel cells in use to provide backup power for cell towers:

<http://www.poweringnow.ca/back-up-power>

Stuart Island Energy Initiative:

<http://www.siei.org/>

"Electricity Generation." Wikipedia, the Free Encyclopedia. Web. 12 Sept. 2011.<http://en.wikipedia.org/wiki/Electricity_generation>.

"Fukushima Decontamination to Cost Japan 220bn - Times LIVE." Home - Breaking SA and World News,Sports, Business, Entertainment and More - Times LIVE. Web. 12 Sept. 2011.<<http://www.timeslive.co.za/world/2011/09/09/fukushima-decontamination-to-cost-japan220bn>>.

J. Buongiorno, R. Ballinger, M. Driscoll, B. Forget, C. Forsberg, M. Golay, M. Kazimi, N. Todreas, and J.Yanch, Technical Lessons Learned from the Fukushima-Daichii Accident and Possible CorrectiveActions for the Nuclear Industry - An Initial Evaluation (May 2011).

"Redundancy (engineering)." Wikipedia, the Free Encyclopedia. Web. 12 Sept. 2011.<[http://en.wikipedia.org/wiki/Redundancy_\(engineering\)](http://en.wikipedia.org/wiki/Redundancy_(engineering))>.