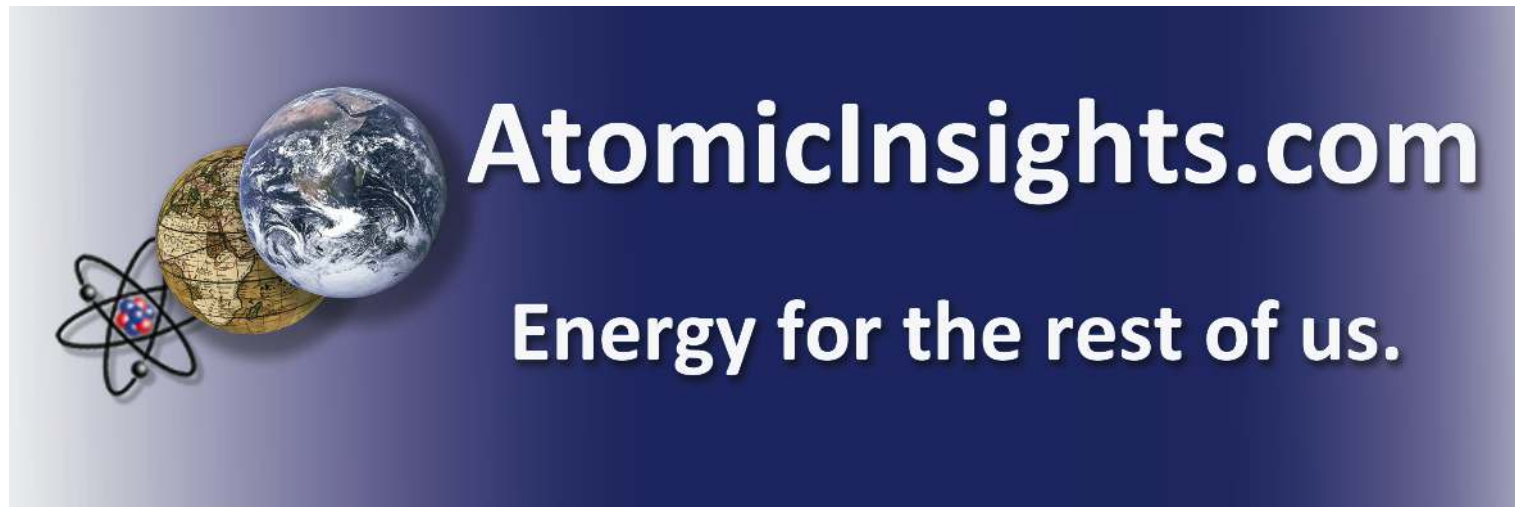


Nuclear Energy:

Important tool for energy abundance & limiting
atmospheric chemistry changes



Rod Adams

Sweet Briar Engineering Students

3 March 2015

What Is Your Current Position On Nuclear Energy?

- A. Neutral
- B. Oppose
- C. Support
- D. Strongly support

How do you feel about
empowering human society?

- A. Neutral
- B. Oppose
- C. Favor
- D. Strongly favor

How do you rate the issue of atmospheric chemistry change?

A. Not important

B. Important

C. Most important issue facing my generation

My answers:

- 1 – D: Strongly support
- 2 – D: Strongly favor
- 3 – C: Most important issue facing my generation

For all of those reasons, I am
an unabashed atomic energy
advocate.

I'm here to share why I'm
excited about something that
others fear.

My inspirations

A pound of uranium



Contains as much energy as:
Thirty tanker trucks full of oil!



USS Von Steuben SSBN632



My second zero emission vessel (ZEV)

Large nuclear power station



Spring wildflowers at the Diablo Canyon nuclear power plant

Copyright ©2005 Jim Zimmerlin. All rights reserved.

2200 Mwe Diablo Canyon, San Luis Obispo, CA

Small nuclear power



Atomic fission on a 400 ton research submarine

Distributed Atomic Power



PM-3A at McMurdo Station, Antarctica

Atomic Ambassador Ship



NS Savannah Circa 1965 – Cruising world's oceans

USS Gerald Ford CVN-78



Newest class of aircraft carrier

What do some of the most influential climate scientists say about nuclear energy?

I'd like to credit Ben Heard, an Australian sustainability consultant, for the next few slides. We all need a little help from our friends.

George Monbiot

I'm not proposing complacency here. I am proposing perspective... On every measure (climate change, mining impact, local pollution, industrial injury and death, even radioactive discharges) coal is 100 times worse than nuclear power... Atomic energy has just been subjected to one of the harshest of possible tests, and the impact on people and the planet has been small. The crisis at Fukushima has converted me to the cause of nuclear power.

<http://www.monbiot.com/2011/03/21/going-critical/>



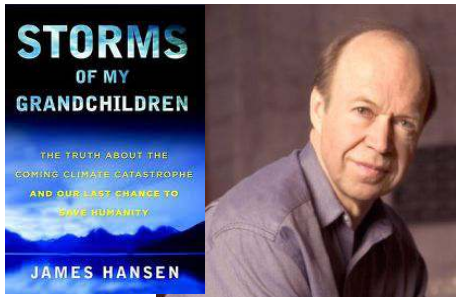
George Monbiot

James Hansen

“That’s what began to make me a bit angry. (outright opposition to nuclear power) ... The antinuke advocates are so certain of their righteousness that they would eliminate the availability of a alternative to fossil fuels.... What if the utility executives are right, and we must choose between coal or nuclear for baseload power?”

The scientific method requires that we keep an open mind and change our conclusions when new evidence indicates that we should. The new evidence affecting the nuclear debate is climate change, specifically the urgency of moving beyond fossil fuels to carbon free energy sources... A phase out of coal emissions in the West can proceed promptly on the basis of efficiency, renewables, third generation nuclear power and possibly a contribution from carbon capture and storage.

Storms of my Grandchildren (2010 p. 204)



James Hansen

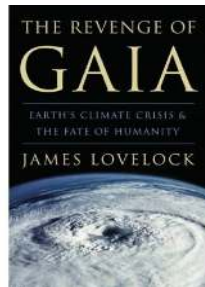
James Lovelock

“Opposition to nuclear energy is based on irrational fear fed by Hollywood-style science fiction the Greens lobby and media...but I am a Green, and I entreat my friends in the movement to drop their wrongheaded objection to nuclear energy... We have no time to experiment with visionary energy sources; civilisation is in imminent danger and has to use nuclear - the one safe, available, energy source - now or suffer the pain soon to be inflicted by our outraged planet.

<http://www.ecolo.org/media/articles/articles.in.english/love-indep-24-05-04.htm>



James Lovelock



Elon Musk

“We should build more nuclear power plants. I think that’s a better way to generate energy than certainly a coal power plant or a natural gas power plant. Burning hydrocarbons -- I think people now recognize is a pretty bad thing. You know over time there’s a certain limit to the CO2 capacity of the atmosphere and the oceans.

<http://www.pbs.org/thinktank/transcript1292.html>



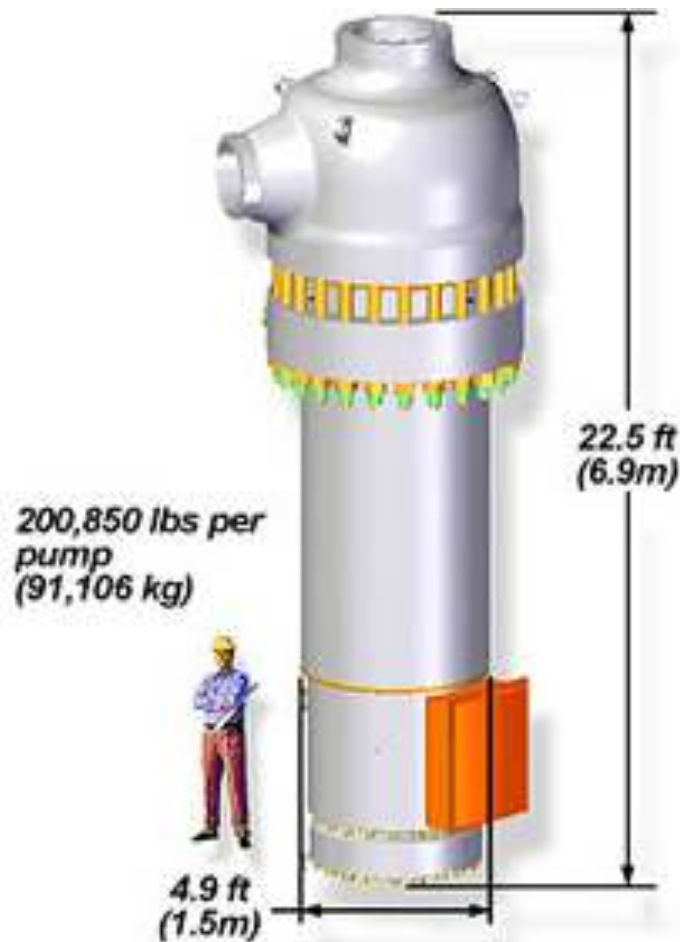
Nuclear energy developments in US

Westinghouse AP1000 – 8 units under construction (4 in China, 4 in Southeast US)



Vogtle units 3 & 4 and VC Summer units 2 & 3

World's Largest Canned Motor Reactor Coolant Pumps



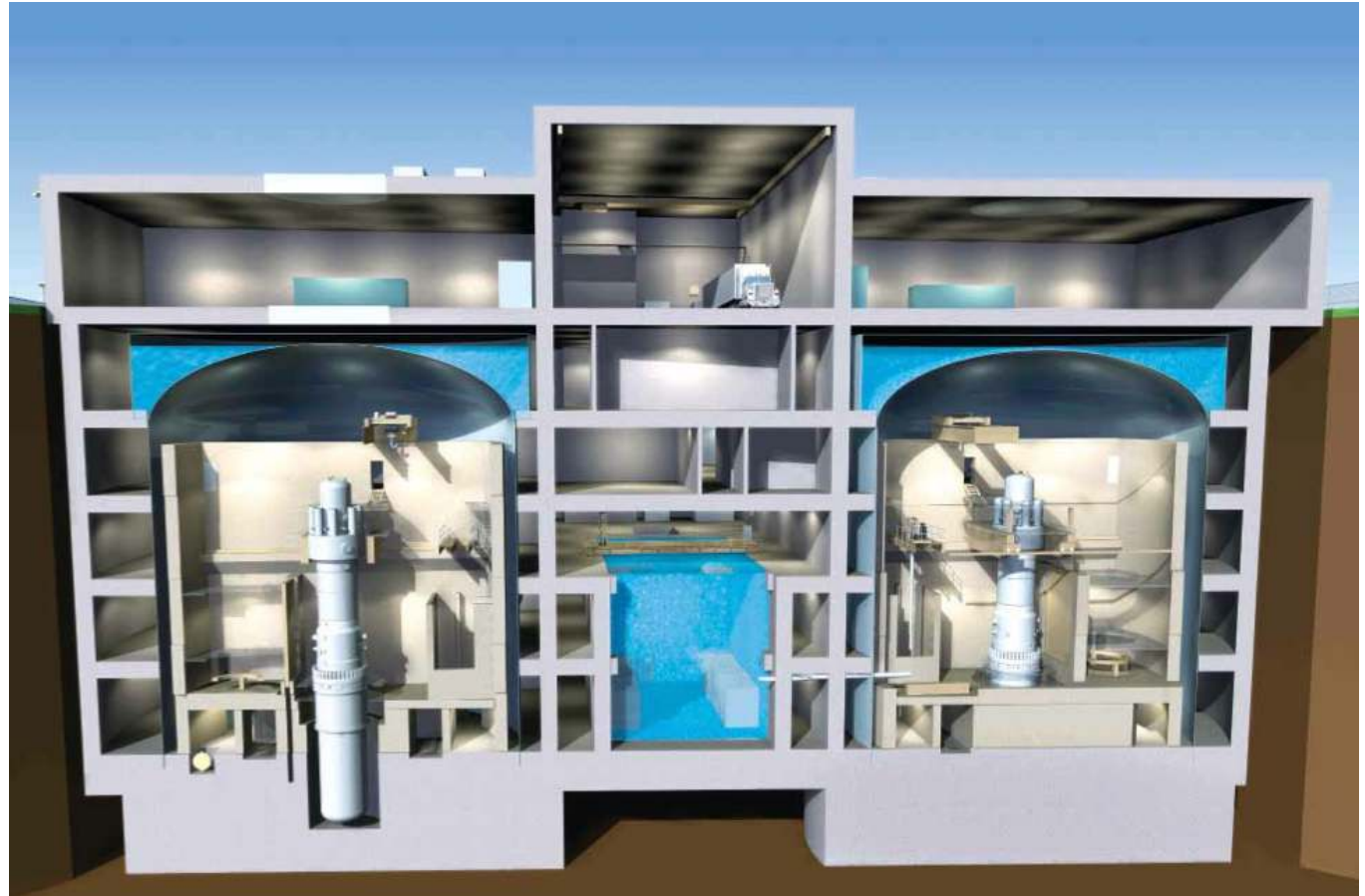
- May 19, 2010 – Successful testing announced
- April 12, 2012 – First pumps shipped to China
- Jan 2013 – Impeller failure found after lab testing
- May 3, 2013 – 10 CFR 21 defect report informed NRC of QA problems at part supplier
- Pumps shipped back from China to western PA for repairs
- Aug 2013 – pumps returned to China
- Sept 19, 2014 – Design issues “resolved.”
- Feb 16, 2015 – “working to redesign a coolant pump.”

New Directions

Obsolete Slide: B&W mPower™ Reactor



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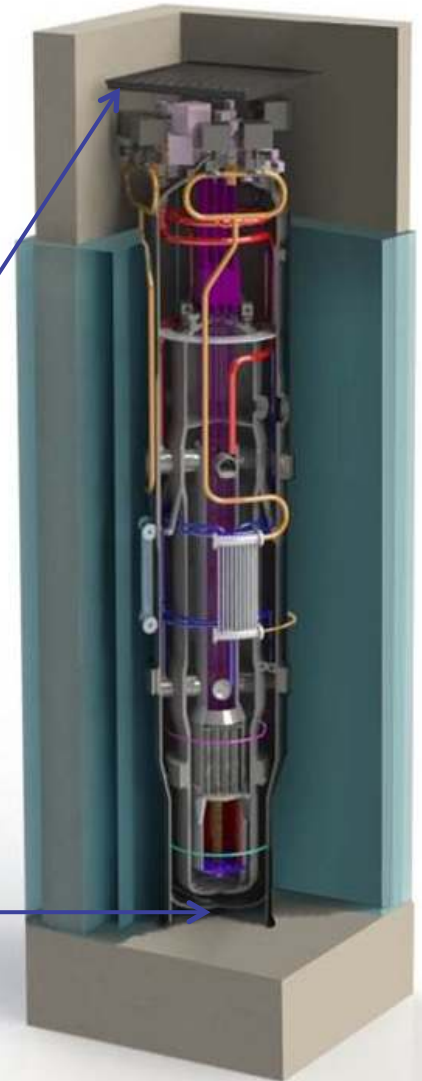
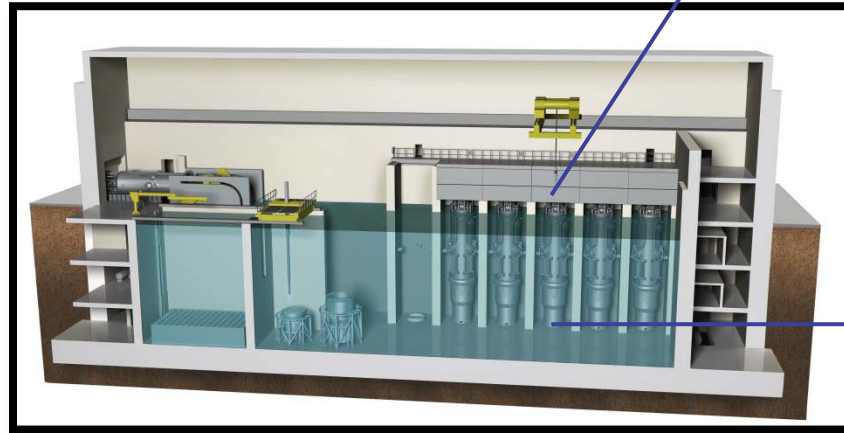
Leading contender in small modular reactor (SMR) industry

Disclosure: B&W mPower Inc. was my employer from Sept 2010-Sept 2013

Project currently on life support

What is a NuScale Power Module?

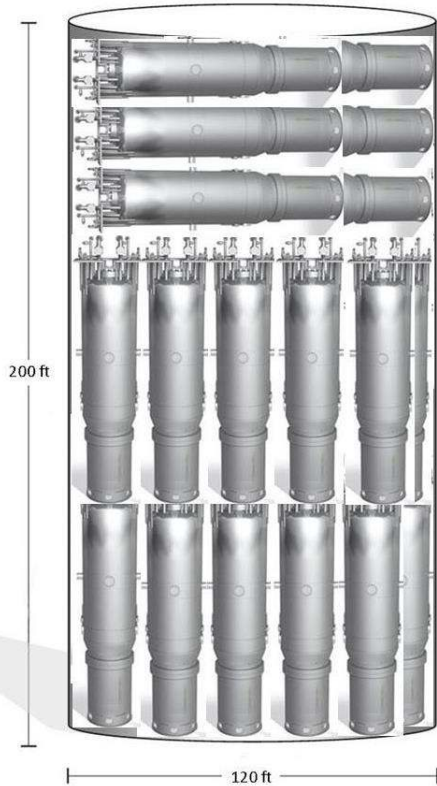
- A NuScale Power Module (NPM) includes the reactor vessel, steam generators, pressurizer and **containment** in an **integral package** that **eliminates reactor coolant pumps** and large bore piping (**no LB-LOCA**)
 - Each NPM is 50 MWe and factory built for easy transport and installation
 - Each NPM has its own skid-mounted steam turbine-generator and condenser
-
- Each NPM is installed below-grade in a seismically robust, steel-lined, concrete pool
 - NPMs can be incrementally added to match load growth - up to 12 NPMs for 600 MWe gross (~570 net) total output



Size Comparison

Comparison size envelope of new nuclear plants currently under construction in the United States

126 NuScale Power Modules

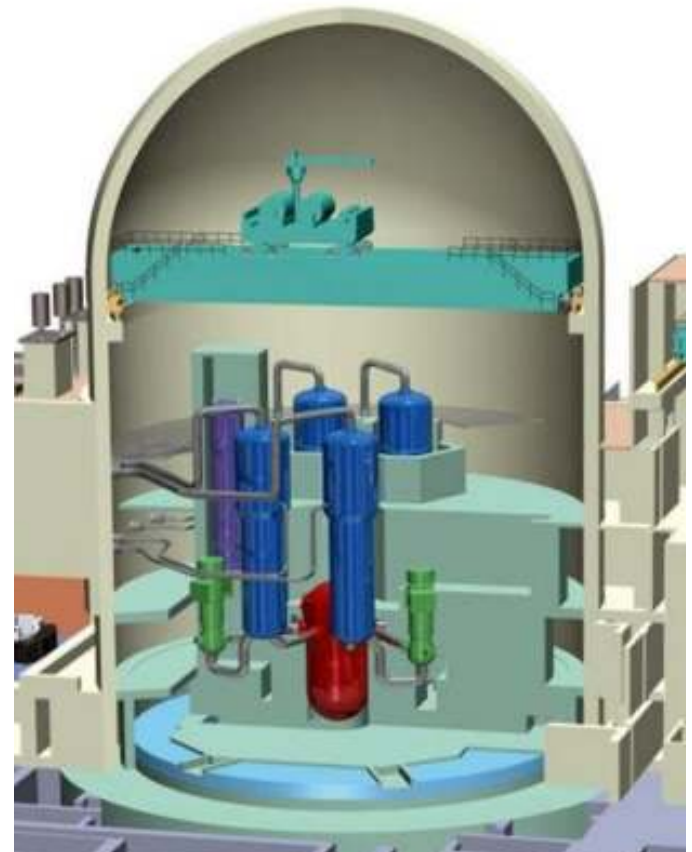


Containment

NuScale's combined containment vessel and reactor system



Typical Pressurized Water Reactor

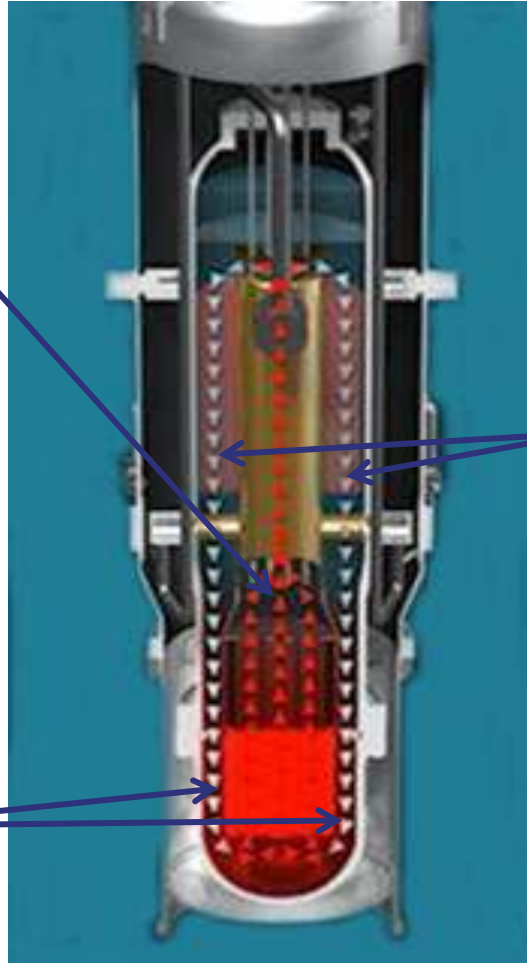


*Source: NRC

Coolant Flow Driven By Physics

Convection – energy from the nuclear reaction heats the primary reactor coolant causing it to rise by convection and natural buoyancy through the riser, much like a chimney effect

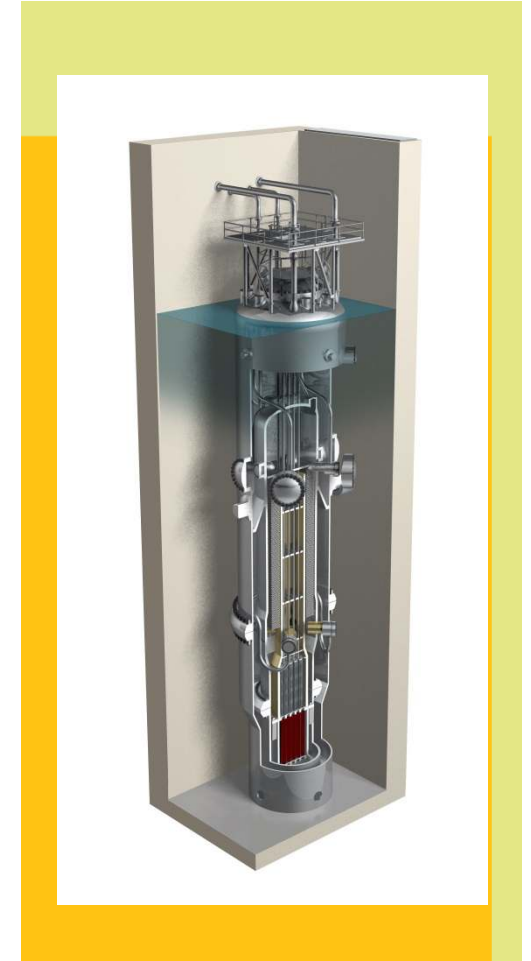
Gravity – colder (denser) primary coolant “falls” to bottom of reactor pressure vessel, cycle continues



Conduction – heat is transferred through the walls of the tubes in the steam generator, heating the water (secondary coolant) inside them to turn it to steam. Primary water cools.

NuScale Announces Major Safety Breakthrough *Wall Street Journal* April 16, 2013

- NuScale design has achieved the “Triple Crown” for nuclear plant safety. The plant can safely shut-down and self-cool, indefinitely, with:
 - **No Operator Action**
 - **No AC or DC Power**
 - **No Additional Water**
- Safety valves align in their safest configuration on loss of all plant power.
- Details of the Alternate System Fail-safe concept were presented to the NRC in December 2012.



Other New North American Designs

- GEH ESBWR
- Holtec SMR – 160 Mwe natural circulation LWR
- Westinghouse SMR – 225 MWe AP600/AP1000 derivative
- GE PRISM – 310 MWe sodium cooled fast reactor
- Terrapower – liquid metal cooled breeder. Sometimes described as traveling wave reactor. 1000 MWe class machine
- Transatomic Power – molten salt fluid fueled reactor designed to use reusable discharged fuel from LWR (1.8% enrichment) Leslie Dewan, a young lady with a recent PhD from MIT is CEO
- Flibe – Liquid Fluoride Thorium Reactor - LFTR
- Terrestrial Energy (CA)– modest tech molten salt using uranium fuel
- ThorCon – modest tech molten salt with ship-like modular construction

Who do I work for?



Jan, James, Caitlyn, Annabelle and Rod

Questions?