TRANSFORMING HOW WE ENERGIZE THE WORLD

generalfusion

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General Fusion Vancouver Canada, Washington D.C., London UK

General Fusion (GF), founded 2002 by Dr. Michel Laberge, is a privately funded ($225M+) company formed to develop and commercialize fusion energy.

- CEO–Christofer Mowry, CTO–Michael Delage, 85+-direct employees, multiple industrial partners, along with multiple more commercial and academic collaborators.
- Magnetized Target Fusion (MTF) concept from U.S. Navy (NRL) LINUS liquid metal liner experiments circa 1972, 200+ GF Patents.
- Focus: building a practical, commercially viable, accelerated path to fusion energy.

Fusion - The Future of Energy!

The transformative technology that will enable practical decarbonization of the global energy industry, enable electrification of the transportation industry, and help deliver a sustainable future for all society.

Fossil Fuels

55,000 barrels of oil

and 23,500 tons of CO_2

Fusion Energy

… can be replaced by

1 liter of fusion fuel …

(distilled from water)

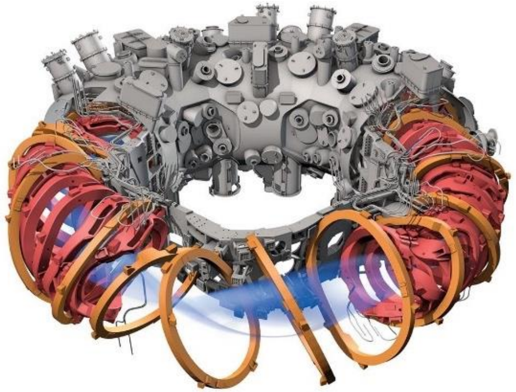
Electricity

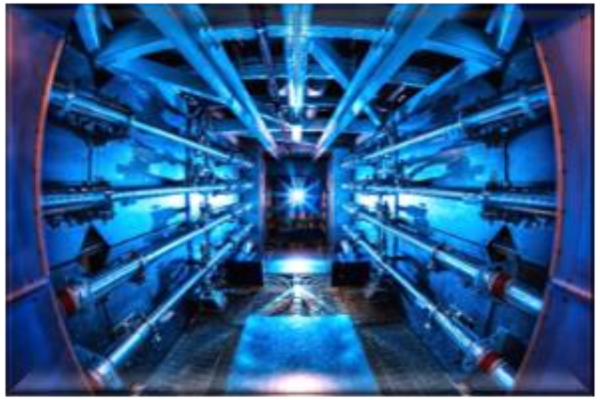
powering **10,000 homes** for 1 year

100,000 Megawatt-hours

Commercialization of Fusion Energy is Accelerating….

Progress in Plasma Physics and Fusion Sciences





- Plasma physics knowledge
- Advanced simulation codes (U.S. DOE Exascale Project)
- Experimental confirmation of fusion theory
- Expanding Fusion Community and Collaborations

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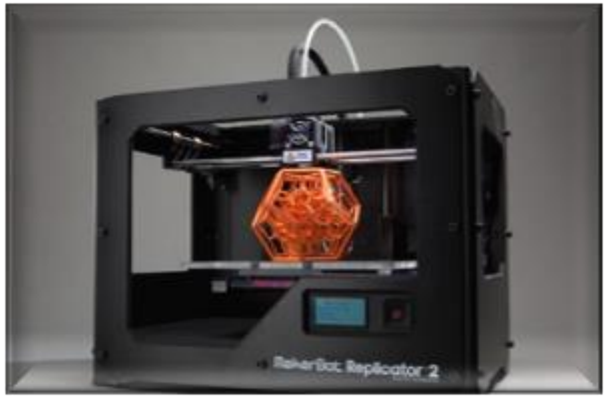
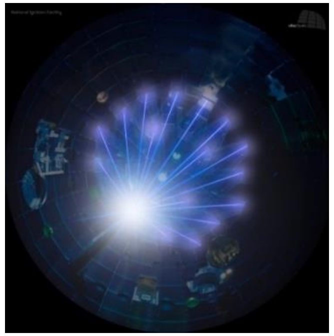
Enabling Technologies Maturing



- Advanced manufacturing (3D printing)
- Computational power and big data analytics
- High speed digital control systems
- High temperature superconducting magnets

Fusion: A Spectrum of Technology Pathways

generalfusion®



Magnetic Confinement Fusion	Magnetized Target Fusion (MTF)	Inertial Confinement Fusion
All Confinement	Balanced	All Compression

Magnetic Confinement Fusion

- Very large, low density
- Continuous Plasma Control
- **"Break Even" System:** >$1B (ITER)
- Massive, expensive SC magnets
- Materials and stability issues

Magnetized Target Fusion (MTF)

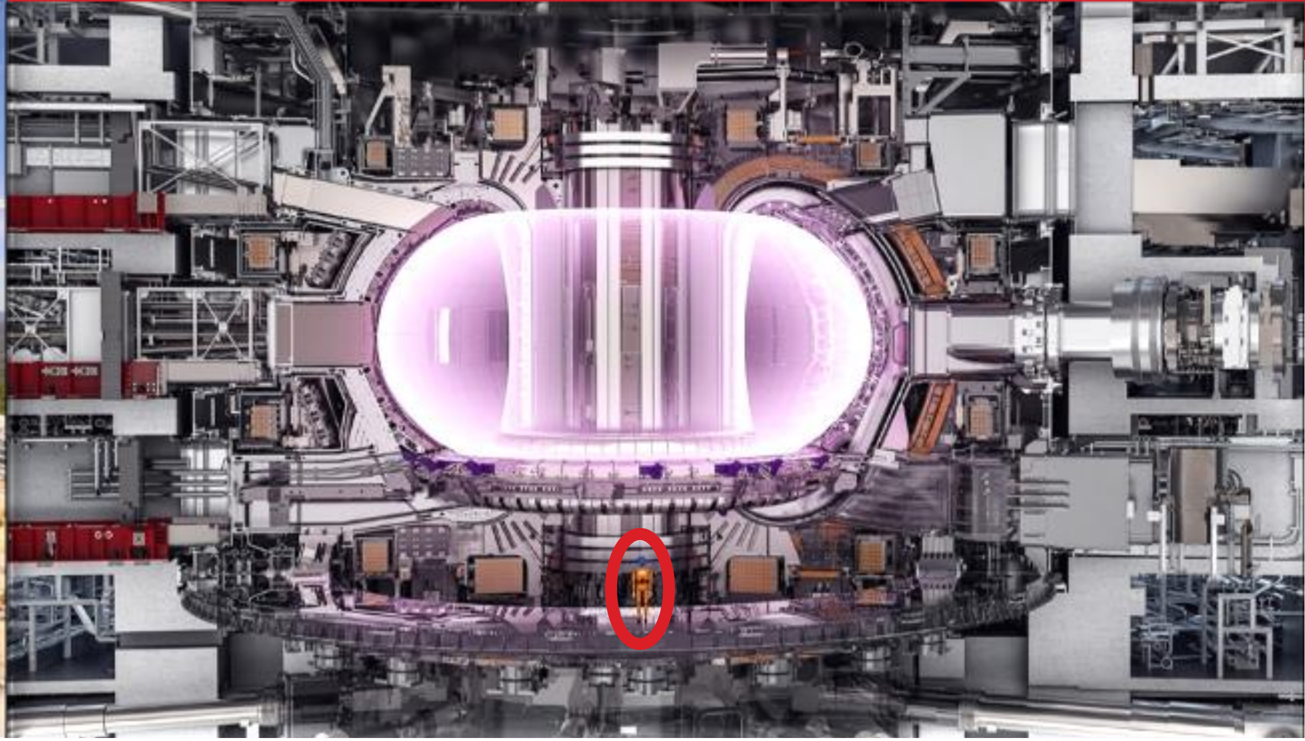
- Medium density
- Slow pulses
- **"Break Even" System:** <$1B
- No large SC magnets or lasers
- Few materials and control issues

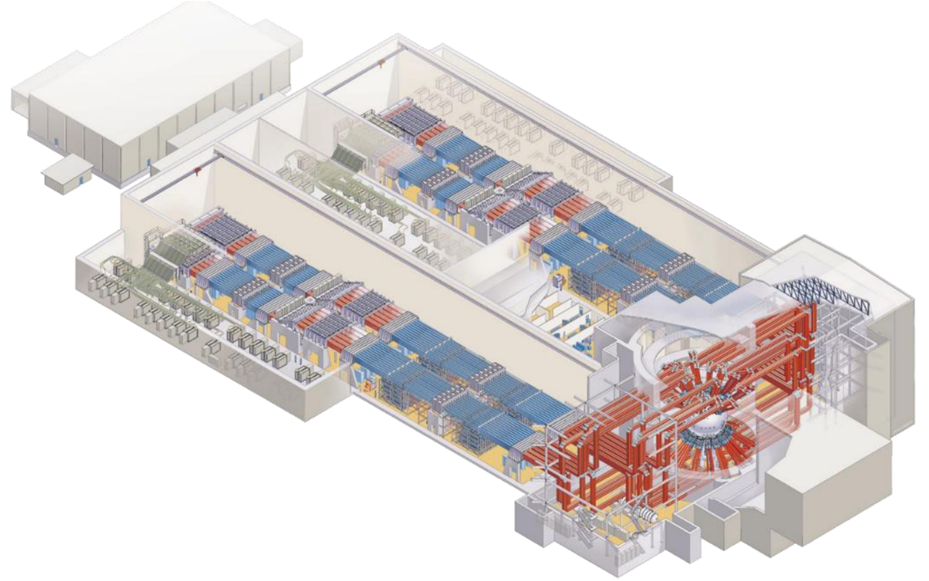
Inertial Confinement Fusion

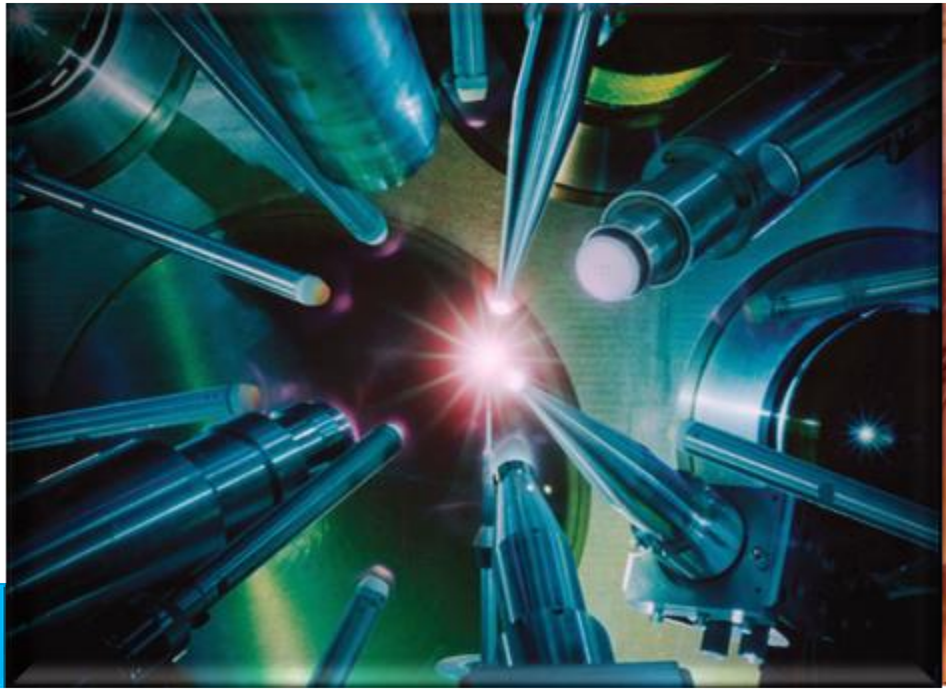
- Very high density
- Super fast pulses
- **"Break Even" System:** >$1B (NIF)
- Expensive high-power lasers
- Efficiency and control issues

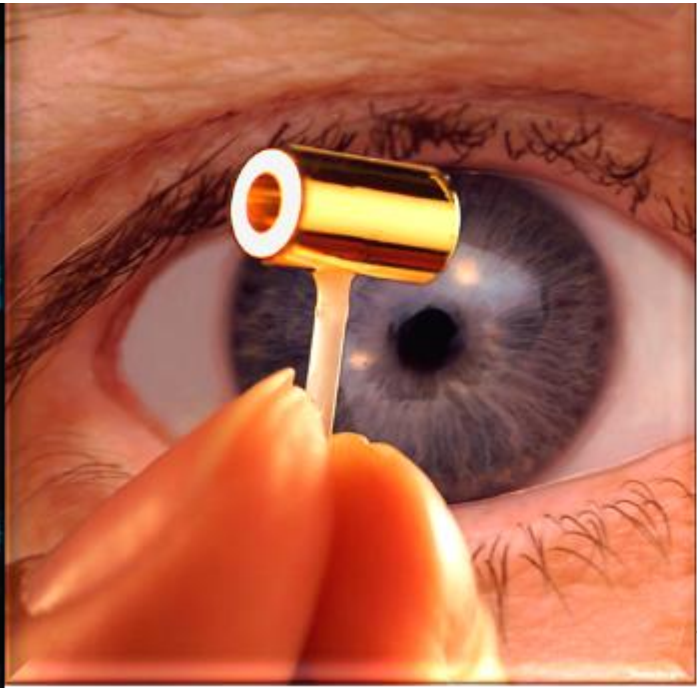
General Fusion technology … optimal hybrid of magnetic confinement and inertial compression

ITER (Magnetic Confinement)





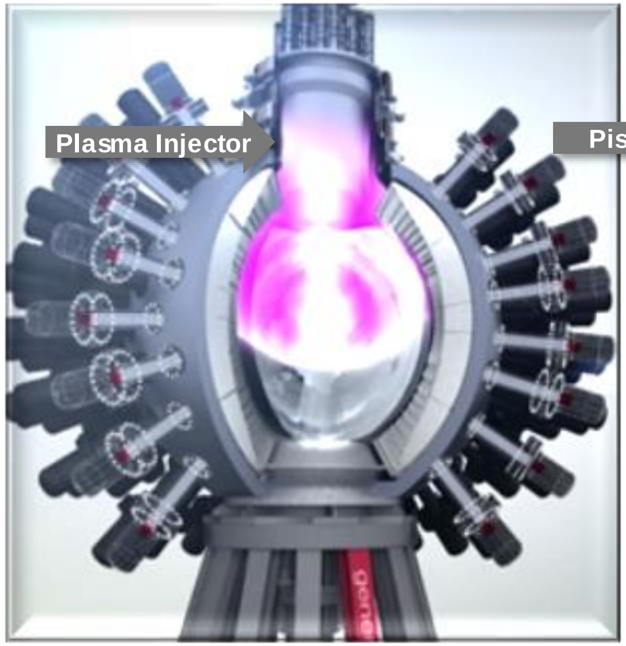




National Ignition Facility (Inertial Confinement)

MTF Machine Configuration – How it Works

Plasma Formation & Injection

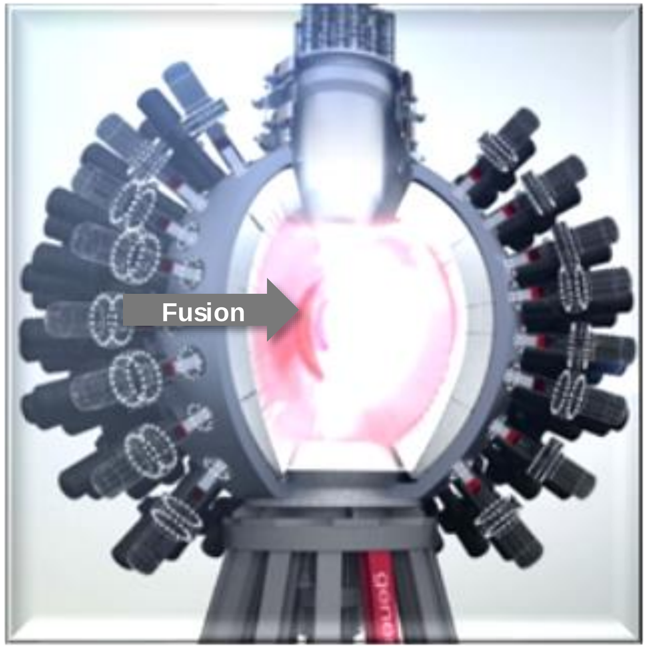


- A hot magnetized plasma at 5 million degrees Celsius is formed by a plasma injector and inserted into an approximately three meter diameter compression chamber cavity inside the fusion vessel

Plasma Compression

- The inner chamber cavity is formed by a rotating liquid metal, which is quickly pushed inwards by a phased array of several hundred precisely synchronized pistons to symmetrically compress the plasma by factor of 1,000 in volume in several milliseconds

Fusion



- Confined within the collapsing metal cavity, the plasma is compressed and heated to over 100 million degrees Celsius, creating fusion conditions
- Fusion energy is released and subsequently absorbed into the surrounding liquid metal, heating it to about 300 degrees Celsius

Phased Development and Commercialization Program for MTF

2003 - 2008	2009 - Present	Fusion Demonstration Plant (FDP)	Power Plant
Early Experiments	Science and Technology Development	Integrated Large Scale Prototype	Commercial Scale System

Early Experiments

Concept Exploration
Compression Neutrons

Science and Technology Development

System Development
- Proof-of-Concept
- Prototype Representative

Plasma Compression Science
- Plasma Stability
- Compression Heating

Integrated Large Scale Prototype

Integrated System Solution
Fusion Relevant Temperatures
Repeatability

Commercial Scale System

Repetition Rate
Closed Fuel Cycle
High Reliability & Availability

COMPANY CONFIDENTIAL

PLASMA INJECTOR

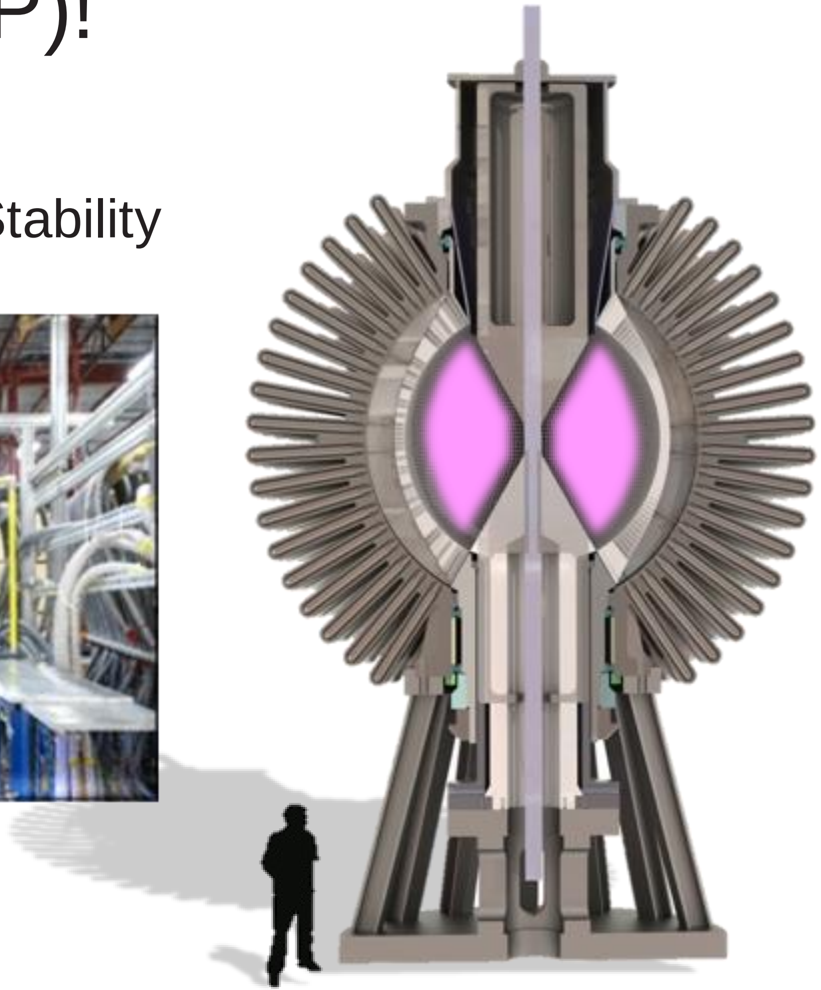
COMPRESSION SYSTEM

Core Technologies are in Place, Time to Build an integrated Fusion Demonstration Plant (FDP)!

Plasma Injector System

Compression System

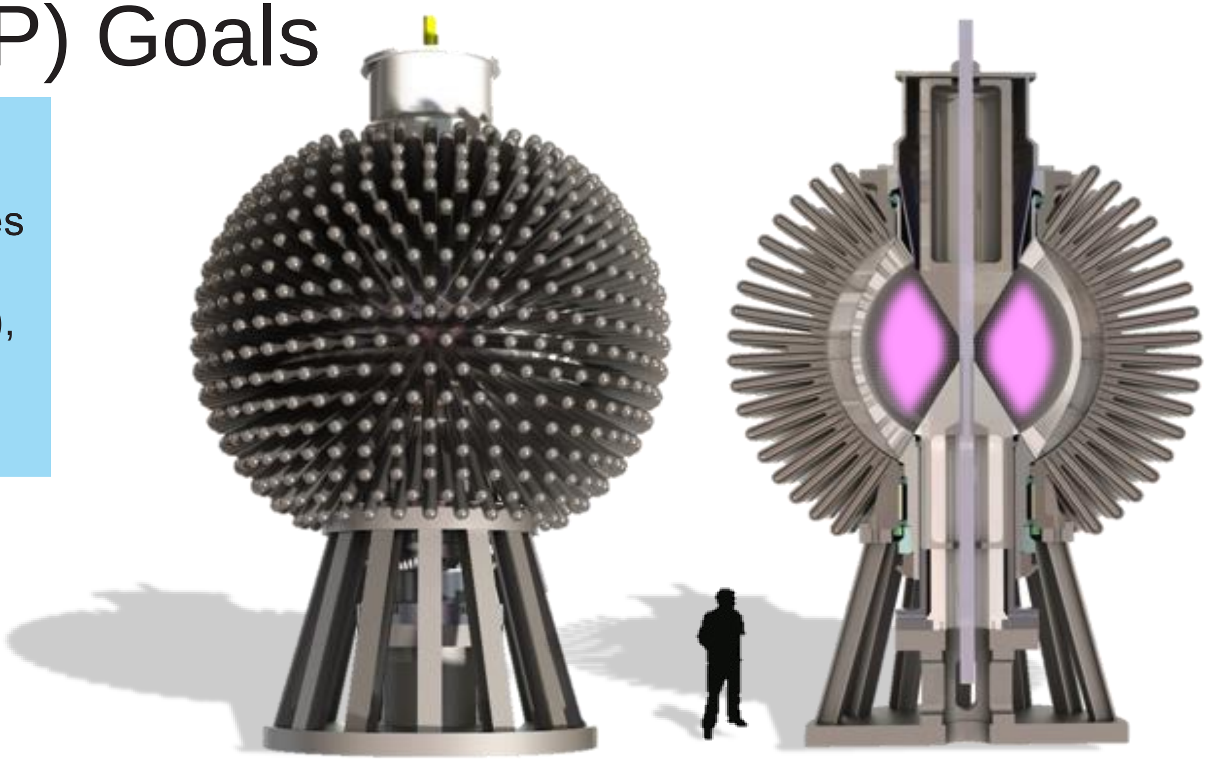
Fusion Process Stability



Backed by years of R&D progress, core technologies are in place, constructed, and tested at large scale

Fusion Demonstration Plant (FDP) Goals

1. Demonstrate, at relevant-scale, that fusion conditions can be practically achieved using General Fusion's MTF technologies
2. Refine commercial power plant economics (ONC and LCOE), based on actual performance



- FDP integrates all of General Fusion's core technologies
- Deuterium only fueled operation enables achievement of engineering and science objectives in a low risk and cost-efficient manner
- Strategic partners mitigate engineering, manufacturing, construction risks

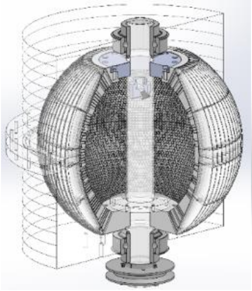
Supported by a Highly Engaged Network of Partners

Relationships lever new enabling technologies, prepare for commercial deployment, and access additional technical resources

Additive Manufacturing and Specialized Equipment

GE Additive

SHEFFIELD FORGEMASTERS INTERNATIONAL



Big Data, AI, and High-Speed Computing

Microsoft

Scientific Collaboration

PPPL
PRINCETON PLASMA PHYSICS LABORATORY

McGill

Queen Mary
University of London

Engineering

HATCH

BWXT
BWXT Canada Ltd.

Fusion Demonstration Plant (FDP) Design and Site Selection Status

- EPC (Hatch Engineering) and Architect (AL_A) have joined the GF Team with investment
- Multi-party integrated designs are underway:
  - Fusion Island Engineering and Design– GF
  - Balance of Plant Eng. and Design– Hatch
  - Facility Building Design– AL_A
- Multiple “Key Component” manufacturer, industrial partnerships are in negotiations:
  - Compression vessel and rotor
  - Compression driver pistons, etc.
- General Building / Facility Specification Developed
- 3 primary sites under consideration- **Regulation certainty is a key selection criteria!**
- Designs progressing from concepts, to industry codes and standards designs
- Approximately 2 years till “construction ready”
- Approximately 4 years till commissioning and start of operations

Key Design Partners working together on the Fusion Demonstration Plant enabling near-term deployment

Fusion Regulation Basis *"Fusion Very Different Than Fission!"*

- Fission – heavy elements, self-sustained reaction, must be driven to stop criticality & safe shutdown
- Fusion – light elements, requires driven reaction (can not self-sustain) and will always auto-stop
- No SNM, or Source Material, utilized or created with Fusion, just uses By-Product material tritium
- With Fusion, no criticality or melt down accidents possible, no reactor emergency decay heat removal, or associated back-up emergency generators required
- No off-site emergency planning required, and no off-site dose to the public with Fusion facilities
- Fusion facilities will have benign nuclear safety risks, more comparable to industrial facilities, their safety and environmental profiles allow close-proximity siting to population centers, requires minimal real estate footprint, no external fuel infrastructure required
- Fusion will not produce long-lived, highly radioactive wastes or require spent fuel storage
- Fusion has minimal fuel usage (liters per year), and no associated front-end Nfuel type manufacturing
- Fusion facilities will not contribute to nuclear non-proliferation risks, nuclear security not required
- Fusion Energy is Safe, Carbon Free, Low Risk, Abundant Fuel, No HLW, Base Load and Dispatchable, Economical, Predictable, Long Term Clean Electricity Generation for all the World!

Risk Based Regulations and Permitting is Required

Existing Regulations and Industry Practices Suffice:

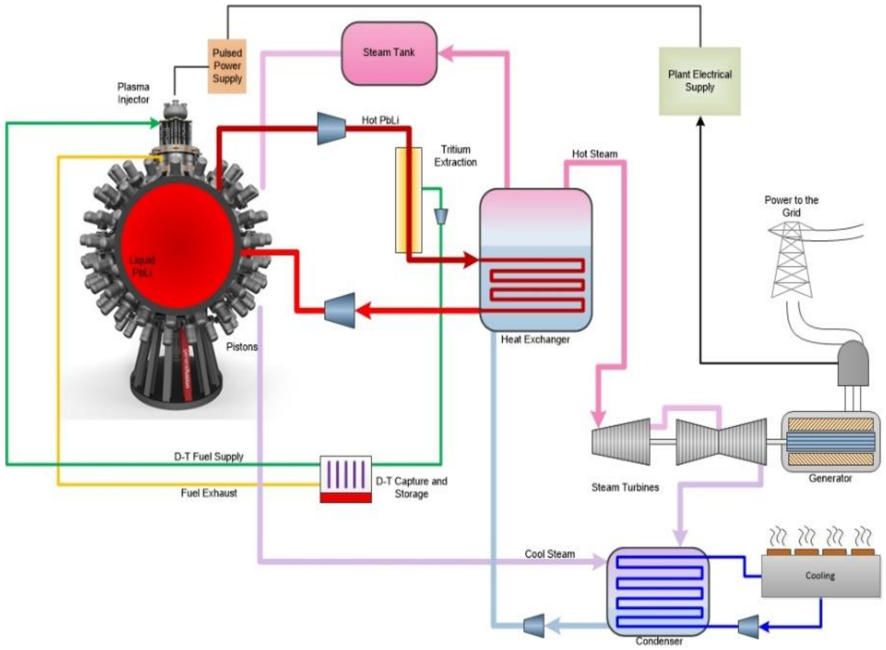
- Byproduct Material (tritium): 10 CFR Part 30, with commercial industry tritium handling practices
- NRC Agreement States Guidelines for state permitting and regulations (like current hydrocarbon power plants and non-NRC regulated radiation generating facilities)
- Radiation protection programs (work force) 10 CFR Part 20, or NCRP Report 144 and OSHA, for non-NRC regulated radiation generating facilities (i.e. particle accelerators), and DOE programs for DOE sites
- Low level waste handling, packaging and shipping utilizing existing commercial practices
- NUREG 1748 Environmental Reviews
- Many alternative fusion approaches and technologies being explored, regulatory flexibility based on a specific technology's risks is required- "One Size Will Not Fit All!"

Fusion Energy Should Not Be Regulated In The Same Manner as Nuclear Fission,or Linked In Anyway!

Regulation Considerations - FDP and Commercial Power Plant (“CPP”)

Tritium Management of Low Volumes

- FDP: Total possible tritium produced over FDP lifetime[1] — < 1 mg (9 Ci)
- CPP: Total inventory of tritium[2] — ~2 g (1.9 x 10^4 Ci)
- CPP: Tritium self-contained throughput — 76 g per day
- Total inventories in both FDP and CPP — <10^{15} Bq (2.7 x 10^4 Ci)
- Total tritium inventory of ITER[3] — 4 kg (3.9 x 10^7 Ci)
- i.e. Bruce Pwr. (A,B,NPP) 2015 Emissions — ~37.5 g (liquid/steam)



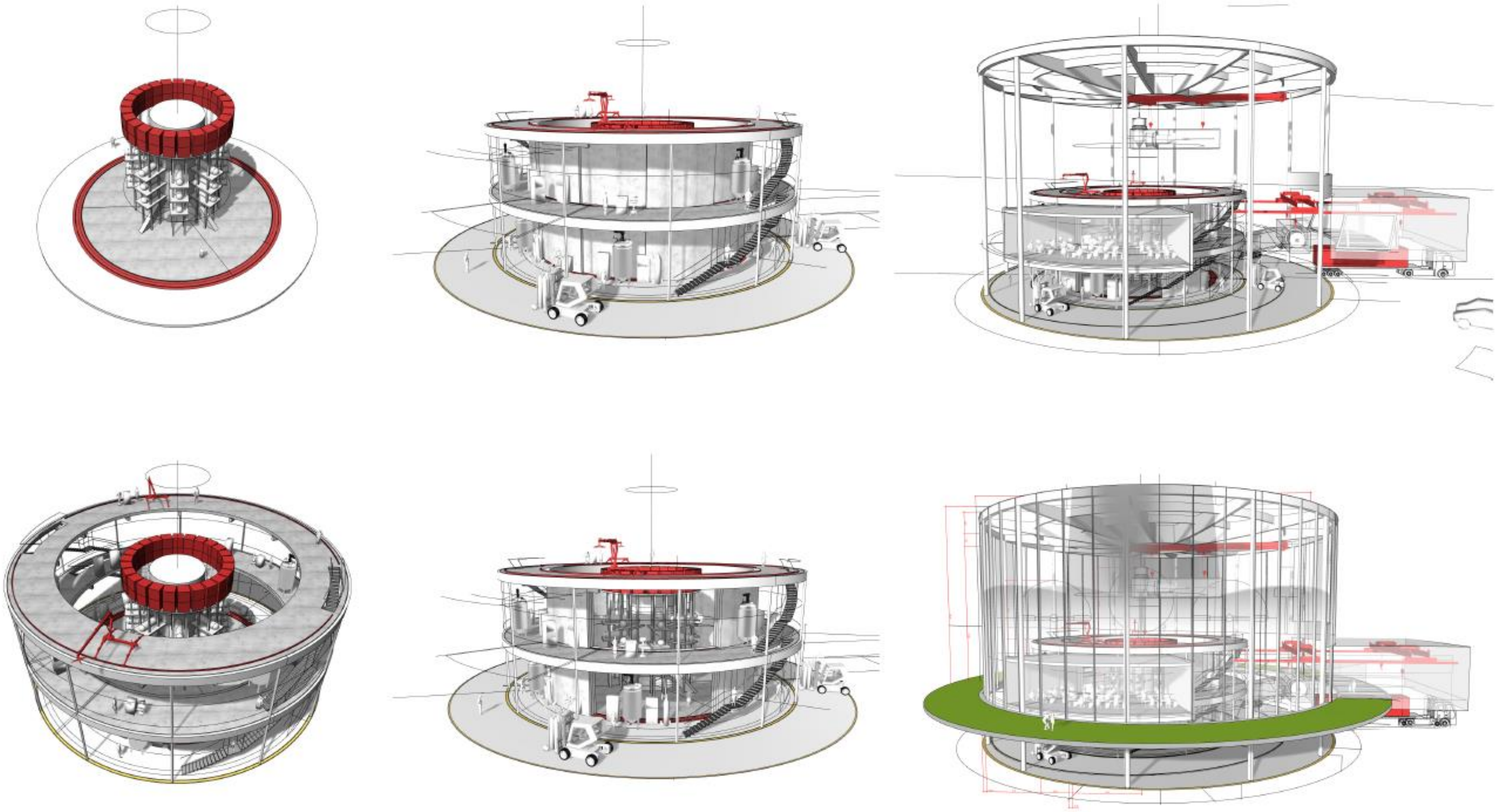
Mature commercial tritium handling practices exist. In CPP real time tritium monitoring and control will be utilized in the plant and related ventilation systems to detect parasitic losses during normal operation- any planned emissions would be minimal

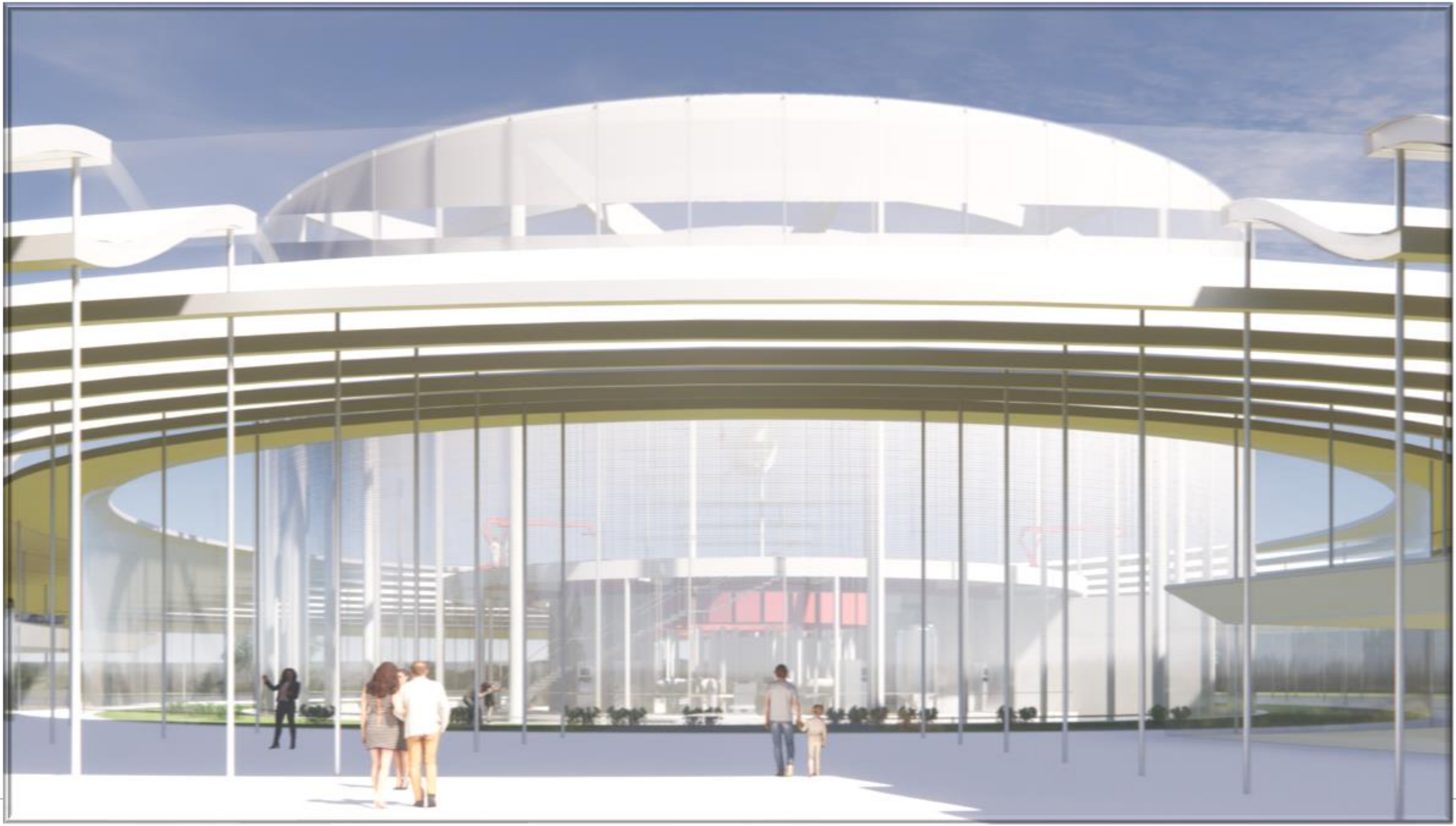
1) High bound estimate on maximum yield for 1,000 shots.
2) Not including excess tritium stored in getter beds.
3) http://www.iter.org/faq#What_will_be_the_total_amount_of_tritium_stored_on_site_What_are_the_procedures_foreseen_to_confine_and_control_the_stock_

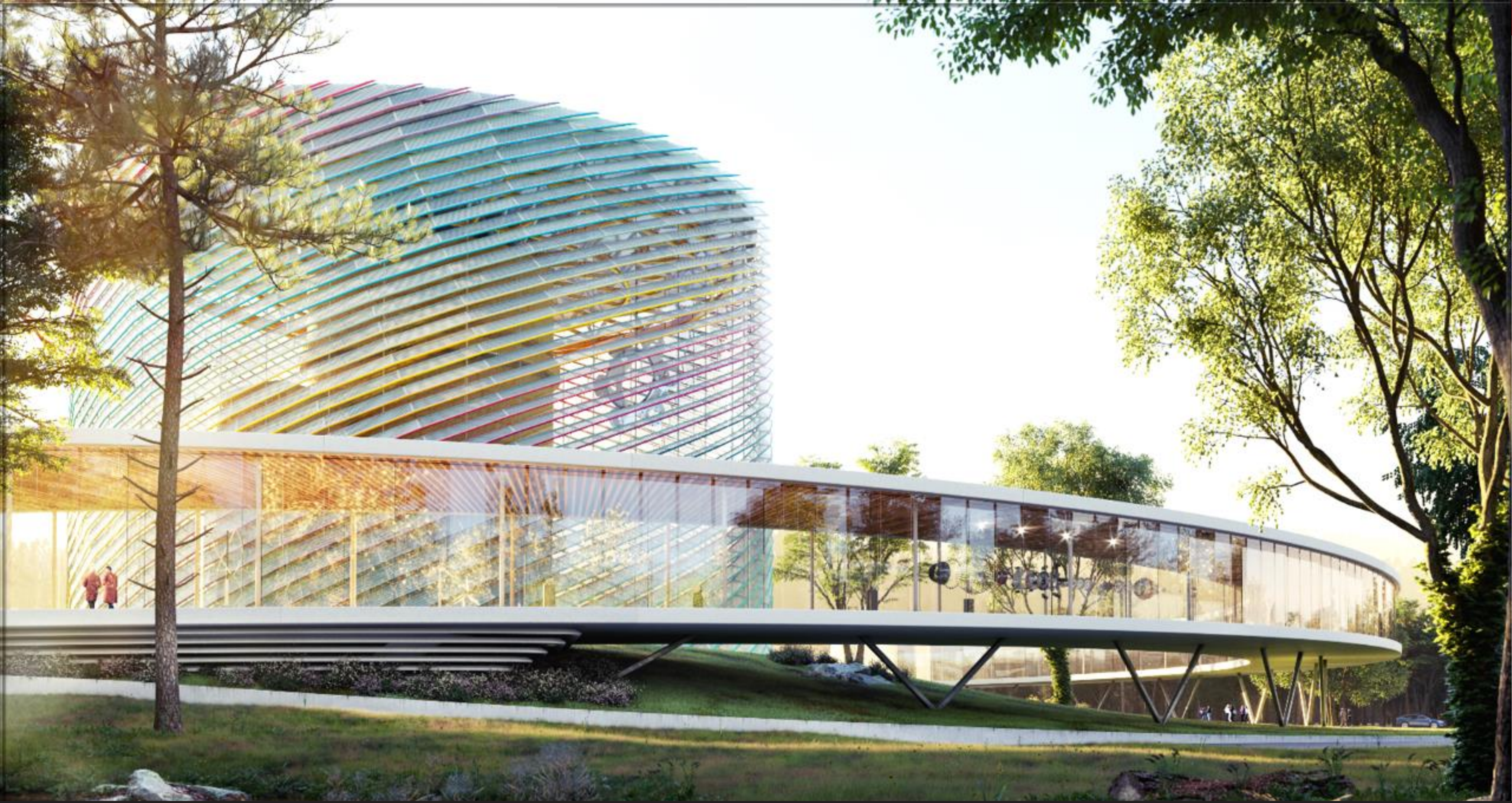
Regulations Considerations - FDP and Commercial Power Plant ("CPP")

Prompt and Secondary Exposures

- All particle energies are below 50 MeV
- Neutron pulse surrounded in 4π by liquid metal – 1.5 m radius lithium in FDP, 2.2 m radius lead lithium in CPP
- For FDP, no significant activation of Fusion Island components
- For CPP, Fusion Island components will experience some activation
- An appropriate radiation protection program will be utilized for both facilities







A transformative clean energy technology - A transformative value creation opportunity

CLEAN ENERGY. EVERYWHERE. FOREVER.

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Neutron Yields

System	Fuel	Starting Plasma Diameter	Starting Plasma Density	Neutrons per pulse	Operating Frequency
PCS (Plasma Pulse Verification Program)	Deuterium	0.4 m	1e14 cm^{-3}	1e10	~ 1 /yr
Fusion Demonstration Plant (FDP)	Deuterium	3 m	2e13 cm^{-3}	1e13	~1 /day
Commercial Power Plant (CPP)	Deuterium – Tritium	4.4 m	2e14 cm^{-3}	2e20	~1 /s

The Thermo Scientific P 385 produces 3×10^8 n/s.

Running for 8 hours it will produce 9×10^{12} neutrons in a day

CNSC Class II License Criteria Considerations for FDP

Particle energy < 50 MeV

Nuclear material < 10^{15} Bq

Neutron generator facility at Simon Fraser University (SFU) is an example of a Class II facility. It uses a commercial deuterium-tritium neutron generator (Thermo Scientific P 385) to produce 14.2 MeV neutrons at a nominal rate of 3 x 10^8 neutrons/s