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Taking You To New Territories

From Scientific Breakeven to Commercial Breakeven and then to Deployment

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Fusion 2030: Roadmap for Canada
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FUSION 2030
ROADMAP FOR CANADA
Alberta/Canada
Fusion Technology Alliance
UNIVERSITY OF ALBERTA
UNIVERSITY OF SASKATCHEWAN
Fedoruk Centre
generalfusion
KINECTRICS
Review of the Canadian Nuclear Safety Commission's Regulatory Framework for Readiness to Regulate Fusion Technologies:
Task #5: Final Overview Report
K-640209/RP/004 R01
March 2022
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Kinectrics
MZConsulting
REPORT
ASSESSMENT OF PRIVATE FUSION DEVELOPMENT COMPANIES
SCOPE OF WORK #2:
ASSESSMENT OF FUSION DEVELOPMENT COMPANIES
DR R.NEIL ALEXANDER & MR MILT CAPLAN
JUNE 25, 2020

Milestone definitions

There are a number of key milestones on the route to commercial fusion including;

Fusion Conditions: getting to a high enough temperature density and time to allow fusion to take place but without using fusion fuels

Fusion: Creating fusion conditions and then introducing fusion fuels so that a fusion reaction takes place.

Breakeven (sometimes referred to as scientific breakeven) where the raw energy produced by the fusion reaction exceeds the energy injected into the reaction. This has a Q (the ratio of energy out to energy) of 1.

Engineering Breakeven: Where the fusion reaction produces enough energy to sustain itself through combining the self heating and the electricity produced from the reaction when it is reinjected through the heating systems. Sometimes known as electrical breakeven.

Commercial or Economic Breakeven: Where the electricity produced, after the reinjection needed to sustain the reaction, can be sold to create enough income to pay for operation of the reactor (note it is unclear whether this includes a return on investment in the capital or just the operating costs).

Ignition: Where the reaction produces enough residual energy, after losses that cannot go back into the reaction, to sustain the reaction. Effectively an infinite Q.

Energy Break Evens

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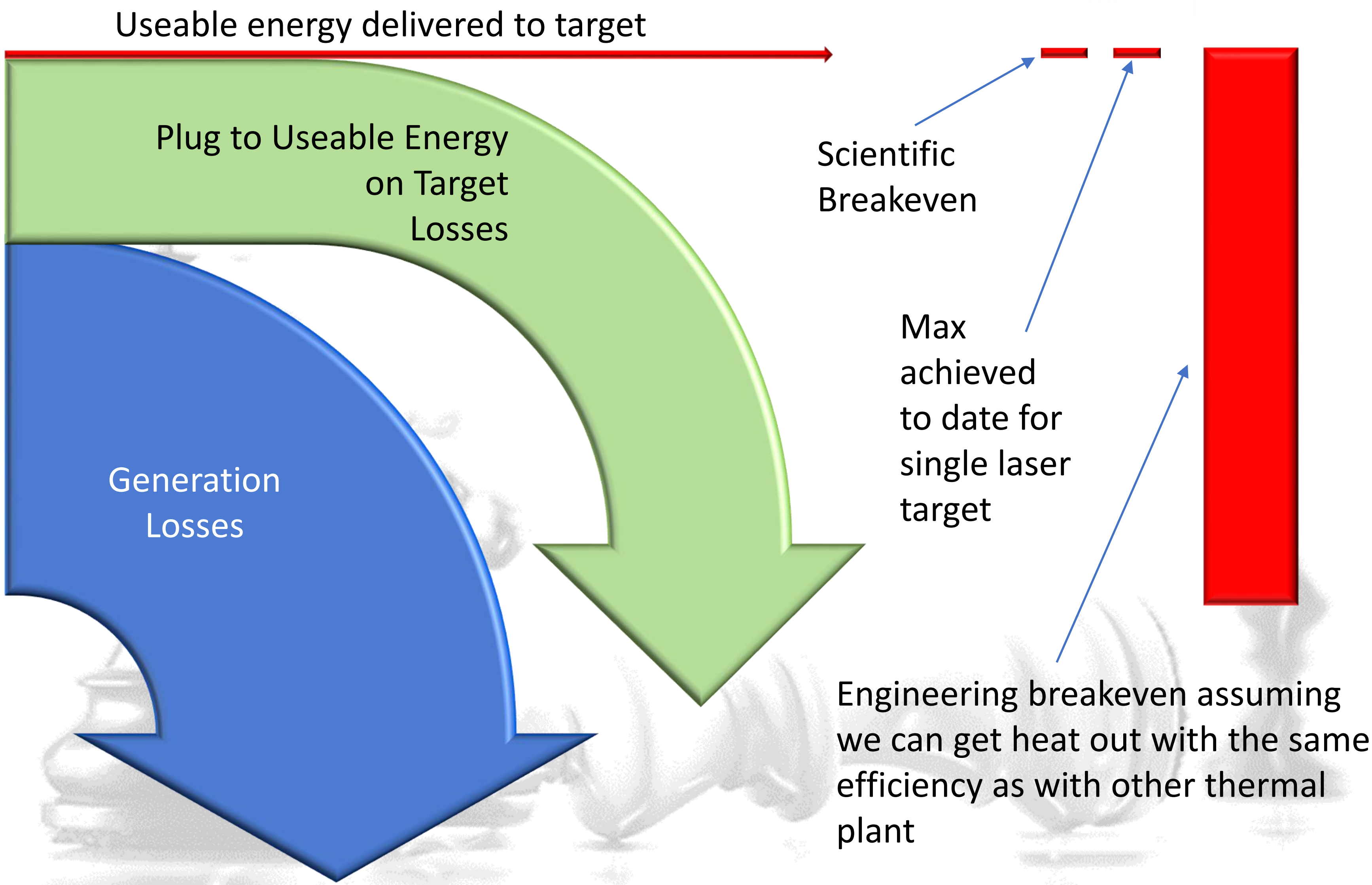

Recent National Ignition Facility Announcement

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Laser Fusion Gain Milestones

1. Fuel Gain
Fusion energy yield = Energy delivered to the fuel

2. Capsule Gain*
Fusion energy yield = Energy delivered to the fuel capsule

3. Target Gain*
Fusion energy yield = Energy delivered to the hohlraum target

4a. Overall Device Gain (Not Normalized to Electric)
Fusion energy yield = Electrical energy consumed by the device

4b. Overall Device Gain (Normalized to Electric)
Electrical equivalent of fusion yield = Electrical energy consumed by device

* In direct drive ICF, capsule gain and target gain are the same because direct drive doesn't use a hohlraum.

SBK20220129

BUSINESS

A blast into a clean energy future? Scientists tout nuclear fusion breakthrough

Fusion Experiment Reaches Vital Power Generation Milestone

By Ryan Whitwam on December 8, 2021 at 12:22 pm | Comments

RESEARCH NEWS

Ignition First in a Fusion Reaction

November 30, 2021 • *Physics* 14, 168

In August, a fusion reaction at the National Ignition Facility yielded a record 1.3 MJ in fusion energy, releasing, for the first time, more energy than the fuel capsule absorbed.

Recent National Ignition Facility Announcement

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Laser Fusion Gain Milestones

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National Ignition Facility Aug. 8, 2021, Record-Setting Laser Fusion Experiment

For Each Type of Gain, Breakeven Is Achieved at 100 Percent

1. Fuel Gain

Fusion energy yield of 1.3 MJ vs. energy delivered to the fuel: 0.02 MJ

Achieved 6,500 percent of breakeven

2. Capsule Gain

Fusion energy yield of 1.3 MJ vs. energy delivered to the fuel capsule: 0.23 MJ

Achieved 565 percent of breakeven

3. Target Gain (Technically Known as Scientific Breakeven)

Fusion energy yield of 1.3 MJ vs. energy delivered to the hohlraum target: 1.9 MJ

Achieved 68 percent of breakeven

4a. Overall Device (Technically Known as Engineering Breakeven) (Thermal to Electric)

Fusion energy yield of 1.3 MJ vs. electrical energy consumed by the device: 400 MJ

Achieved 0.3 percent of breakeven

4b. Overall Device (Technically Known as Engineering Breakeven) (Normalized to Electric)

Electric equivalent of 1.3 MJ fusion yield vs. electricity consumed by device: 400 MJ

Achieved 0.1 percent of breakeven

Steven B Krivitz….New Energy Times SBK20220129

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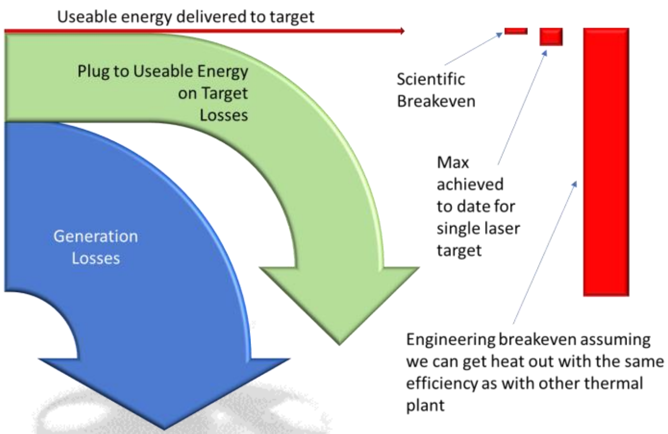
And now for something completely different:

Commercial Breakeven



Commercial Breakeven

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And now for something completely different:

Commercial Breakeven

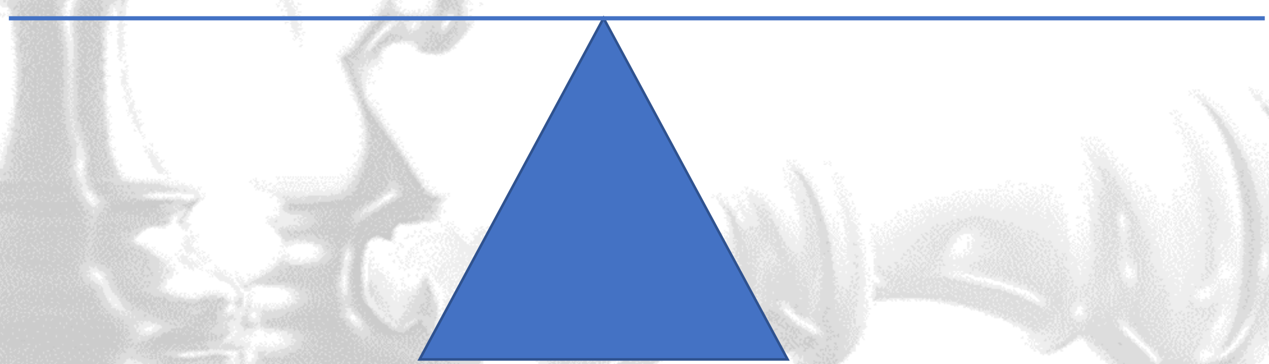
Costs

Operating costs
(staff, consumables,
maintenance etc)

Repayment of
Capital

Income

Sale of power



Some other novel issues that need to be resolved before a commercial plant is possible ………..

- The fuel cycle – producing, recovering purifying, storing and re-injecting fuels like Tritium
- The fuel cycle –availability of stable isotopes
- Materials – corrosion resistance, radiation damage resistance, hydrogen resistance etc
- Energy conversion for aneutronic technologies

Conclusions

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Fusion when developed will have the potential to deliver “clean” energy wherever it is wanted whenever it is wanted providing energy wealth and security with minimal environmental impact.

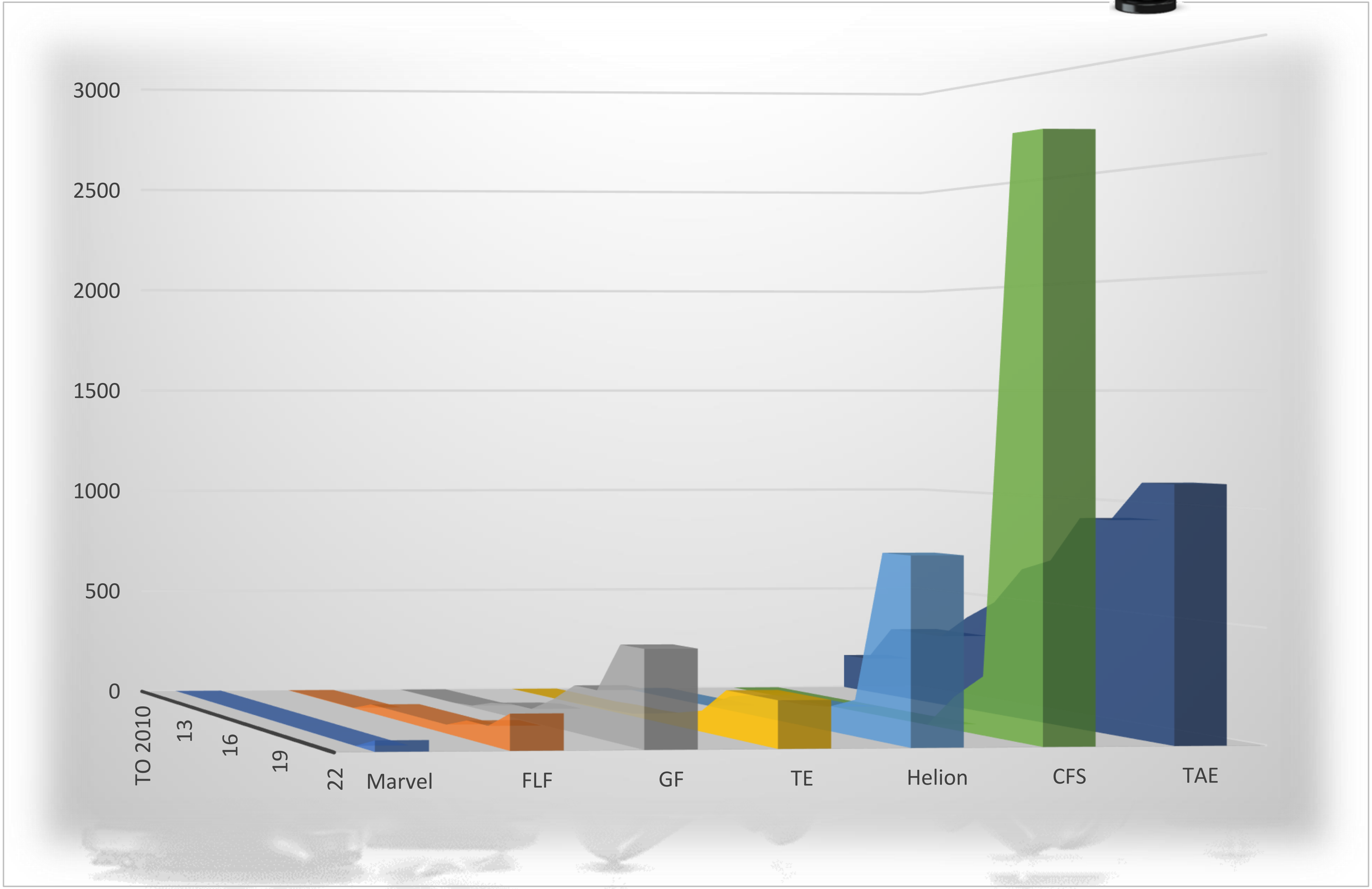
The public enthusiasm for Fusion combined with a lesser need for regulatory oversight could lead to the sort of rapid build out that the fission industry could not contemplate.

But

While showing the production of energy is a wonderful hurdle to overcome it is only the first hurdle in what could be a grueling race. We would be well advised to inform people of this in order that they are not disappointed and lose faith in this exciting concept.

Economics is just one of the challenges…there are others…like Tritium production and handling

Commercial Investments in Fusion



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