Livermore Valley California's Fusion Energy Facilities

By John Benson

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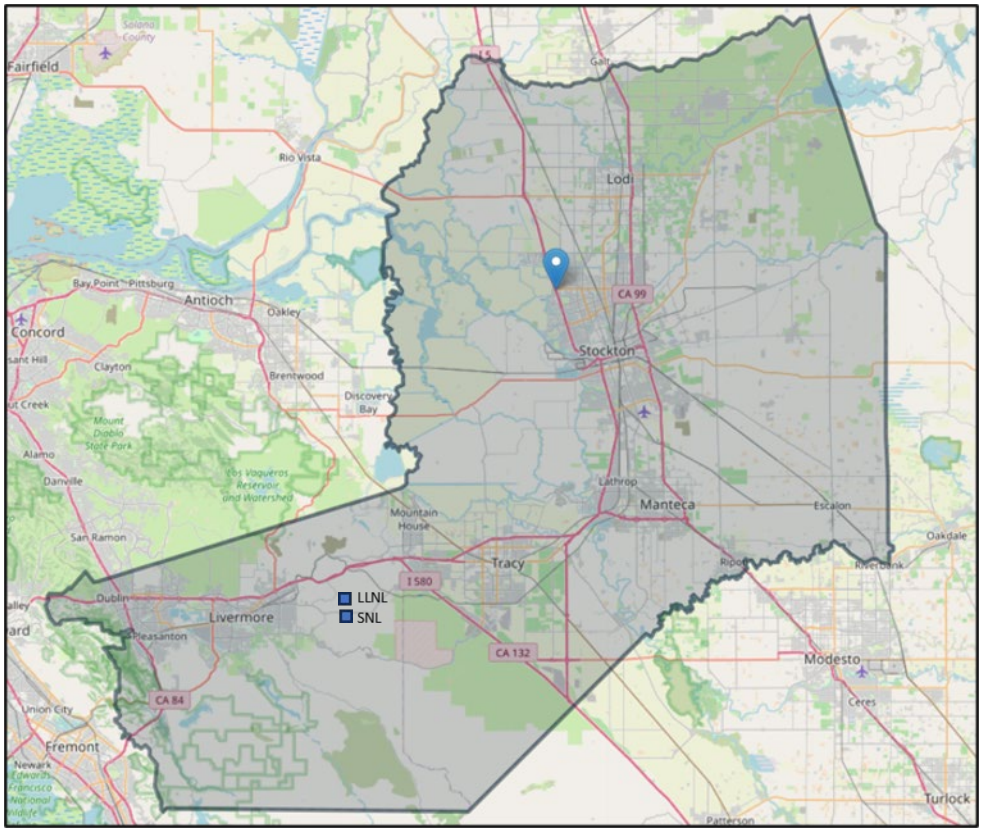
1. Introduction

I was researching a (somewhat) different subject. (the future of nuclear fission reactors in California), and managed to cross over to a different subject (above). If any readers read my posts frequently, they know I live in Livermore, CA.

Senate Bill 925, authored by Sen. Jerry McNerney, D-Livermore & Central Valleys, requires the state to formulate a plan to develop nuclear fusion energy development facilities. The report detailing the plan is due to the Legislature by Dec. 31, 2029, according to a legislative analysis of the bill.[1]

Author's comment: Sen McNerney Represents Senate District 5, which includes Lawrence Livermore National Lab (LLNL), and Scandia National Lab, Livermore Campus (SNL), across the street from LLNL). See the map below, the shaded area is California Senate District 5.

2. Livermore Valley CA's Fusion Energy Facilities



[1] https://legiscan.com/CA/text/SB925/id/3448441 -

Both LLNL and SNL are leading the development of Fusion Technologies.

That bill / plan would need to include strategies for expanding and developing fusion research in the state, developing commercialization of fusion energy, creating a regulatory framework for fusion energy, permitting and licensing, and assessing the levels of fusion energy needed for California to meet its long-term renewable energy and greenhouse emissions goals.

"I've always been a big promoter of fusion energy because it has so many benefits," Sen. McNerney told The Center Square on Friday. "The drawbacks, the waste and the risk of accidents is so low that it's an ideal source. Of course, we have to develop the technology for that to happen."

That means producing strong enough magnets to be able to hold the fusion together, producing materials to absorb neutrons and not be damaged and produce vast amounts of energy in a short time frame, McNerney said.

Author's comment: There are two emerging fusion technologies: magnetic-confinement fusion and inertial-confinement fusion. For a recent post regarding these designs, see the paper linked below from May of this year.

Fusion Energy – A Reasonable Starting Point? I track electricity generation facilities of all types, but mainly focus on what I call renewables. My definition of this category includes all types of nuclear generators, including fission and fusion. The last type is just now starting to emerge, so my posts are not frequent.

https://www.energycentral.com/nuclear/post/fusion-energy---a-reasonable-starting-point-UwiMx3OYScKvraD

"All this is infrastructure." McNerney said. "We need to develop that infrastructure here so we can produce this technology. That means jobs; it means economic growth for the state of California."

In fission, atoms are split to create two new atoms, which are frequently short-lived isotopes, and produce radioactivity when they continue to decay to other isotopes in periods ranging from seconds (for less stable isotopes) to millennia (for more stable isotopes). The radioactive effect is what can make fission nuclear energy so dangerous, as noted by critics of nuclear energy development.

"Fusion has inherent benefits that fission does not," Haakon Williams, the CEO of The Committee to Bridge the Gap, told The Center Square on Friday. "One of the core problems with fission-based nuclear technologies is that the fission reaction is self-sustaining, and without a constant, never-ceasing ability to cool the fuel, you have the self-sustaining fission reaction that leads to excessive heat and melting down of the fuel, and a release of radioactivity. With fusion, you don't have those problems."

Committee to Bridge the Gap is a non-profit nuclear policy organization focusing on safety, waste disposal, proliferation, disarmament, & environmental protection.[2]

[2] https://committeetobridgethegap.org/about-u/

If something happens that disrupts the fusion process, like an earthquake or terrorist attack, the fusion just stops on its own, Williams said.

"The problem with fusion is that fusion energy is 30 years away and always will be," Williams said. "The technology is not mature enough for commercial deployment. My understanding of it is that fusion is closer than ever to being viable, but the main developments you see on fusion in recent years amount to an incremental increase in the amount of time you are able to sustain the fusion."

The California Energy Commission, which will oversee the report to the Legislature under the new law, will have to hire multiple new staff members to complete the work, the bill analysis says. The state will spend roughly $1.1 million of taxpayer funds to hire five new staff members of the commission and an additional $500,000 in contract work. Nine additional staff members will be hired to form a new unit that would work on permitting for fusion energy projects, costing the commission $2 million annually.

Another bill Newsom signed into law this week, Assembly Bill 2647, authored by Assemblymember Lisa Calderon, D-Whittier, tasks the California Energy Commission with assessing the role of nuclear energy development in powering the state's critical infrastructure and determining if new nuclear energy plants could help power the state's increase in electricity demand in the coming years. The bill also aimed to meet the state's 100% zero-carbon electricity production goals by 2045, according to the bill analysis.

3. LLNL's Fusion Energy Science (FES) Research:

Magnetic fusion energy (MFE) experimental research conducted through collaborations on the General Atomics DIII-D tokamak experiment and on Princeton Plasma Physics Laboratory (PPPL) National Spherical Torus Experiment Upgrade (NSTX-U) spherical tokamak experiment.

Author's comment: *As of February 12, 2025, the longest demonstrated magnetic-confinement fusion plasma duration in a tokamak is just over 22 minutes (1,337 seconds), achieved by France's WEST tokamak at CEA Cadarache.*

Most (if not all) inertial-confinement technologies use pulsed technologies, with each pulse lasting under a second. For a more thorough explanation of these technologies, see the post from June of this year summarized and linked below.

Fusion Energy gets Prioritized: *A commercial power plant based on nuclear fusion is decades in the future. The path to that future is through a forest of many alternative designs. The two major groves in this forest are magnetic confinement fusion (as in the DIII-D tokamak, the largest operating tokamak in North America) and inertial confinement fusion (as in my hometown's Lawrence Livermore National Lab's National Ignition Facility.)*

Inertial and magnetic confinement technologies have NOT produced any operating power plants, but simply experiments, and additional experiments and prototypes may lead to power plants. Also, there are other experiments that might (long-shot) lead to operating power plants. This paper is about one of the off-mainstream fusion experiments.

https://www.energycentral.com/nuclear/post/fusion-energy-gets-prioritized-EI41cSSlwWpkpD3

Fusion and plasma theory and modeling in support of the DIII-D and NSTX-U collaborations, as well as international MFE facilities in Asia and Europe.

Fusion materials and technology research in support of fusion nuclear science.

High-energy-density laboratory plasma (HEDLP) research that explores fundamental plasma science questions in densities and temperatures relevant to HED science.

Computational physics under FES is an important application and development space for quantum information systems machine learning AI exascale computing.

3.1. LLNL's Fusion Energy Program

Lawrence Livermore National Lab's (LLNL's) fusion program combines advanced scientific research, experimental facilities, and public–private partnerships to advance both inertial and magnetic fusion energy toward commercial viability.

LLNL's Fusion Energy Sciences (FES) research program focuses on establishing the scientific basis of fusion energy—through fusion theory and modeling by LLNL scientists, and in partnership with experimental teams at major U.S.-based magnetic fusion facilities. In addition, LLNL is home to an inertial fusion energy (IFE) research center funded by the Department of Energy (DOE), along with initiatives aimed at developing fusion-relevant materials and technology—efforts that leverage LLNL's expertise in high-energy-density plasma physics

Our FES research program contributes to the Office of Science's focus on basic science by deepening researchers' understanding of matter at very high temperatures and densities and building the knowledge needed to develop a fusion energy source.

Fusion science and plasma physics underpin much of the science driving the DOE's national security mission space. In addition to FES mission objectives, the FES program at LLNL creates important connections throughout the DOE complex to build scientific credibility, foster academic engagement, advance outreach goals, and promote workforce development.

4. Sandia National Lab's Research Areas Include:

Sandia National Laboratories conducts advanced fusion research through both magnetic confinement and inertial confinement approaches, with a strong focus on pulsed-power-driven concepts like Magnetized Liner Inertial Fusion (MagLIF) and materials science for fusion reactors.

Sandia's fusion program supports U.S. Department of Energy (DOE) Fusion Energy Sciences goals to make fusion a practical, clean, and abundant energy source. It covers:

Magnetic Confinement Fusion (MCF): Plasma-material interactions, boundary physics measurements at the DIII-D tokamak, and development of fusion reactor blanket materials and tritium fuel cycle systems

Inertial Confinement Fusion (ICF): Using the Z Pulsed Power Facility to create extreme conditions for fusion ignition.

MagLIF: A novel direct-drive ICF concept that uses magnetic fields to compress a fuel-filled liner, potentially improving energy coupling efficiency by an order of magnitude over traditional x-ray drive.

4.1.1. Key Facilities

Z Pulsed Power Facility: Produces currents up to 26 MA, magnetic fields >1000 T, and pressures >10 Mbar, enabling high-energy-density physics experiments for ICF, radiation hydrodynamics, and materials studies.

Combustion Research Facility (CRF): Applies advanced diagnostics, uncertainty quantification, and plasma physics research to fusion-relevant problems.

4.1.2. Collaboration and Funding

Sandia's fusion work is conducted in partnership with DOE, universities, and other national labs, with funding from programs like ARPA-E and DOE's Fusion Energy Sciences.

Both LLNL and SNL are leading the development of Fusion Technologies.

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"I've always been a big promoter of fusion energy because it has so many benefits," McNerney told The Center Square on Friday. "The drawbacks, the waste and the risk of accidents is so low that it's an ideal source. Of course, we have to develop the technology for that to happen."

That means producing strong enough magnets to be able to hold the fusion together, producing materials to absorb neutrons and not be damaged and produce vast amounts of energy in a short time frame, McNerney said.

"All this is infrastructure," McNerney said. "We need to develop that infrastructure here so we can produce this technology. That means jobs; it means economic growth for the state of California."

According to the U.S. Department of Energy, fusion energy occurs when two atoms are combined to produce a heavier atom. This is different from fission energy, which is the type of nuclear reaction currently used to power nuclear energy.

"Fusion has inherent benefits that fission does not," Haakon Williams, the CEO of The Committee to Bridge the Gap, told The Center Square on Friday. "One of the core problems with fission-based nuclear technologies is that the fission reaction is self-sustaining, and without a constant, never-ceasing ability to cool the fuel, you have the self-sustaining fission reaction that leads to excessive heat and melting down of the fuel, and a release of radioactivity. With fusion, you don't have those problems."

If something happens that disrupts the fusion process, like an earthquake or terrorist attack, the fusion just stops on its own, Williams said.

In the past the public perception was: "the problem with fusion is that fusion energy is 30 years away and always will be," Williams said, "the technology is not mature enough for commercial deployment. My current understanding is that fusion is closer than ever to being viable, but the main developments you see on fusion in recent years amount to an incremental increase in the amount of time you are able to sustain the fusion."

The California Energy Commission, which will oversee the report to the Legislature under the new law, will have to hire multiple new staff members to complete the work, the bill analysis says. The state will spend roughly $1.1 million of taxpayer funds to hire five new staff members of the commission and an additional $500,000 in contract work. Nine additional staff members will be hired to form a new unit that would work on permitting for fusion energy projects, costing the commission $2 million annually.

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