Public Comment for:

STATE OF CALIFORNIA – THE NATURAL RESOURCES AGENCY Arnold Schwarzenegger, Governor

**California Energy Commission**
1516 North Street
Sacramento, CA 95814
Website: www.energy.ca.gov
Consumer Website: www.ConsumerEnergyCenter.org
Children's Website: www.energyquest.ca.gov

| In the Matter of: | Docket No. 09-IEP-1M |
|---|---|
| Preparation of the *2009 Integrated Energy Policy Report (IEPR)* and Advanced Generation Program Roadmap | NOTICE OF STAFF WORKSHOP RE: Advanced Generation |



# Small Nuclear Power Plants of Advanced Design for California's Clean Energy

By
Edwin D. Sayre

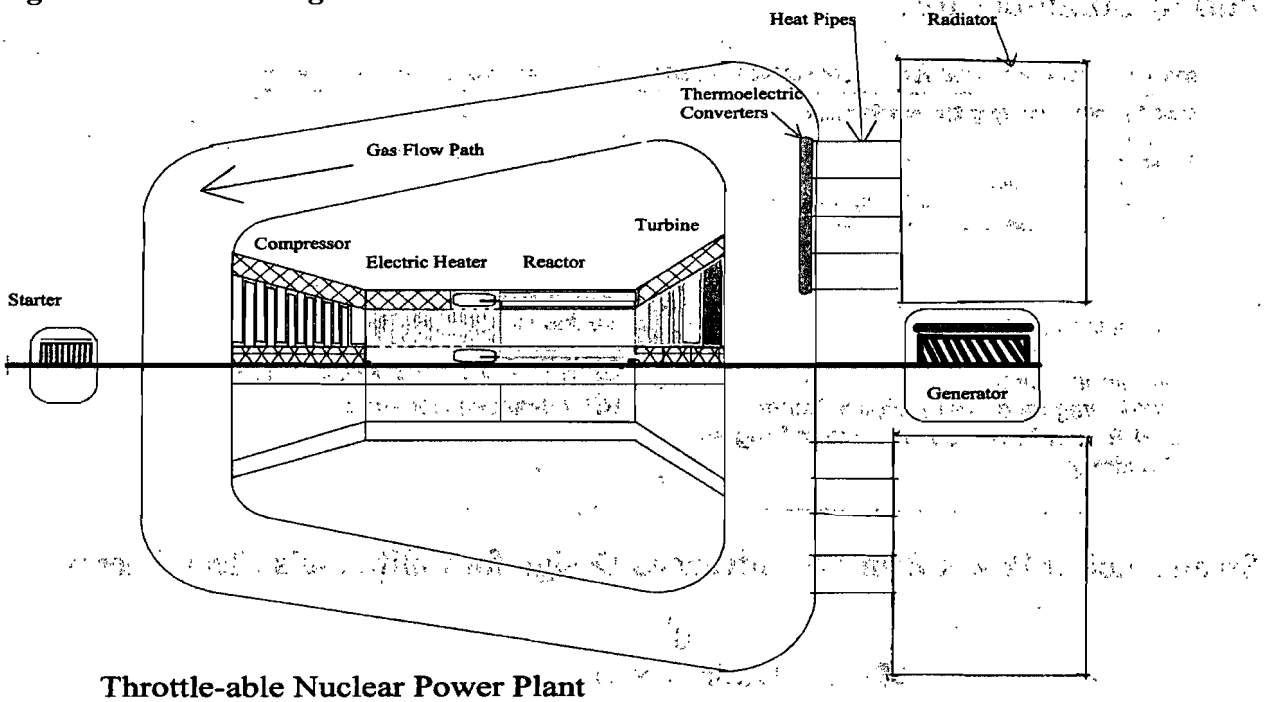
Representing ACRE, Advocates for Clean Responsible Energy

**Smaller Nuclear Power Plants, 10 to 200 MW are Ideal for California's Future**
Some nuclear power plants are under development that may have the potential for being throttle-able and still maintain efficiency and be economical. The ideal design is from 30 to 100 megawatts capacity and be able to be turned on in minutes time, pick up the load onto the grid and be turned off when not needed with solar and wind power prevailing. Some of the small nuclear power plant designs can't be turned on in a few minutes but can be collected in groups and operated in varying percentages of output to the grid. This way they can be integrated with the renewables output variations during the day. Very small nuclear plants, around 10 MW. that can operate for about 20 years without much attention are ideal for remote communities that are not accessible to the grid. Some small nuclear plant concepts are described below.

**Small Gas Cooled Throttle-able Nuclear Power Plant**
Aircraft nuclear plant programs during the 1950s had concepts that could probably fulfill these needs with the improved performance gained with advanced technology over the last 50 years. Figure 1 is a sketch of a small fast reactor nuclear power plant with closed cycle of noble gas going from the compressor through electrical heater, fast reactor and through the turbine. The electrical heater is used to start the power in a few seconds. .This system has six 10 megawatt reactors and an electrical output of a little over 23 megawatts with the additional thermoelectric converters.

**NuScale Nuclear Power Plant.**
Another possible small nuclear power plant that can fill the variable needs is the NuScale Power 40 megawatt water cooled reactor. While it will not be efficient to turn on and off in a very few minutes a group of them can be put on the grid and operated on a percentage basis to regulate the input variations from the renewables. The total plant concept and the reactor concept are shown in Figure 2.

**Figure 1. Small 23 Megawatt Gas cooled Throttle-able Nuclear Power Plant**




Throttle-able Nuclear Power Plant

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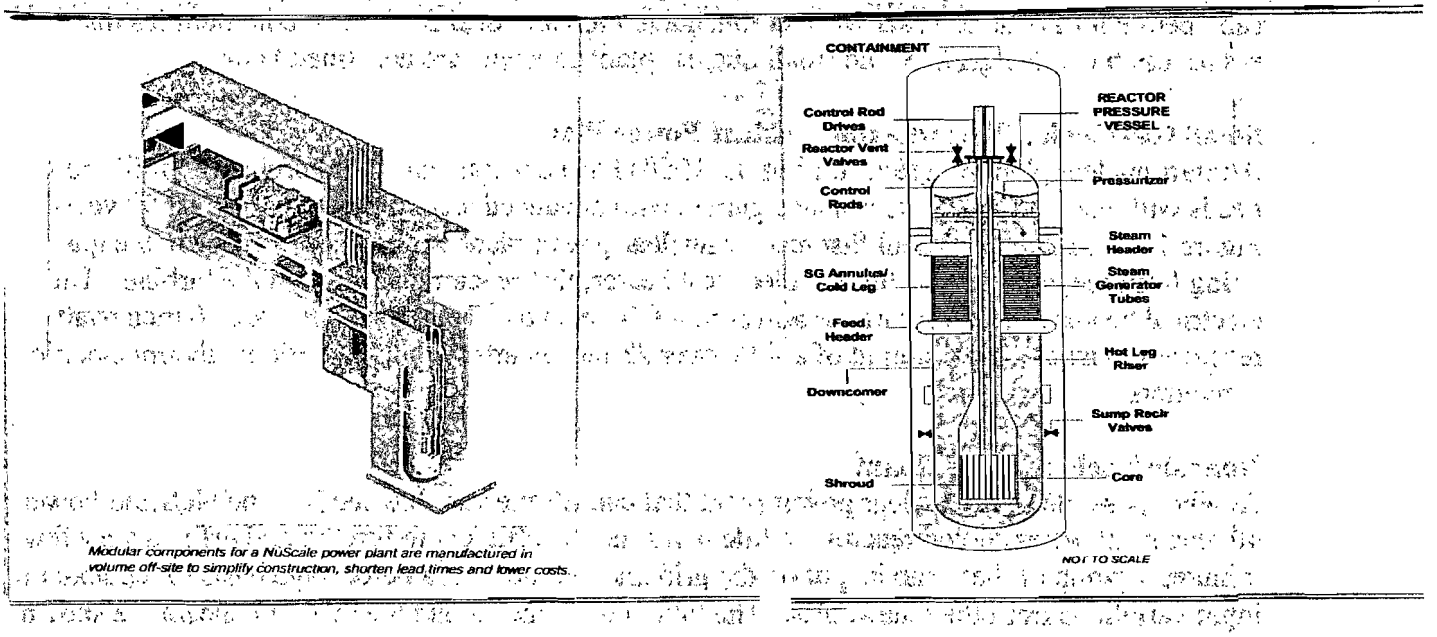
**Figure 2. NuScale 40 Megawatt Water Cooled Nuclear P**

**Plant Illustration** **Reactor Illustration**

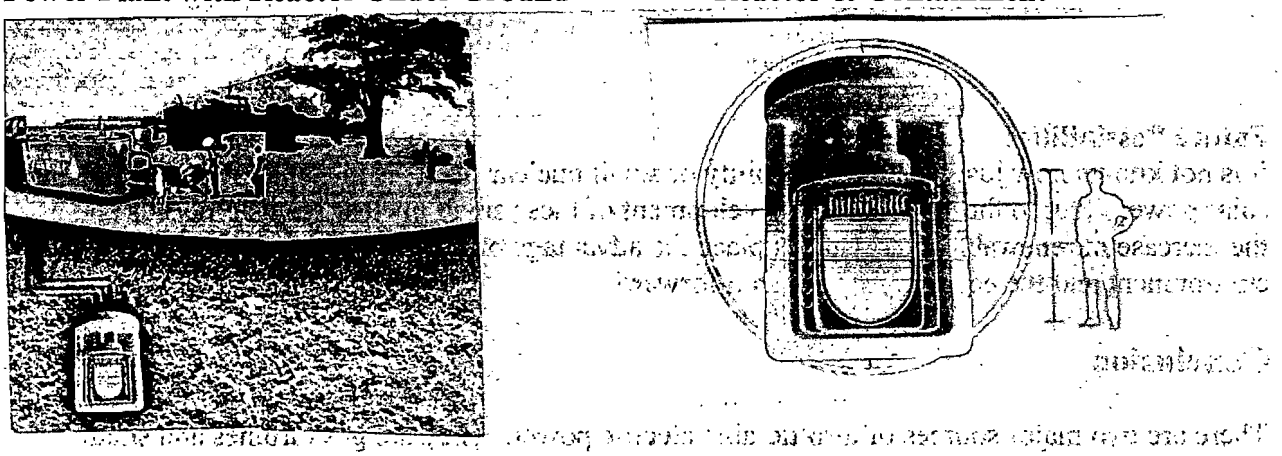


**Hyperion Nuclear Power Plant**

The Hyperion nuclear reactor is a new unique design with uranium hydride fuel. With the hydride fuel and a hydrogen atmosphere inside a hot chamber the reaction is automatically controlled and a very safe system. The heat generated is sent to a heat exchanger to provide steam for a steam turbo generator system. The fuel in the reactor has a performance age of 8 to 10 years. This makes it possible for the reactor to be placed in a chamber underground for a very safe environment. Instead of refueling on site like most nuclear reactors this reactor is replaced after it runs low on energy. This reactor may not be throttle-able in a matter of minutes like gas turbines with efficiency. It can be grouped to 5or 6 and the group output to the grid can be reduced and increased by required percentages to moderate the grid energy efficiently.

**Figure 3. Hyperion Small 40 Megawatt Power Plant with Reactor Under Ground**

**Power Plant with Reactor Under Ground** **Reactor & Containment**



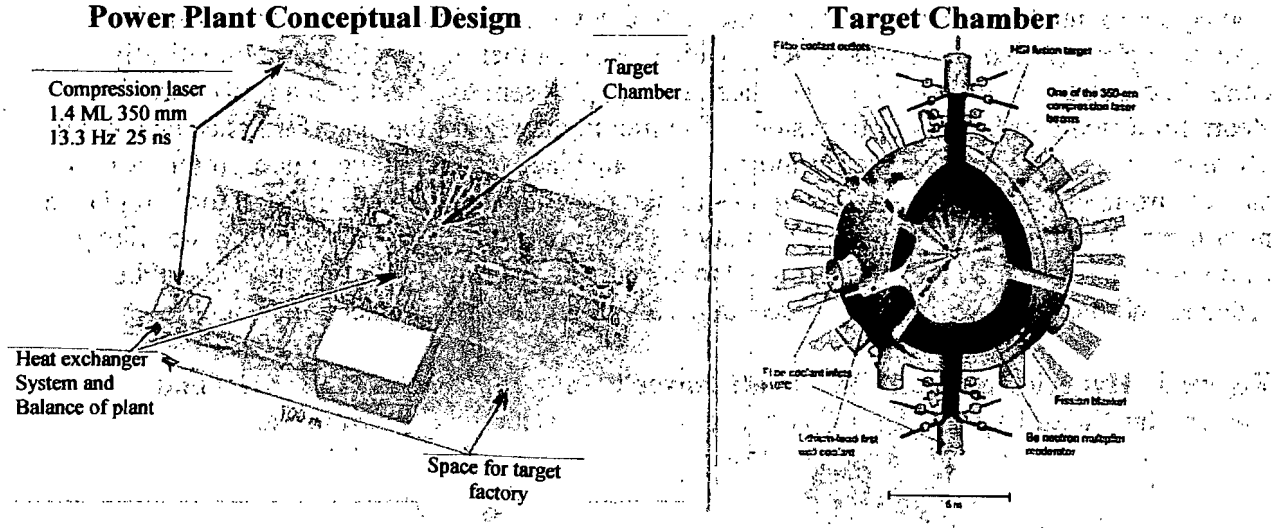
**The LIFE, Laser Initiated Fusion-Fission Energy Nuclear Power Plant**

This kind of power plant is under development by The Lawrence Livermore Laboratory and the University of Texas at Austin. The power plant concept and the fission and fusion chambers are shown in Figure 4.

This power plant will be a long time in development but it will have many advantages in the future over the regular nuclear plants that use fission only. It does have a major disadvantage in that it may use a significant percentage of its electrical output for powering the laser system to produce fusion energy. A question is whether the plant can be throttle-able. The laser generated fusion can be turned on and off quickly in a matter of seconds. The question is, can an electrical system keep the fission fuel warm enough that the energy extraction can start immediately after the fusion-fission starts.

The current plan for this plant is for it to produce 2000 to 3000 MegaWatts of fission thermal energy from 300 MegaWatts of fusion energy. A plant with 2000 Megawatts of fission thermal energy can produce about 35% of that in electrical energy which is about 700 MegaWatts
One very significant advantage of this kind pf nuclear plant is that it can use many varieties of fuel such as weapon grade uranium and plutonium, depleted uranium, used nuclear fuel, military radioactive actinide waste and thorium.

**Figure 4. The LIFE Laser Initiated Fusion-Fission Energy Nuclear Power Plant**




**Future Possibilities**

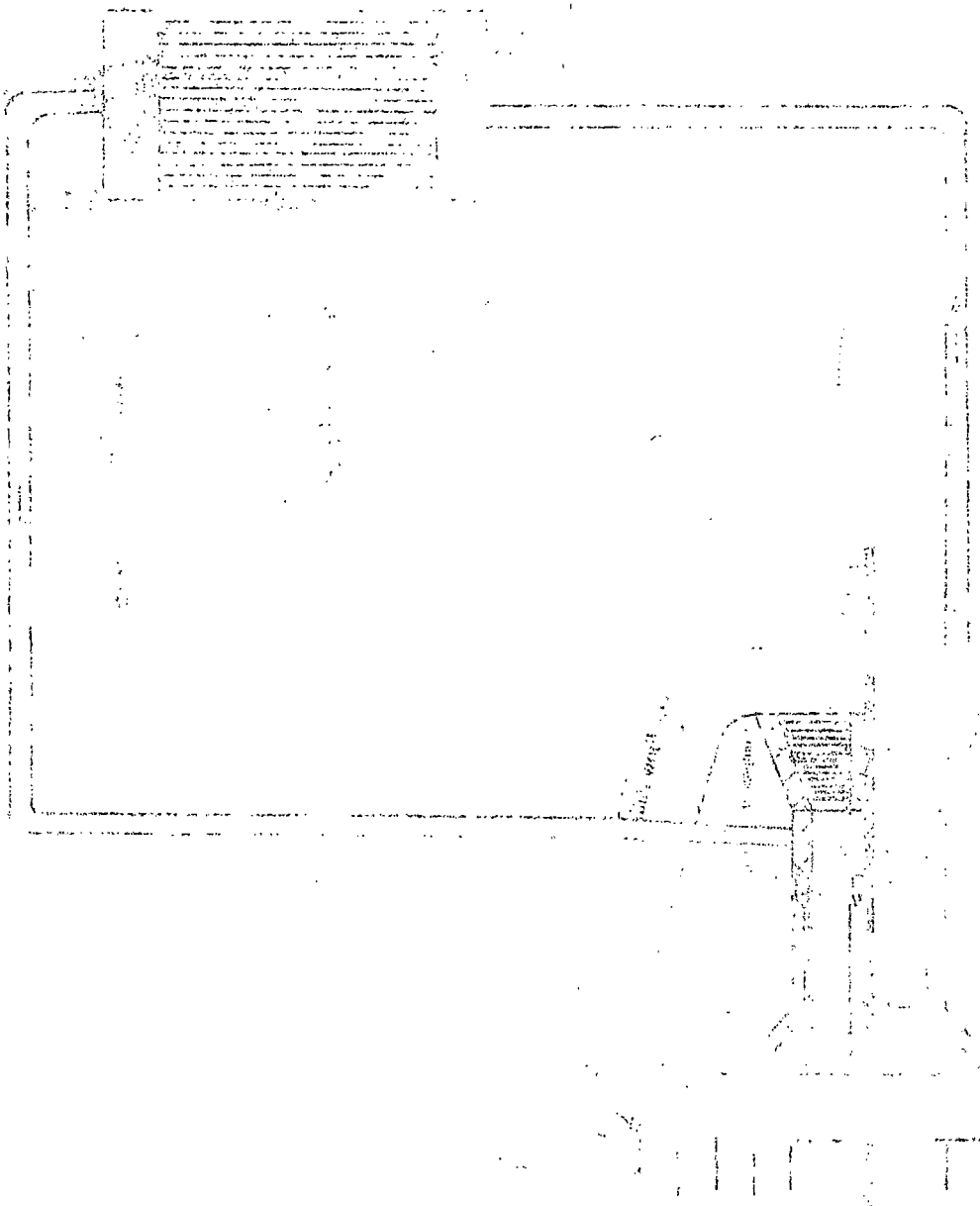
It is not known now just what the capability of small nuclear plants is in stabilizing the wind and solar power input to the grid. As the development of these small nuclear plants proceeds and as the increase in renewable energy takes place the advantage of the nuclear power for the environment and the economy will push it forward.

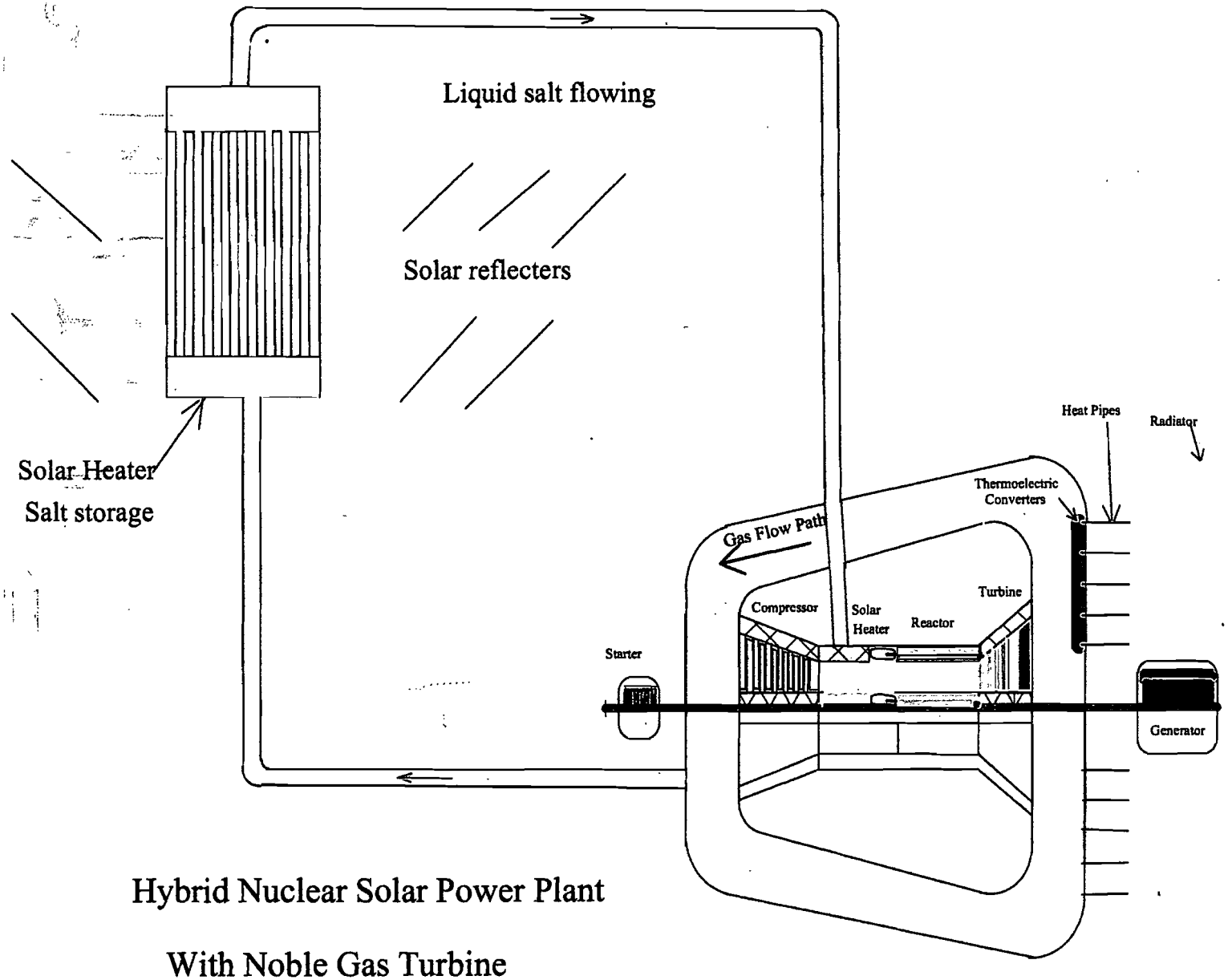
## Conclusion

There are two major sources of throttle-able electric power. They are gas turbines and small hydro plants. Some small coal powered plants are also used. Gas turbines and coal plants put carbon dioxide into the atmosphere.

Large hydropower plants with several small turbines can also be used. Hydropower is getting to be under pressure to be eliminated on many rivers because of their bad effect on fish. Probably a number of small hydropower plants will gradually be eliminated.

More safe, economical, and clean throttle-able sources need to be developed. Small nuclear plants are under development that can probably fill those needs in the future. The four different types of nuclear plants, fission heated gas turbine, fission heated small water cooled, hydride fuel reactors and fusion fission heated systems are the sources that have the potential for filling the needs. Their development should be expedited by the governments, product sources and the electric power companies.






# Hybrid Nuclear Solar Power Plant

# With Noble Gas Turbine

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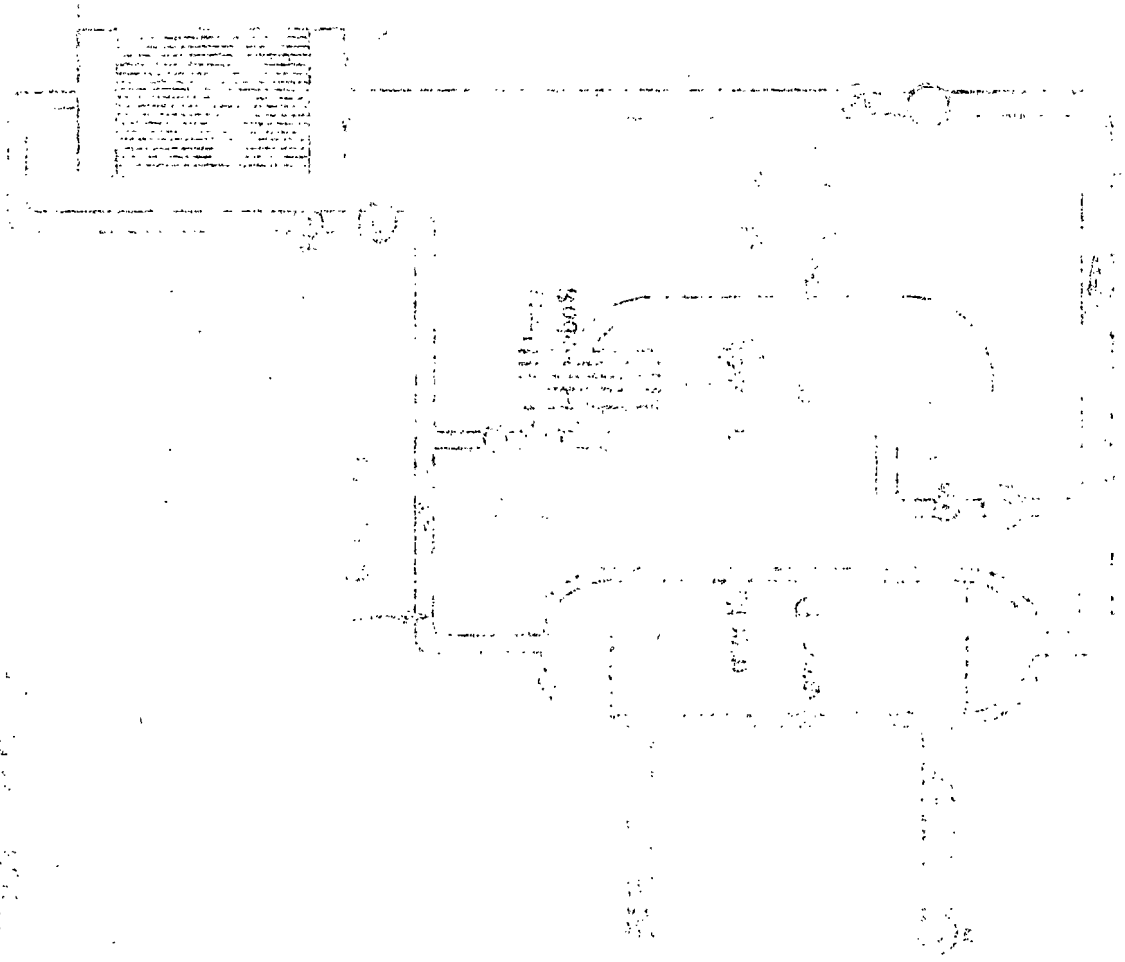

# Hybrid Solar-Nuclear Power Plant

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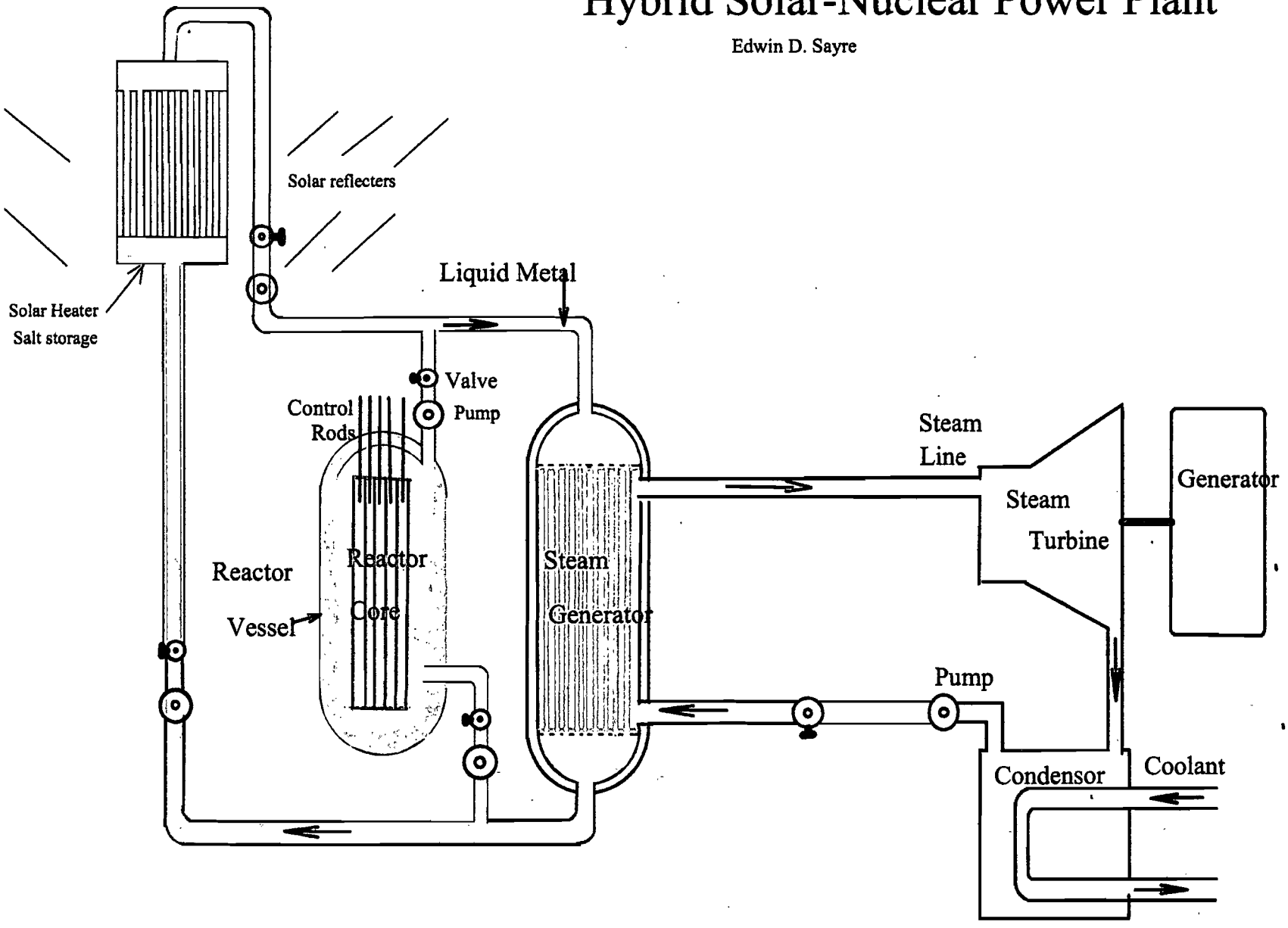

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## Advanced Generation Hybrid Nuclear Solar Power Plant Concept Technology Program

By
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Provided are two sketches of advanced concepts for hybrid nuclear solar power plants. No detailed development of these concepts is underway at this time. They are small fast breeder reactors that will use the reprocessed and recycled used fuel from our thermal reactors. The California Energy Commission may want to consider these concepts for the future since they are two systems that can meet the environmental and economical goals of California's energy requirements.