Cheap, Zero Emission Energy Breakthrough!

A New Molten Salt Reactor to Replace Fossil Fuels

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Why nuclear?

We now know all too well that hosting 7+ billion people on Earth, nearly all of whom aspire to live a middle-class lifestyle, will end in unthinkable calamity if fossil fuels continue to power our industries, transport, electricity and agriculture for much longer. We urgently need a safe alternative source of energy that can scale quickly and economically to replace them. Fortunately, a new design of molten salt reactor (MSR) has been conservatively estimated - if mass produced - to generate abundant power on demand **at lower cost than coal power.**

Safety of nuclear power

Contrary to popular belief, existing nuclear power technology is already the safest mainstream source of energy. Forty-seven people are known to have died from the effects of radiation at the Chernobyl accident, none at Fukushima and Three Mile Island. Far more people died from the stress of the evacuations from these accidents, which are now thought to have been largely unnecessary. Indeed, by negating the need for coal power, today's 380GW nuclear industry is calculated to have saved at least 1.8m people from premature death from the heavy metals and other air pollutants coal produces.

Radiation safety

Data from millions of radiotherapy treatments and X-Ray examinations indicate that, like low sun exposure, small doses of radiation are essentially harmless (and can even be beneficial to health, by a phenomenon known as hormesis).

Power density

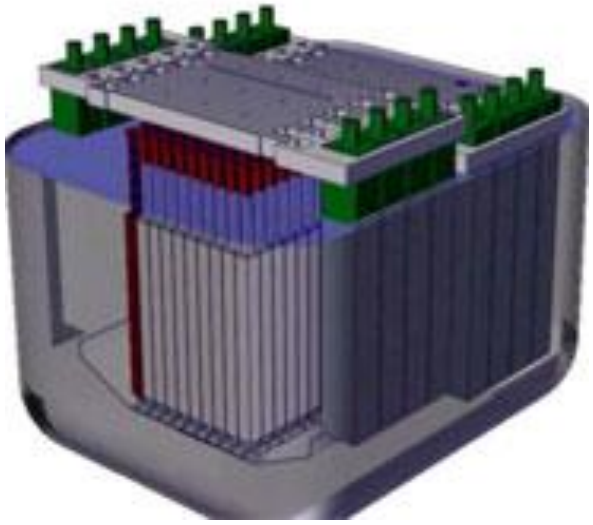
The fission of a single uranium or thorium atom releases millions of times as much energy as the oxidation of a single carbon atom. This enables a power plant occupying a small area to produce enormous power with hundreds of times less waste than the equivalent fossil fueled plant and with near zero greenhouse gas emissions.

Solid fuel is problematic

Today's Pressurised Water Reactors (PWRs) use solid fuel pellets, which is intrinsically unsafe and expensive to manage. Atomic fission produces a variety of elements including xenon gas that builds up inside the pellets. Since xenon kills the reaction, the pellets have to be removed for reprocessing after only 1-2% of the fuel is burned. Other fission products, which are radioactive and therefore must not be allowed to escape, require that the reactor is encased in an expensive pressure vessel, accompanied by other costly safety systems.

Liquid fuel makes more sense

MSRs make use of the fact that salts such as ordinary table salt melt at around 500°C, and uranium, plutonium and thorium fuels can be dissolved into that hot liquid. This enables fission gases to bubble out safely at atmospheric pressure. Additionally, cesium and iodine, the most dangerously radioactive fission products, become a stable constituent of it.



The Stable Salt Reactor

Technology Breakthrough

An experimental MSR ran successfully in the USA during the 1960s but transferring its heat energy involved pumping radioactive fuel mixture around a series of pipes and chambers. In today's more safety conscious world this represents a very costly engineering challenge.

The key to reduced cost is simplicity. A British inventor recently posed the question: Could sufficient heat energy be transferred from a molten salt fuel mixture *by convection* only? When experts in thermo-fluid dynamics answered yes, the Stable Salt Reactor (SSR) was born, in which hot fuel circulates naturally inside static vertical tubes. Coolant is pumped around the tubes, providing the heat power for the electricity generation system.

Advantages of the Stable Salt Reactor:

☺ Safety Advantages

- Operating at atmospheric pressure, a containment breach would not release dangerous levels of radioactive gases or dust.
- Even a small criticality (nuclear explosion) could not occur, because the coolant is also molten salt and fuel, if 'spilt', would disperse safely into it.
- If the fuel begins to overheat, its reactivity naturally ***decreases,*** providing fail-safe operation.
- Unlike PWRs fuel is continuously topped up, so the amount in operation at any time is much lower.
- No 'melt down' can occur. The fuel is already liquid.
- The boiling point of the molten salt is high (~1400°C), providing a large safety margin from normal operating temperature.
- Passive shut-down features mean a loss of power would not lead to public safety issues.

Proliferation resistance

- The enrichment level of the molten salt mixture is too low to be suitable for weapons use.
- The thorium fuel cycle makes extraction of weapons grade fissile material not only extremely difficult and dangerous for perpetrators but also detectable. In effect this means terrorist organisations wanting to develop fissile material for nuclear weapons would instead use existing simpler, cheaper methods.

☺ Long Term Environmental Advantages

- The SSR's high-temperature heat output can be a suitable replacement for today's high-CO_2 emissions industrial processes, such as production of metals, cement, hydrogen, fertiliser, chemicals, paper and desalination.
- It could power synthesis of petroleum fuel for aviation, shipping, haulage and other needs using CO_2 electrolysed from seawater, estimated at a little over $1/L
- The SSR has a 'power on demand' capability, enabling it to cheaply replace the coal, oil and gas used today to ameliorate renewables intermittency.
- Much less nuclear waste is produced because up to 90% fuel burn-up is achievable.
- Long-term radio-toxicity of waste is orders of magnitude lower than today's PWR solid fuel cycles. For example, the high-level waste produced from thorium decays to a safe level after around 300 years, as opposed to thousands.
- Stockpiles of legacy waste from decommissioned weapons and PWRs can fuel the SSR.
- Thorium is four times more abundant in the earth's crust than uranium and could provide enough energy for global use for tens of thousands of years.

☺ Cost Advantages

- Inherent stability means fewer safety systems are needed and no large pressure dome is required.
- The SSR's higher operating temperature enables a third more power to be converted from heat to electricity than PWRs and fossil fueled generators.
- Operation can be continuous while fuel is refreshed.
- Waste disposal costs are reduced because of the high burn up achieved.
- The radioactive core is designed to be easily removed at the end of the reactor's life, making decommissioning much cheaper.

☺ Technology Ready

- The technology is based on established molten salt chemistry and chemical engineering.
- Vital core components are already certified for use in nuclear industry environments.
- No R&D is needed. An industrial scale demonstration plant is the next step.

Feasibility study

A validation and assessment study by Energy Process Developments Ltd. (EPD) was completed in July 2015, and the Moltex Stable Salt Reactor design was recommended for development in the UK. The study included:

- a review of MSR developments internationally;
- input from industry leaders and reactor designers;
- a public opinion study of views on nuclear power (which was surprisingly positive);
- assessment of the regulatory process for advanced prototype reactors.

☹ Obstacles

Today, nuclear technology innovation is impeded by:

- the necessary but costly regulatory process and shortage of experienced regulatory staff
- governments being distracted by other priorities
- lack of finance, owing to nuclear power's unfortunate PR history
- uninformed green campaigners prejudiced against nuclear power generally;
- unscientifically based health and safety models.

What's next?

Moltex have submitted a design to the government's Small Modular Reactor Competition to support the creation of a demonstration SSR in the UK, and are awaiting the outcome. Government commitment would make possible the widespread commercialisation of an affordable, safe and sustainable source of zero-emission power – a vital outcome if climate change is ever to be successfully addressed.