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SYZYGY-energy from oilfields without any of the carbon. Potential routes to electrical power generation at scale from oil fields.

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Summary

Direct electrical energy production at large scale from oil fields would be a game changing technology. At small-scale it would enable electrification of upstream activities, with large emissions and cost benefits, and at large scale, would enable the oil and gas industry to transition towards zero emission energy production and use from its oil reserves. There are several potential routes to electrical energy production from oilfields(Head et al, 2014; Head and Gray, 2016), but a dominant candidate technology involves electron shuttle circulation. While theoretically viable as an energy source, electron shuttle based processes to recover electrical energy directly from oilfields, face several research and engineering challenges. We outline the areas of research and development challenge, and indicate timelines for assessing the feasibility of large-scale electrical generation directly from oilfields.

Introduction

One of our challenges is the transition to a carbon-neutral energy future. Many jurisdictions face this challenge of balancing environmental, economic and energy security goals – the so-called “energy trilemma.” Various routes to achieve this goal have been proposed including:- Increased efficiency of energy recovery/use; Develop renewable/ nuclear energy systems; Store carbon away from the atmosphere/ oceans(CCS; BECCS; DACCS); Convert CO2 to recyclable and usable materials such as fuels(CCUS); Transition away from hydrocarbons to fossil fuel alternate energy vectors (such as hydrogen, ammonia or electricity), and the use of negative emissions technologies(DAC).

This paper review possible alternate energy vector routes, summarises our understanding of the petroleum reservoir biosphere today and describes one potential route, to recover at commercial scale, the chemical energy in subsurface hydrocarbons as electricity at the surface of the earth, while sequestering all carbon residues in the reservoir. The approach uses understanding of petroleum reservoir biogeochemistry, petroleum engineering and technology nuggets and notions from microbial community management, large-scale flow batteries, chemical looping combustion and carbon capture and storage.

Theory and/or Method

Our recent R&D programs defined the nature of microbial life in unconventional fossil fuel reservoirs(Jones et al, 2008), biological routes to mitigating CO2 produced during use of fossil fuels (Head et al, 2014), and led to discovery, of several novel microbial transformations (Strous et al., 2006; Ettwig et al., 2010; Kraft et al, 2014). This led us to focus on microbially mediated processes as potential routes to electrical power generation directly from oilfields. A process, could involve electron shuttle rich brines, injected via a well and moving through the reservoir toward a second well. Microbes, present in the reservoir, use the shuttle (e.g. MnIV, a common battery component), to oxidize fossil fuel molecules in situ, leading to a reduced shuttle (MnII), rich brine, at the second well. The produced shuttle is recovered and reoxidized, above-ground, with atmospheric oxygen in a fuel cell, yielding electricity and regenerated MnIV, which is recycled. The CO2 produced in the reservoir, is trapped there. The approach couples concepts of large scale flow batteries and carbon capture and storage(CCS), linked through chemical looping redox vectors-electron shuttles.

Thermochemical and thermodynamic studies indicate such processes are theoretically viable and a substantial fraction of the chemical energy stored as hydrocarbons, could in principle be recovered as surface electricity, depending on shuttles (e.g. SO_4,Mn,Fe,X ions, quinones) and reactions used. As oil recovery is inefficient, in principle, we could recover even more energy than today-without the carbon. R&D issues relate to kinetics, shuttle recycling efficiencies, biome management, engineering retention of CO2 in the reservoir and of course, life cycle impacts and economics. We discussed routes to investigating these issues.

Conclusions

If developed and proven technically and economically viable, in a life cycle context, such power generating capabilities would be transformative for the oil and gas industry. At small-scale these could enable full electrification at low cost, of the entire upstream industry enterprise, and at large-scale oil and gas companies could be power exporters and marketers. Interestingly, the ideal oilfields for conversion by such processes, would tend to be the marginal or already partly produced reservoir’s, opening many collateral benefits to industry and society.

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