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MPlan

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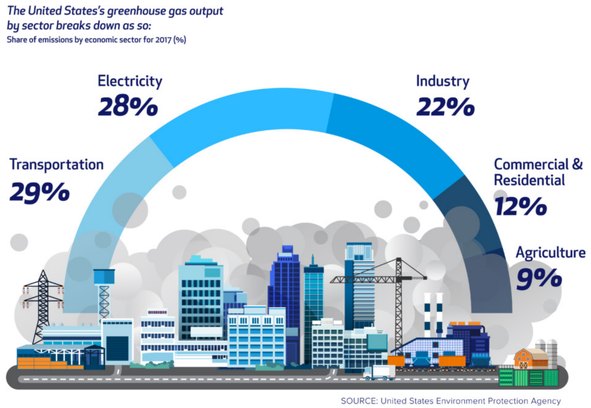
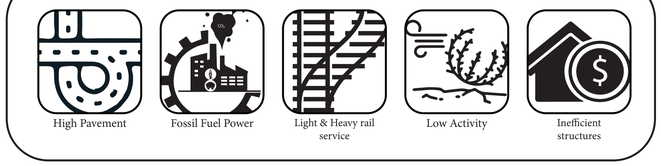
The Hydrogen Economy

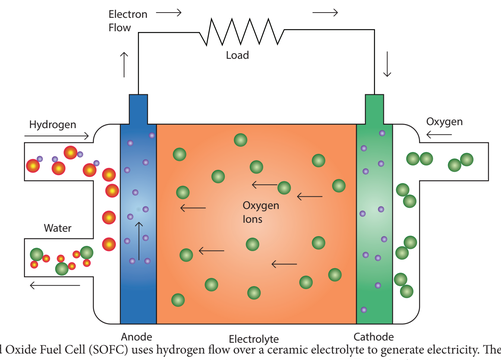


Present-day Manchester is an under utilized neighbourhood of Calgary that is just outside of the downtown core. It is heavily paved and sparse both in residential and commercial/ industry. As an older neighbourhood, much of the infrastructure is at or near the end of its life cycle. Despite this, Manchester is adjacent to an arterial road and is serviced by two LRT stations. Its proximity to the core, opportunity for redevelopment and access to mass transit make it an intriguing neighbourhood to re-imagine. In today's carbon-intensive world, this poster intends to evaluate the need for power and heating in Manchester and how it might be deployed.

Present Conditions



Solid Oxide Fuel Cell



Solid Oxide Fuel Cell (SOFC) uses hydrogen flow over a ceramic electrolyte to generate electricity. The output is water vapour and heat when a pure hydrogen source is used. SOFCs offer flexibility in the way of fuel sources and can use natural gas (CH_4) via steam reformation to liberate hydrogen for use. In this case, the outputs also include CO_2. SOFCs are significantly more efficient than solar or fossil fuels in terms of generating electricity (80%+). Therefore, switching to fuel cells in Manchester immediately will increase fossil fuel use efficiency and decrease associated gaseous emissions. Additionally, by building to Passivhaus standards, the heating needs will be vastly reduced.

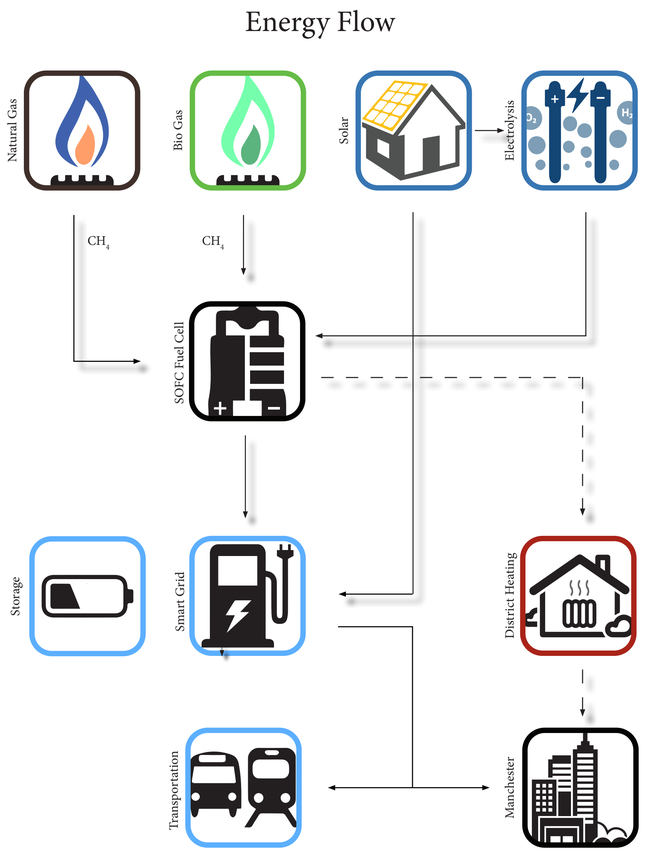
Precedents

Japan's ENE-FARM program has installed 120,000 fuel cell units into residential homes since 2015. Using a Proton Exchange Membrane (PEM), users achieve 95% efficiency, a 57% reduction in CO_2 emissions and a consumer savings of 129,000 yen.

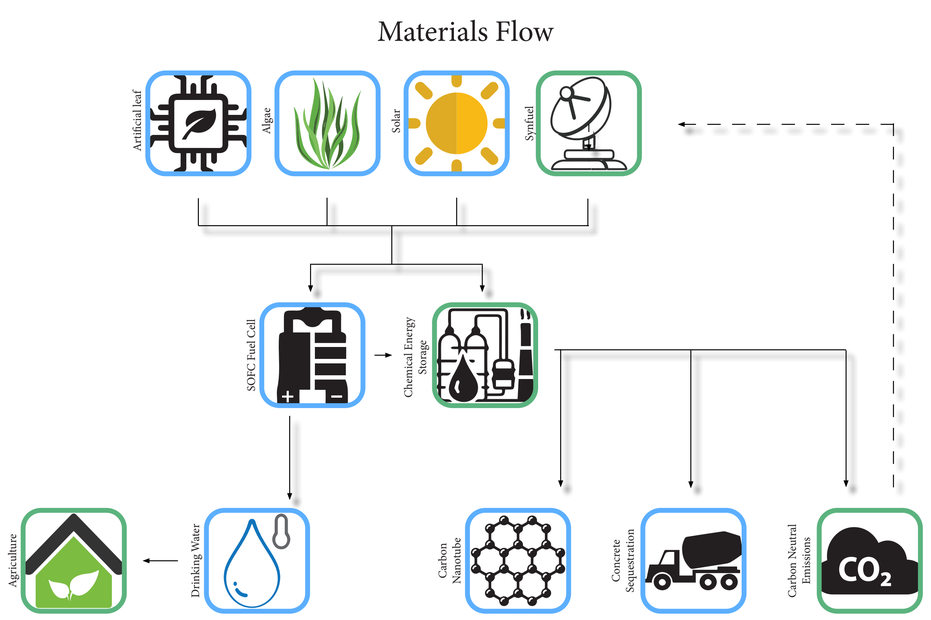
South Korea is investing heavily into fuel cell research and development for use in vehicles. However, their vision has expanded and they have set the lofty goal of having 3 fully hydrogen powered cities by 2022 and the rest of the country generating 30% of its energy needs from hydrogen by 2030.

Bloom Energy in California has developed and deployed fuel cells to provide backup power for several major corporations including Google, Apple, EBay, NASA, Wal-Mart and many more.

Energy Flow



Materials Flow

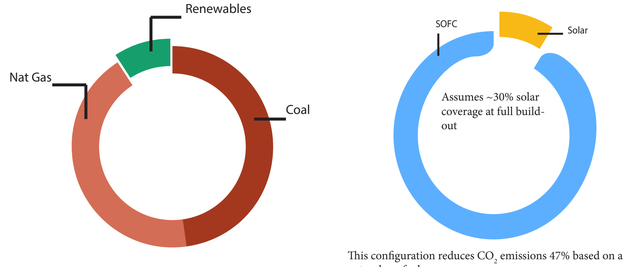


The supply of energy will be essential for Manchester and, as mentioned earlier, that energy needs to minimize carbon immediately. The technology exists to supply a SOFC with pure hydrogen gas however it is inefficient. Like solar in the 1990s, with appropriate policy and incentive scaffolding in place, renewable sources of hydrogen can be developed. Therefore, in Manchester, I suggest a 2 phase approach to converting to renewables. The diagram to the left illustrates how that might be done. Natural gas can supply hydrogen via steam reformation process and because of its high efficiency, reduce CO2 emissions by 25%. CO2 will still be a by-product which will be discussed below. As Technology improves and larger hydrogen volumes become more readily available, electricity generation can proceed to phase 2 where by the fuel cells are powered by pure hydrogen generated from renewable resources. As hot water is also a by-product of a fuel cell, the additional thermal energy would be captured and distributed by tying in to a district energy system.

There is no map. Why? SOFC are modular and scalable and can grow and be placed as needed. As such, there is no reason to make nodes or centralize them. With the implementation of a smart grid and batteries, redundancies are in place to supply the neighbourhood with power and heat without taking up large and unsightly amounts of public space.

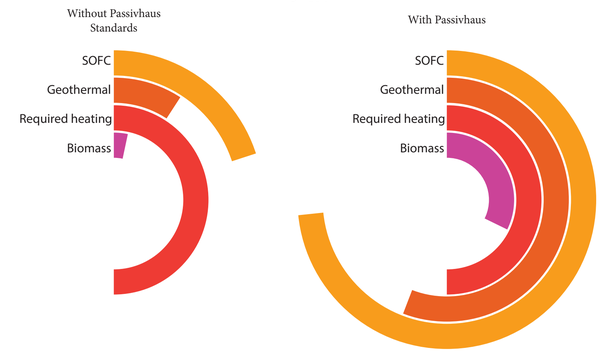
As materials go, hydrogen from whatever source would be flowing in and at first, CO2 out. The benefit of this CO2 is it is all completely captured at the exhaust. Today's technology allows for several options for dealing with it via CO2 mineralization to be used as carbonate aggregate of a curing agent while also saving billions of litres of fresh water. Interestingly, carbon nanotubes (CNT) can also be produced. CNTs are useful for electrical transmission and minimizing losses but it's also incredibly strong and could potential be used as a building material to reinforce or replace steel construction. All of this to say that in these forms, the carbon become permanently sequestered. There is also an opportunity to provide CO2 to agriculture for the growing of produce or algae - either for food or fuel - as a means of uptake of CO2 and temporary sequestration

Energy Breakdown



This configuration reduces CO_2 emissions 47% based on a natural gas fuel source.

Heating supply



At full community build-out, Manchester would require 81 2.5MW fuel cells distributed throughout the neighbourhood. The heat generated from the fuel cells alone is over 2.5x the expected requirements under Passivhaus building standards which leaves Manchester with a wealth of heat to be put to other uses. The community of Manchester and the City of Calgary have an opportunity to be leaders in modern planning standards and raising the bar on sustainability, environmental stewardship and the quality of life for its residents.