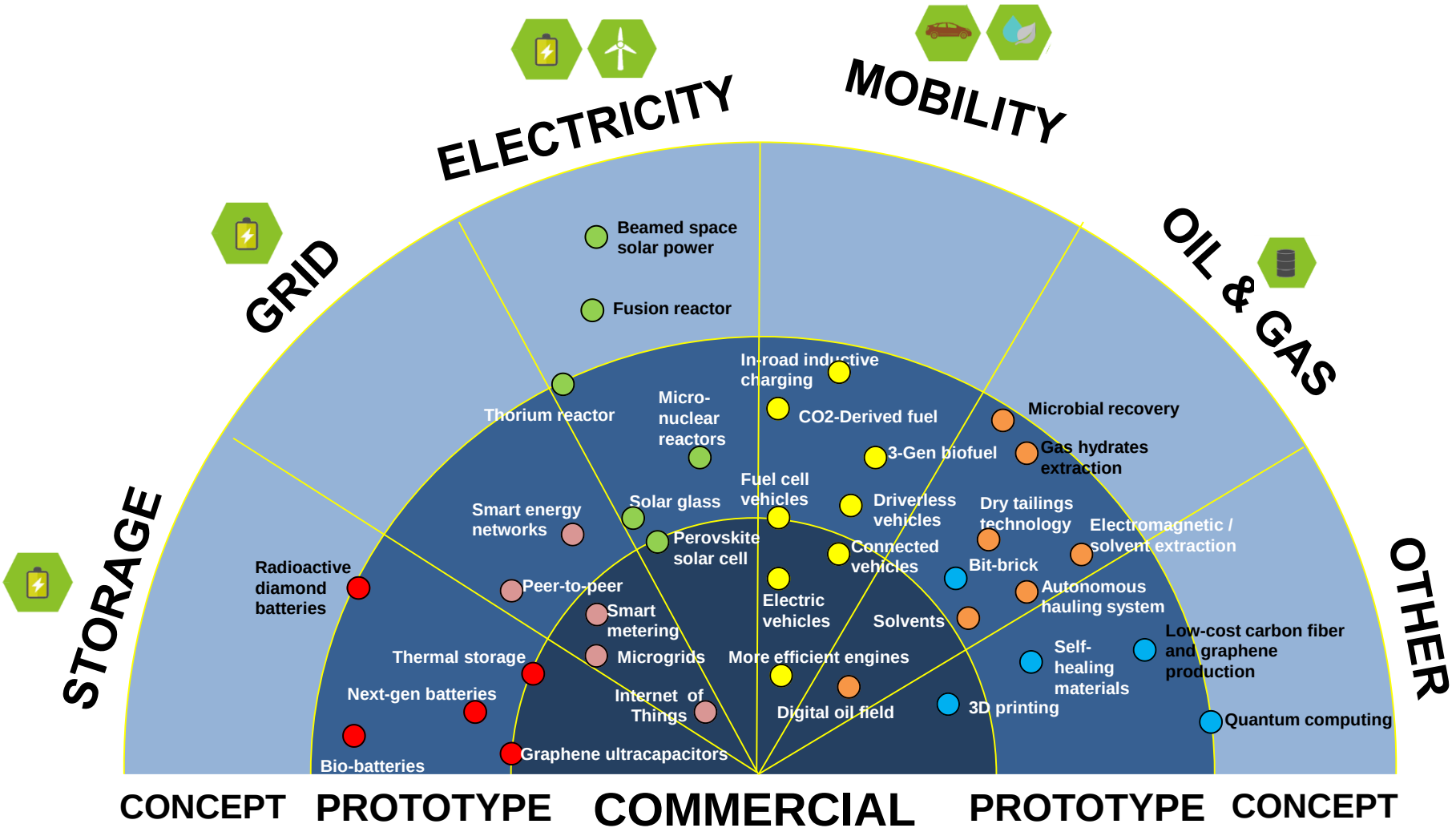
Emerging Energy Technologies



CoLab.
Complexity | Collaboration | Co-design | Co-creation

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STORAGE

Bio-batteries

Bio-batteries are energy storing devices powered by organic compounds, usually sugar. Bio-batteries hold the promise to replace harmful chemicals with environmentally friendly material, even from waste. In 2012, researchers at Virginia Tech successfully created a sugar-powered battery that has an energy storage density one order of magnitude higher than lithium-ion batteries. (https://www.extremetech.com/extreme/175137-sugar-powered-biobattery-has-10-times-the-energy-storage-of-lithium-your-smartphone-might-soon-run-on-enzymes)

Next-gen batteries

Recent advances in energy storage using sodium, aluminum, lithium-air, and zinc-based batteries are expected to result in safer, more dense rechargeable batteries while mitigating some of the supply risks around lithium.
http://business.financialpost.com/midas-letter/next-generation-battery-technology-goodbye-lithium/wcm/b4f21213-604c-4162-b034-2bcb092573dc

Thermal storage

As more intermittent power comes online, the need for cost-effective storage solutions increases. Thermal storage is emerging as an alternative or complement to battery storage, with the distinct advantages of being cheaper, being able to operate at high temperatures, and having an infinite charge/discharge cycle. In thermal storage systems, excess renewable electricity is used to heat a material to a high temperature, and the stored heat is then used at a later time to generate electricity.
https://www.theguardian.com/sustainable-business/2017/apr/06/salt-silicon-or-graphite-energy-storage-goes-beyond-lithium-ion-batteries

Radioactive diamond battery

Researchers at the University of Bristol have developed a lab-made diamond that can generate electricity from upcycled radioactive waste. The battery has a lifetime of about 14,000 years and is an efficient way to treat radioactive waste, whose harmful emissions are absorbed by the diamond.
https://www.weforum.org/agenda/2017/02/these-scientists-are-turning-radioactive-waste-into-diamond-batteries

Graphene ultracapacitors

The applications of graphene has enabled the creation of capacitors with energy densities and power densities far beyond existing electrochemical capacitors and within reach of conventional lithium-ion batteries. Ultracapacitors, which suffer virtually zero degradation over 10,000 cycles, are expected to replace batteries in lower-energy devices like smartphones. With their huge power density, ultracapacitors could also revolutionize electric vehicles, where lithium-ion batteries struggle to strike a balance between mileage, acceleration, and longevity.
https://www.extremetech.com/extreme/122763-graphene-supercapacitors-are-20-times-as-powerful-can-be-made-with-a-dvd-burner

GRID

Internet of Things

Increasingly, devices and appliances (and their components) are connected to, and monitored and controlled through the Internet, opening up new opportunities for efficiency and demand response.
https://www.forbes.com/sites/jacobmorgan/2014/05/13/simple-explanation-internet-things-that-anyone-can-understand/#11475b571d09

Microgrid

With wind and solar costs coming down, electricity prosumers and remote communities will increasingly have the option to operate independently or in conjuction with the main electrical grid.
https://energy.gov/articles/how-microgrids-work

Smart metering

A common form of smart grid technology, smart meters are digital meters that replace the old analog meters used in homes to record electrical usage. They enable utilities and consumer to monitor consumption more precisely and frequently.
http://www.whatissmartgrid.org/smart-grid-101/smart-meters

Peer-to-peer

With smart metering and the emergence of the blockchain, residential prosumers could have the opportunity to sell excess electricity in a free market instead of selling to the local utility at a fixed price. In 2016, a start-up based in London, Open Utility, launched a pilot for a peer-to-peer marketplace for renewable power.
https://www.fastcompany.com/3041675/could-a-peer-to-peer-marketplace-for-renewable-energy-be-the-wave-of-the-future

Smart energy network

Smart energy networks use advanced information and communication technology to monitor and optimally manage the transport of energy from multiple fuel sources, to meet the varying energy service demands of end users. Unlike smart grids, which apply information and communication technology to the electric grid, smart energy network encompass multiple fuels, including heat.
https://uwaterloo.ca/sustainable-energy-policy/sites/ca.sustainable-energy-policy/files/uploads/files/Smart%20Energy%20Network_A%20Review%20of%20the%20%27State%20of%20the%20Art%27.pdf

ELECTRICITY

Perovskite solar cell

This photovoltaic material offers three advantages over the classic silicon solar cell: it's easier to make, can be used virtually everywhere, and generates power more efficiently. Barriers to commercialization include rapid deterioration, toxicity, and efficiency losses associated with scaling up.
https://www.perovskite-info.com/perovskite-solar
https://www.weforum.org/agenda/2016/06/perovskite-solar-cells

Solar glass

In 2014, researcher at Michigan State University created a fully transparent solar concentrator, which could turn any window or sheet of glass into a photovoltaic solar cell. The concentrator consists of organic salts that absorb non-visible wavelengths, which is turned into infrared and guided to the edge where strips of solar cell convert it to electricity.
https://www.extremetech.com/extreme/188667-a-fully-transparent-solar-cell-that-could-make-every-window-and-screen-a-power-source

Micro-nuclear (modular) reactor

There is a revival of interest in small and simpler nuclear units for generating electricity and process heat, due mostly by a desire to reduce capital costs, provide power away from large grid systems, and produce reliable, emission-free power.
http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/small-nuclear-power-reactors.aspx

Thorium reactor

The next-generation of nuclear fission could replace uranium with thorium, which is abundant, does not require costly processing, leaves less radioactive waste behind. The new fuel could be used in some old nuclear plants, but the durability of special containers for thorium molten salts remain to be proven.
https://www.wired.com/2009/12/ff_new_nukes/

Fusion reactor

Nuclear fusion is the same process that fuels stars like the sun, and could produce a potentially limitless supply of clean energy. In contrast to fission (which splits atoms), fusion involves fusing atoms together. The major challenges facing fusion energy is the exceedingly high energy input required to produce the temperatures and pressures that enable significant fusion reactions. Recent estimate have pushed the commercialization of fusion energy to 2050.
https://futurism.com/a-world-first-fusion-reactor-just-created-its-first-plasma/
http://thebulletin.org/fusion-reactors-not-what-they%E2%80%99re-cracked-be10699

Beamed space solar power

Space-based solar panels could collect solar energy and turn into electromagnetic waves, which could then be collected on earth. The panels could deliver up to 40 times the annual amount of reliable 24/7 energy that the same solar panel would generate on earth, because of constant and brighter illumination by the sun.
http://www.businessinsider.com/space-based-solar-panels-beam-unlimited-energy-to-earth-2015-9

FUEL AND VEHICLES

More efficient engines

With fuel-economy standards getting tougher, car-makers are set to drive efficiency improvements in internal combustion engines. Current solutions include direct fuel injection, turbo, variable displacement, variable valve timing and lift, and stop-start systems.
http://www.caranddriver.com/features/the-future-of-the-internal-combustion-engine-near-term-and-long-term-innovations-page-2

Electric vehicles

In July 2017, automaker Volvo announced it would phase out conventional engines in the next two years; the French government announced plans to end sales of gas- and diesel-powered cars in 2040. Bloomberg predicts that electric cars will represent 54% of all new cars sold globally by 2040.
https://insideclimatenews.org/news/06072017/electric-cars-majority-bnef-forecast-volvo-batteries-scott-pruitt

Connected vehicles

Connected vehicles use different communication technologies to communicate with the driver, other cars on the road, roadside infrastructure, and the cloud. This technology can improve vehicle safety, efficiency, and commute time. Some connected vehicle technologies are already available, but are a fraction of what is expected to be available in the future.
http://autocaat.org/Technologies/Automated_and_Connected_Vehicles/

Driverless vehicles

Several carmakers, including Tesla, Nissan, and Ford, have shown off cars that can drive themselves and have declared that within a decade, they plan to sell advanced automation. While the road to full automation is in sight, several obstacles need to be overcome, including costs, regulatory clarity on liability, and consumer acceptance. Meanwhile, technology-assisted driving is becoming more widespread.
https://www.technologyreview.com/s/520431/driverless-cars-are-further-away-than-you-think/

Fuel-cell vehicles

Progress is being made on the hydrogen-fed fuel cell. To date, progress has been stymied by the high price of catalysts, which contain platinum. However, advances are being made reducing the reliance on this metal through substitution with another metal or, in some cases, no metal at all.
https://www.weforum.org/agenda/2017/06/these-are-the-top-10-emerging-technologies-of-2017/

3-Gen biofuel

Biofuel derived from algae. Large-scale use of algae to produce biofuels is currently hampered by the large amounts of water and fertilizers to grow –which add costs and produce emissions.
http://biofuel.org.uk/third-generation-biofuels.html

CO2-Derived fuel

Advances in artificial photosynthesis and electro-reduction are making possible the creation of net-zero fuels from the reaction of hydrogen and sequestered carbon dioxide.
https://phys.org/news/2016-07-breakthrough-solar-cell-captures-carbon.html
http://fortune.com/2015/04/28/audi-just-invented-fuel-made-from-co2-and-water/

In-road inductive charging

This technology enables to forgo the need for big batteries in electric vehicles and assuages concerns around range by powering vehicles wirelessly from under the pavement. The technology is still in its infancy, but will be put to the test in Israel, where a start-up recently won a contract to test wireless charging roads for electric buses.
https://www.scientificamerican.com/article/israel-tests-wireless-charging-roads-for-electric-vehicles/

EXTRACTION

Digital oil field

The application of digital technologies and automation is increasingly enabling oil producers to know exactly what is happening at any given time (intelligent monitoring), to know what is about to happen (prediction), and to drive performance in safety and productivity (optimization).
http://www.bp.com/en/global/corporate/technology/technology-now/digital-technology.html
https://www.strategyand.pwc.com/media/file/UnleashingProductivity.pdf

Solvents

Non-aqueous extraction has reached a new milestone, as a Calgary-based company announced the end of a pilot project using a solvent-based extraction technique in March 2017. The process uses no water and results in lower greenhouse gas emissions relative to traditional oil sands production.
http://www.cbc.ca/news/canada/calgary/nsolv-pilot-project-success-1.4012709
https://www.albertaoilmagazine.com/2015/03/five-areas-energy-sector-should-focus/

Autonomous hauling system

Suncor has embarked on a pilot project involving the use of autonomous haulers in one of its mine sites in Northern Alberta. The trucks are expected to increase productivity and safety, but are also mired in controversy due to potential job losses.
http://www.mining.com/canadian-oil-sands-giant-testing-autonomous-haul-trucks/

Electromagnetic/solvent extraction

This kind of extraction replaces the need for steam to heat the reservoir by using electromagnetic heating and diluting bitumen deposits with solvent. The benefits of the process are potentially lower capital costs due to lack of steam generation and less water treating, lower emissions and higher recovery rates.
CIBC – Oil sands watch: Technology update

Dry tailings technology

Investments in dry tailings technology is expected to decrease or eliminate the need for tailings ponds and accelerate reclamation. Technologies include dewatered tailings, centrifuges, cyclones, thickeners, evaporation, and captured CO_2 emissions as a rapid solidifier.
https://www.albertaoilmagazine.com/2015/03/five-areas-energy-sector-should-focus/

Gas hydrates extraction

In May 2017, teams from Japan and China have successfully extracted methane hydrates, a hydrocarbon gas trapped in a structure of water molecules off the seafloor. While commercialization is estimated to be at least 5 years away, methane hydrates are abundant and are estimated to contain more carbon than all the world's oil, gas, and coal combined.
https://arstechnica.com/science/2017/05/energy-dense-methane-hydrate-extracted-by-japanese-chinese-researchers/

Microbial recovery

Microbial enhanced oil recovery uses biotechnology to improve residual crude oil production from oil wells as a tertiary oil recovery method. While further research is needed to optimize microbial recovery for the oil industry, biotechnology-based methods hold promise for oil recovery operations as well as oil spill remediation.
http://www.sciencedirect.com/science/article/pii/S1364032115007820

OTHER

Bit brick

In February 2017, Canadian National Railway filed a patent for a new technology that turns bitumen into a solid dry good that can be stacked, forgoes the need for diluent, and reduces flammability. This technology could emerge as an alternative to current methods of shipping bitumen by train.
https://www.theglobeandmail.com/news/national/cn-develops-technology-that-could-make-bitumen-transportation-safer/article34082304/

3D printing

Under pressure to keep up profits in the face of low oil prices, the oil and gas industry is turning to 3D printing to address complex oil and gas product structure, the costly consequences of downtime, and inefficiencies in the production of low-volume, high-value parts.
http://www.jwnenergy.com/article/2016/11/oil-and-gas-industry-turning-toward-3d-printing-cut-costs-and-raise-efficiencies-lux-research/
https://www.typeamachines.com/blog/3d-printing-is-making-its-way-into-the-oil-and-gas-industry

Quantum computing

2017 is forecast to be an important year for quantum computing, as several labs and computing giants are expected reach technical milestones such as performing computations that are beyond even the most powerful classical supercomputers.
http://www.nature.com/news/quantum-computers-ready-to-leap-out-of-the-lab-in-2017-1.21239

Self-healing materials

Researchers at the University of Illinois are creating self-healing coatings for metals and pipelines that can sense damage, stop it from getting worse, and even self-repair without external intervention. The future applications of self-healing materials have enormous potential, not only for the energy industry but also in construction and civil engineering.
http://www.bp.com/en/global/corporate/technology/technology-strategy/advanced-materials-research.html

Low-cost production of graphene and carbon fiber

In 2016, researchers at the US Department of Energy's Oak Ridge Lab demonstrated a production method they estimate will reduce the cost of carbon fiber by 50% and the energy used in its production by 60%. Similar experiments have shown drastic reduction in the production of graphene. Manufacturing for both materials could use bitumen as feedstock.
http://newatlas.com/graphene-inexpensive-electronics-university-glasgow/40508/
https://phys.org/news/2016-03-ornl-low-cost-carbon-fiber.html