From the Lab into our Lives

Technologies that Promise to Transform how we Generate and Save Energy

Technology will be central to the Great Decarbonization.

But technologies as we know them now? Perhaps and perhaps not.

Here we explore the not-so-common but promising technologies that may help us reach our climate change mitigation goals.

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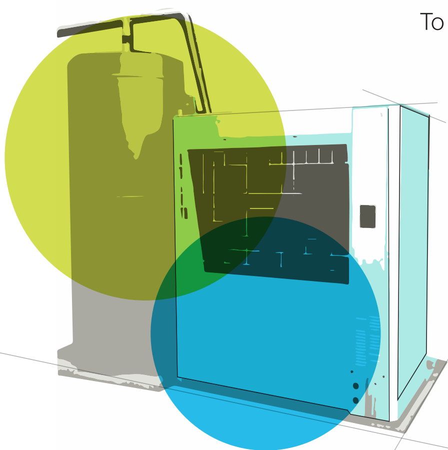
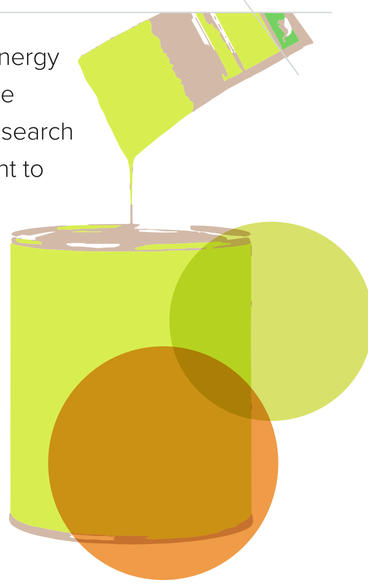
Home

In just the last ten years, we have seen an abundance of innovation in our homes. These have included the emergence of connected and smart home appliances and the increased adoption of electric climate control and even clothes dryers. While much of our progress toward households' decarbonization leans on electric heat pumps, they require refrigerants to readily absorb heat from the environment. But conventional hydrochlorofluorocarbon (HCFCs) refrigerants, while an improvement from their chlorofluorocarbon (CFCs) precursors, are still toxic, flammable, ozone depleters, and have come under scrutiny for these attributes.[1]



To find the perfect refrigerant, researchers must balance a product's low global warming potential (GWP) against how environmentally friendly the refrigerant and its decomposition products are. **Hydrofluoroolefin refrigerants** have been lauded for their comparatively low GWP relative to conventional CFCs or HCFCs, more readily decomposing in the atmosphere. However, they eventually form trifluoroacetate which ends up contaminating ground water, and is very difficult to remove once it's there. Figuring out how to effectively remove these byproduct contaminants could open the opportunity space for these low GWP refrigerants and make them a more widespread reality.

An alternative to conventional refrigerants is the long-emerging world of **magnetic refrigeration**, which enables conventional refrigerants to be replaced by cyclic heat transfer between a special "magnetocaloric" material (e.g., gadolinium or more recently, holmium) and a benign, often water- or helium-based "cooling fluid."[2, 3, 4, 5] When these special materials encounter a magnet, their magnetic field is rearranged such that their heat capacity, and therefore temperature, increases. Various techniques and materials are being researched to make magnetic refrigeration more efficient and less expensive, moving the technology out of the lab and into the household.

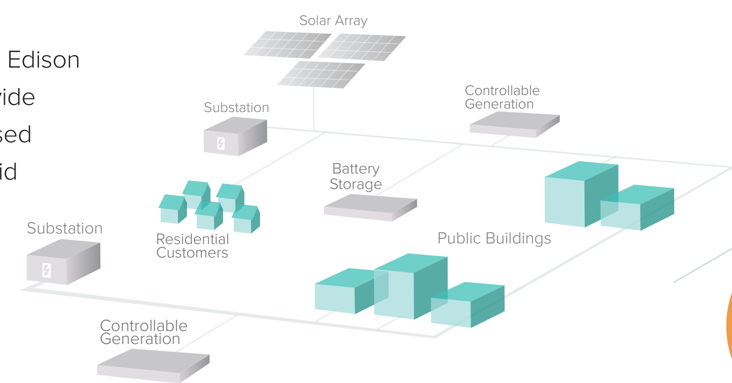


Solar paint is an exciting innovation in energy capture with the potential to turn an entire building into a solar panel. Early-stage research has added a moisture capture component to conventional titanium dioxide-containing paint. This combination of ingredients allows ambient water to be captured and split to produce hydrogen, a source of storable clean energy. While safely using and storing hydrogen is a barrier, this is a big step toward a paintable solar capture energy source.[6] When used in combination with traditional solar panels which convert light directly to electricity, a home could conceivably have direct (electric) and backup (hydrogen) energy sources, just from basking in the sunlight.

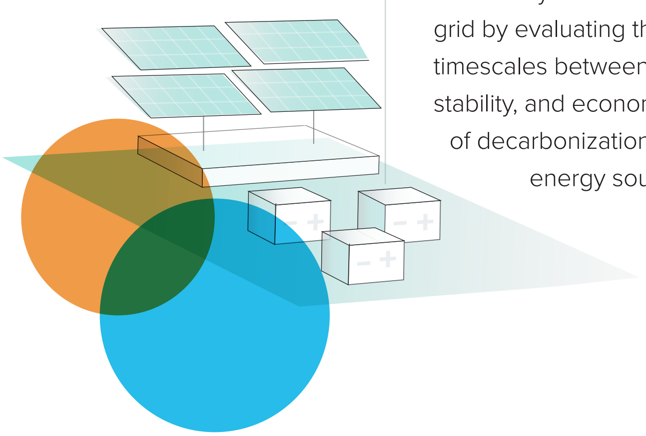
Loca

Cutting edge energy capture and conversion technology is being continuously developed and improved. Distributed energy resources (DER) like solar house paint are a critical element in building a more resilient, decarbonized power landscape. The concepts of partial grid defection and utility-mediated microgrids are growing in popularity as a means of backup power generation for more reliable and space-saving alternatives to, for instance, diesel generators.[7] As climate change forces us to expect the unexpected, options for back up generation or the ability to “island” from the larger grid grow ever more attractive.

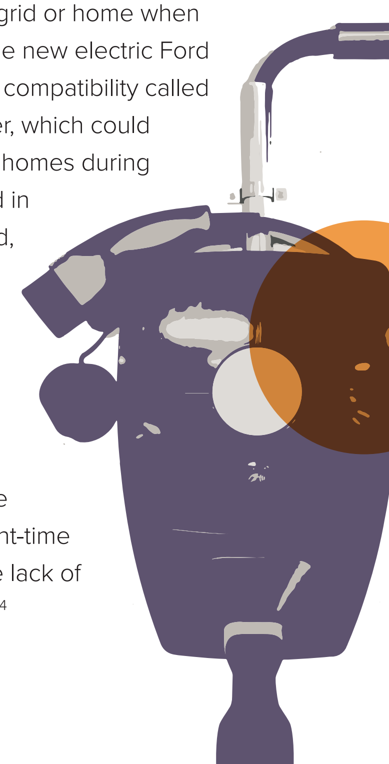
The **smart microgrid** developed by Commonwealth Edison (ComEd) in Chicago will be the first of its kind to provide a largely underserved metropolitan area with increased resilience in the face of power outages. The microgrid has 750 kW of solar and a 500-kW battery system that can run for four hours. The project will be the first utility-operated microgrid cluster, designed in part to better understand how shared energy resources work.[8, 9]



A truly flexible and resilient system requires its ability to store renewable power and integrate it with existing systems. The **Multi-Timescale Integrated Dynamic and Scheduling (MIDAS)** framework developed at the National Renewable Energy Laboratory aims to understand the grid by evaluating the differences in timescales between grid reliability, stability, and economics in the face of decarbonization from renewable energy sources.[10, 11]



The innovative concept of **vehicle-to-grid (V2G)** or **(or vehicle-to-home) (V2H)** technologies are particularly appealing around the home and in local travel. The battery in an electric vehicle (EV) can give energy back to the grid or home when plugged in and not in use. The new electric Ford F150 promises eventual V2H compatibility called Ford Intelligent Backup Power, which could be used to provide power to homes during peak energy use. When used in accordance with grid demand, V2G could decrease costs and optimize pull from renewable energy sources.[12] School bus fleets have been used with V2G technology due to their high intermittent downtime in the middle of the day and at night, with the night-time contribution able to offset the lack of solar power at those times.[13, 14]



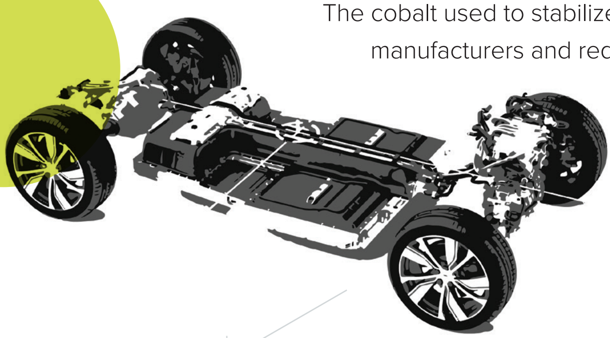
Global

Electric vehicles (EVs) are a major player in the global push toward decarbonizing the transportation sector. ILLUME did a whole piece on their history in our 2019 magazine![15]

This is led in part by EV-related or—adjacent policies—from Europe's strict CO2 emissions caps to China's "new energy vehicle" credit, to India's emissions mandates, and the Biden administration's acceleration proposal for 100% renewable energy by 2035.

However, experts say that the direct replacement of all personal gasoline/diesel vehicles with EVs would require such an enormous production volume that the carbon burden would not ultimately be mitigated.

Instead, the only way to truly decarbonize soon is to rely less on personal vehicles and more on public transportation.[16] That aside, even EV experts say that EVs are not inherently fully green because manufacturers' power sources are fossil-based, there is a limited recycling infrastructure for lithium ion (Li+) batteries, and their production depends on mining practices that are sometimes neither sustainable nor ethical.



The cobalt used to stabilize Li+ batteries is likely the riskiest link in the supply chain for EV manufacturers and requires mining primarily from regions unregulated by U.S. health and safety standards. Research has aimed to address these issues by developing **cobalt-free EV batteries** that are still reliable but made from more accessible materials.[17, 18, 19] Additionally Tesla, whose vehicle batteries even now contain below 5% cobalt, has announced their ongoing work toward cobalt-free batteries.[20]

And of course, global travel today requires flight. With jet fuel demand set to double pre-pandemic levels by 2050, decarbonization of the aviation industry is needed. The road (cloud?) to **electric airplanes** is exciting and potentially long, given challenges of battery weight, concerns over efficiency once airborne, and issues with being far from grounded charging stations once in flight. To solve these issues, hybrid fuel-electric aircraft may be a solution, where partially electrified flight could be a nearer-term possibility.[21]

Renewable jet fuel offers a way to decarbonize existing infrastructure and engine design. A collaborative effort between researchers at multiple national labs and universities has made **carbon-neutral jet fuel from waste** material.[22] Diverting waste that would otherwise emit methane while sitting in a landfill theoretically enables net-zero carbon flights while also taking advantage of a largely underutilized feedstock. Test flights for this fuel are set to begin in the very near future.[23]

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