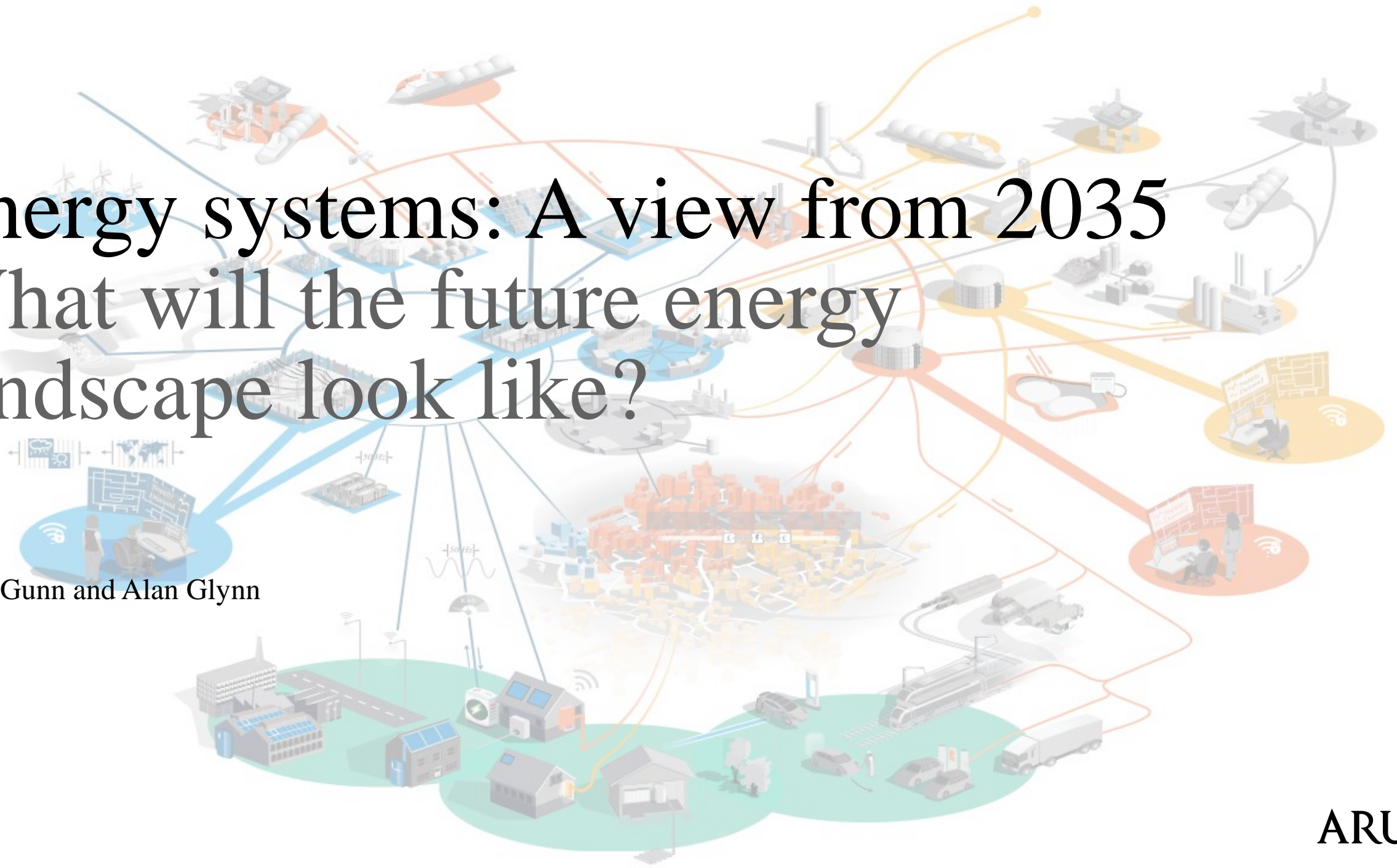


# Energy systems: A view from 2035

## What will the future energy landscape look like?

Geoff Gunn and Alan Glynn



We are in a unique period of market disruption...

## Grid Destabilization

renewables + electrification (buildings and mobility)

## Demand for Climate Action

zero net energy, carbon neutral power

## Innovative Business Models

community choice, P3, 3rd party programs

## New Knowledge

future climate, digital technology, grid modernization

Set in 2035 and based around a vision of the future energy system, this thought piece details a conceivable energy system that is helping transition to a low-carbon economy. It sets out the practical steps needed now for the country to move towards this future.

We have included relevant project examples to show what can be done today.

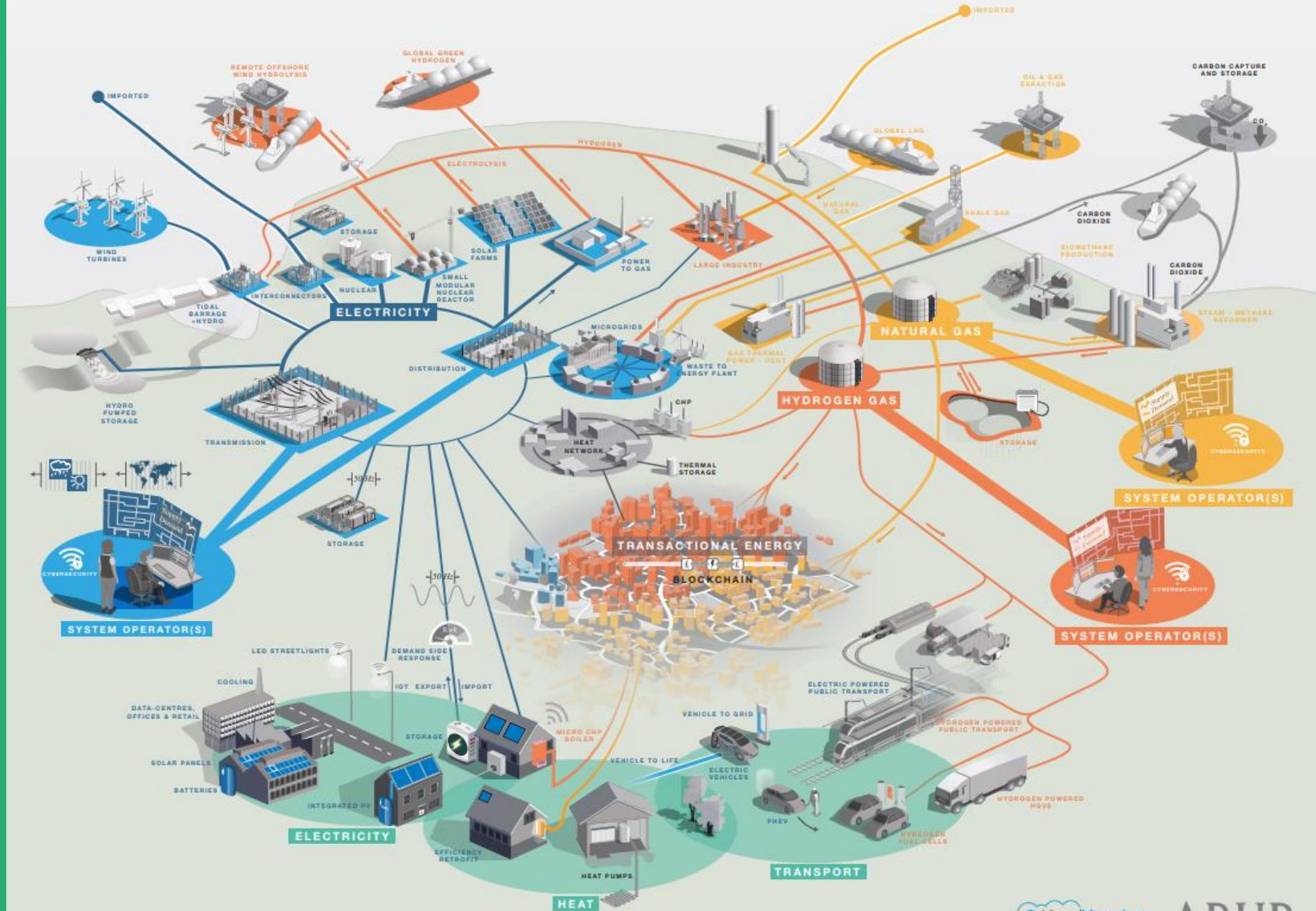


# Goals:

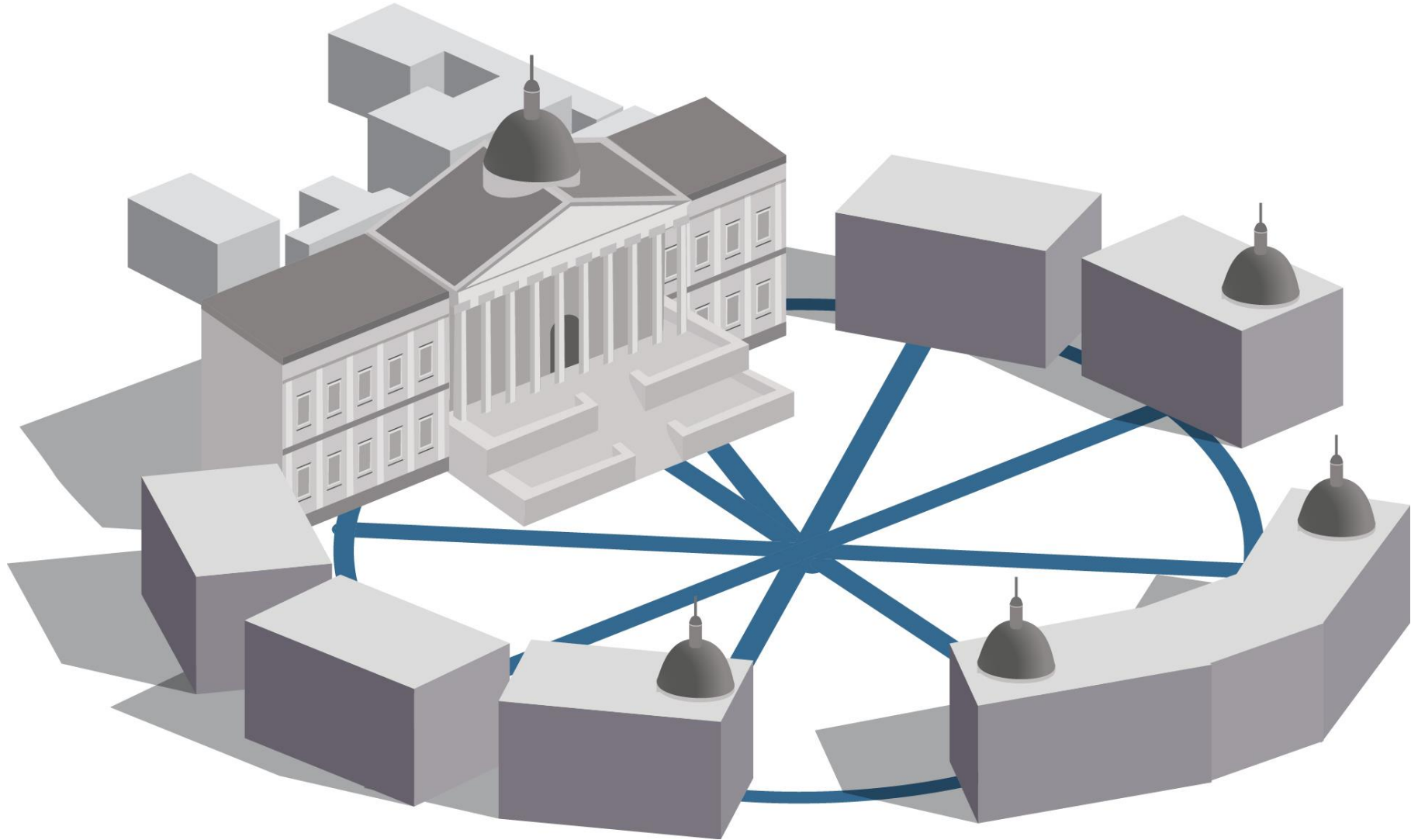
Ensure diversity and market competition

Avoid abandoning the inherent value of existing infrastructure

Use the best technology for a particular applications



# Low Carbon, Local Electricity



# Low Carbon, Local Electricity

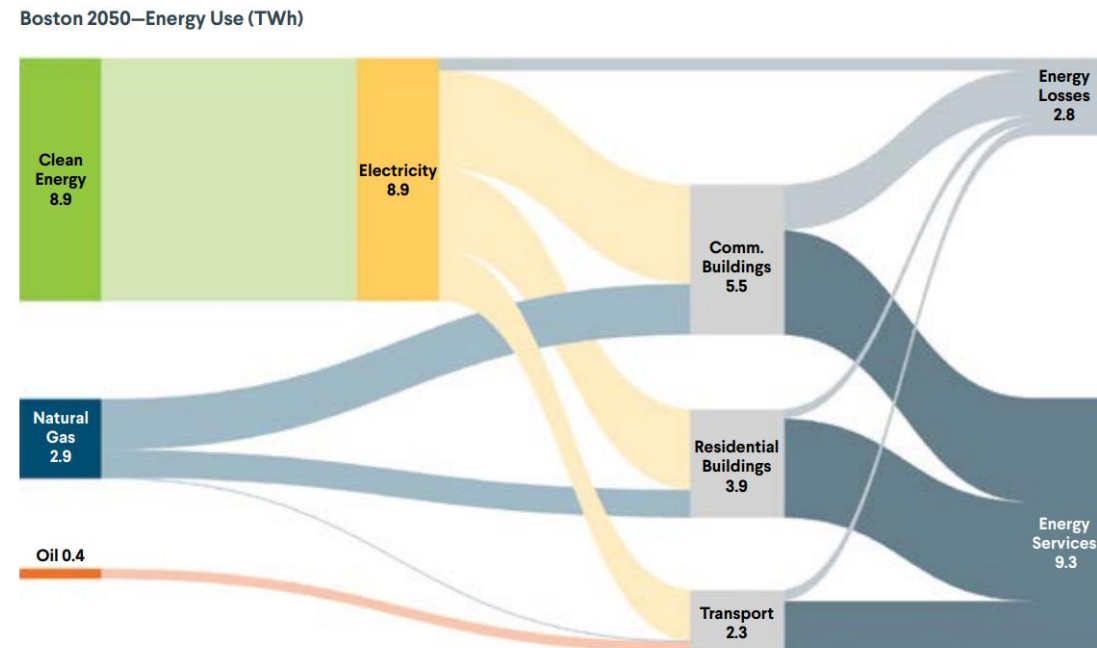
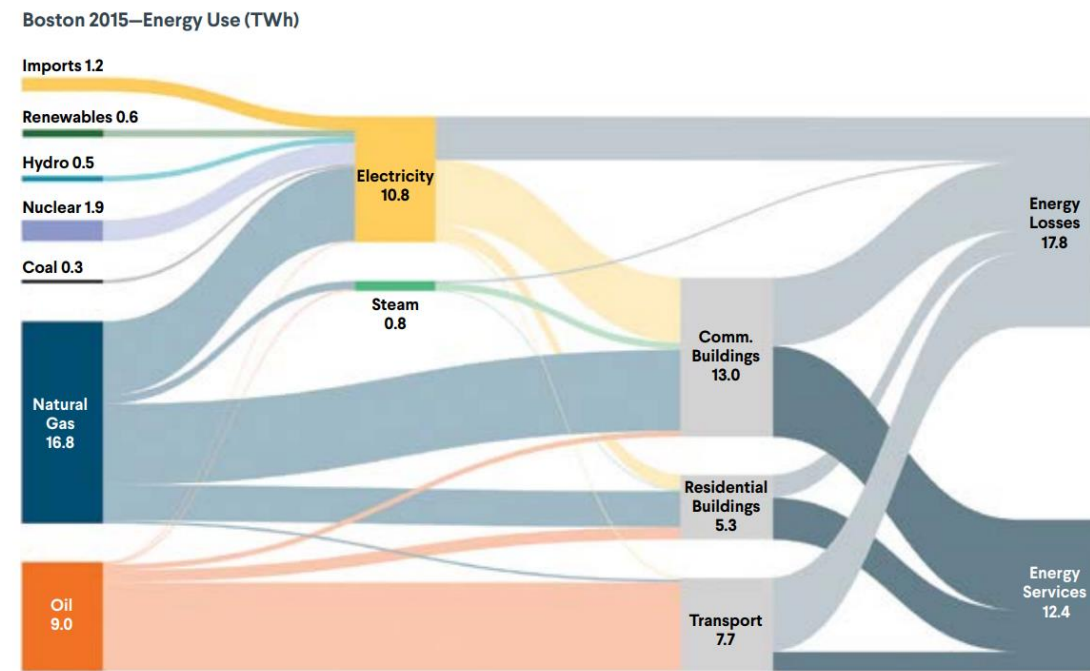
## From 2035 Energy Systems

	WIND	SOLAR	NUCLEAR	GAS	COAL	OTHER*
<b>TODAY</b>	15%	11%	9%	29%	13%	23%
<b>2035</b>	21-28%	13-22%	5-8%	8-30%	0%	31-38%

\*Other = Storage, Biomass, CCS, CHP, Hydro, Interconnectors, Marine, Other thermal, Other renewable

Source: National Grid Future Energy Scenarios

Energy supply  
will transition to  
wind, solar, and  
other renewables





# Low Carbon, Local Electricity

## From 2035 Energy Systems

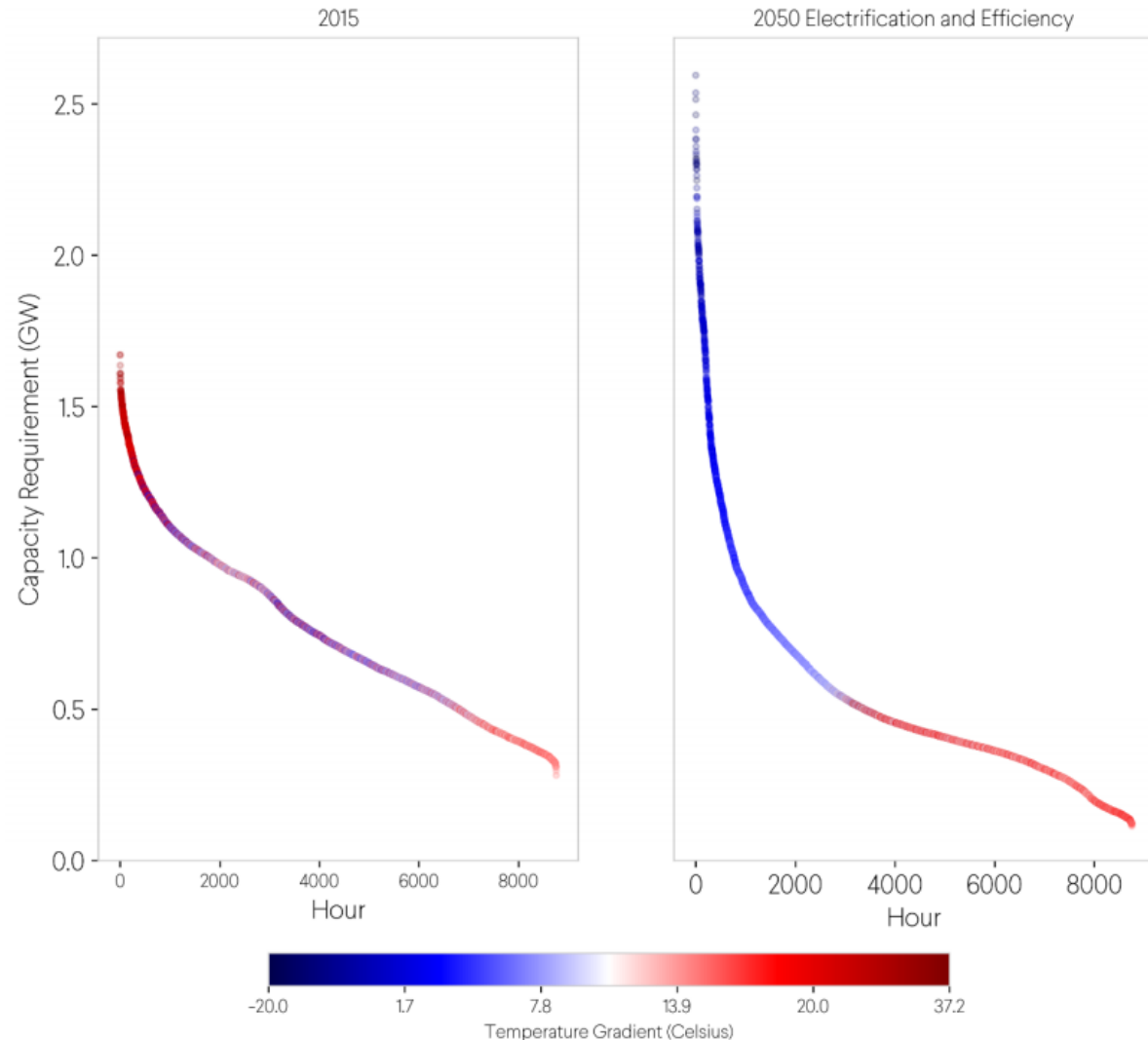
	2016	2035
<b>ELECTRICITY PEAK DEMAND</b>	60.9 GW	62-71 GW

## From Carbon Free Boston



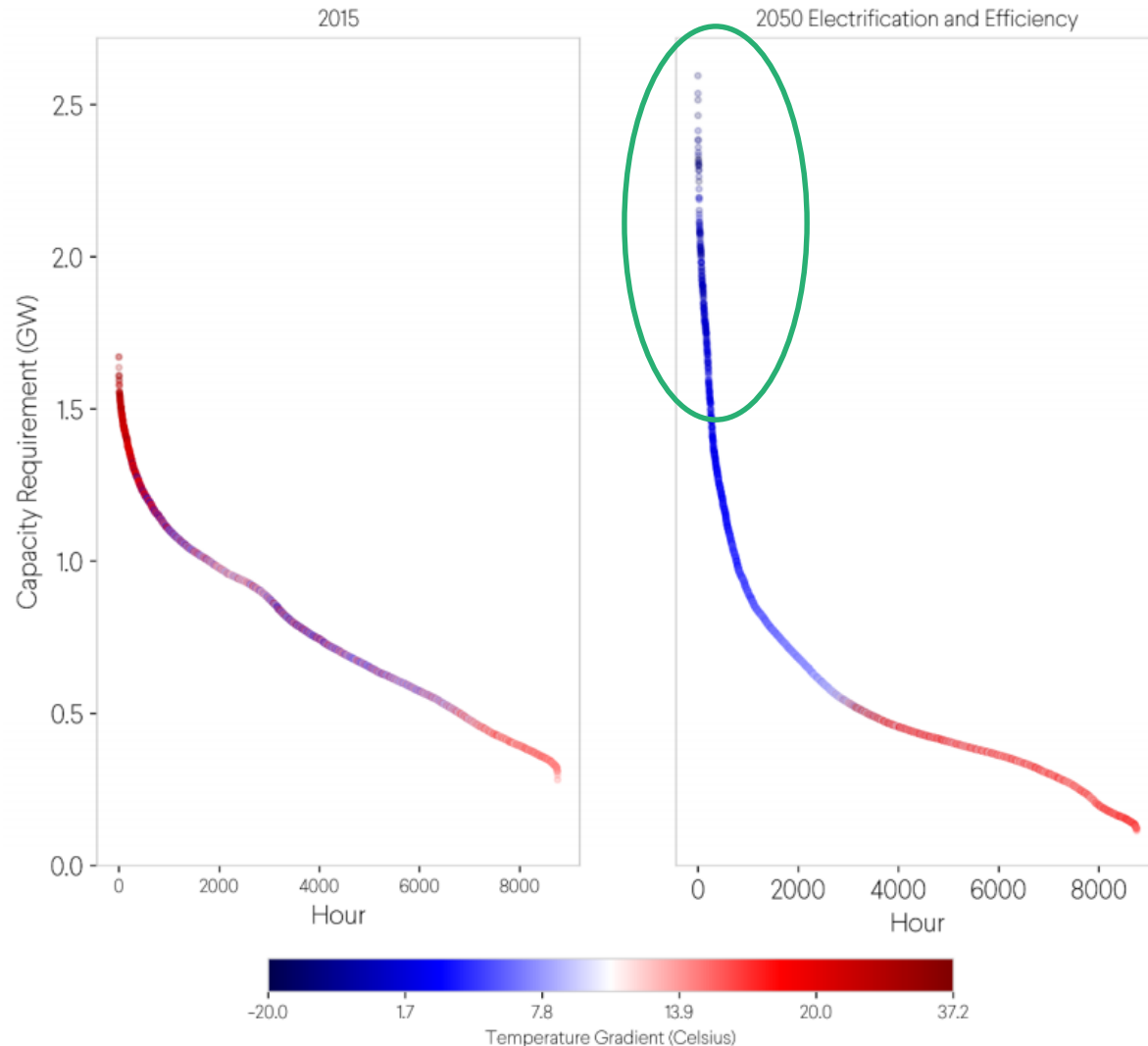


# Low Carbon, Local Electricity



From Carbon Free Boston

# Low Carbon, Local Electricity



- Peak electrical demand expected to occur during heating days
- Could be mitigated by alternative heating fuels such as hydrogen

From Carbon Free Boston

# Intermittency is addressed through increased penetration of energy storage

## At the point of generation

UTILITY-SCALE SOLAR

### Nevada's 2.3-Cent Bid Beats Arizona's Record-Low Solar PPA Price

NV Energy's portfolio of solar and solar-plus-storage takes the low-price competition up a notch.

JULIAN SPECTOR | JUNE 12, 2018



Nevada's sunshine and wide open spaces are finally being converted into record-low solar contracts.

Photo Credit: 8minutenergy



<https://www.greentechmedia.com/articles/read/nevada-beat-arizona-record-low-solar-ppa-price#gs.kan2c8>



## On the grid

### 2MW/4MWh Flow Battery for SDG&E



<https://www.arup.com/projects/creating-industry-first-resilient-energy-storage-in-san-diego>

## In homes and businesses



SMART provides an extra incentive for Energy Storage which is co-located in PV

MA Clean Peak Standard will incentivize Energy Storage

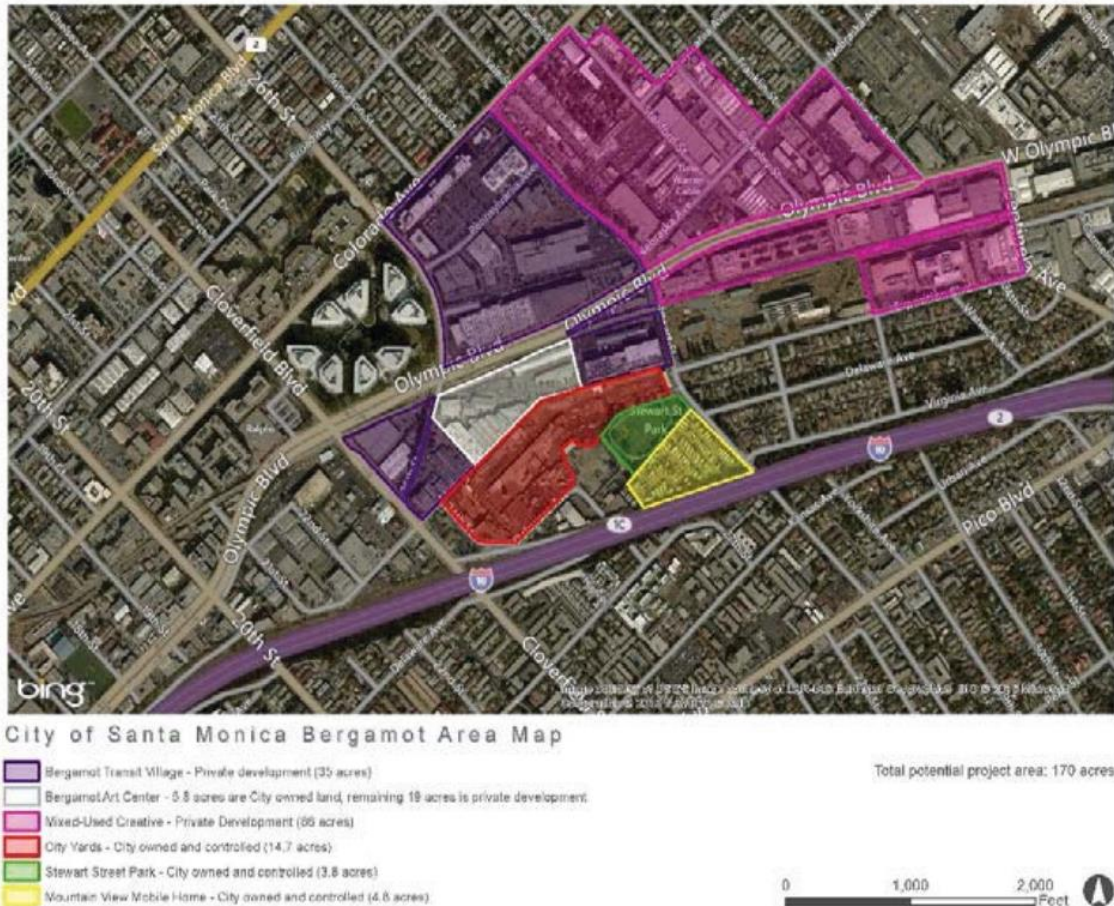
Solar Massachusetts  
Renewable Target  
(SMART) Program

<http://masmartsolar.com/>



# Increased penetration of distributed energy resources will spur development of microgrids

## Santa Monica Advanced Energy District



[https://www.smgov.net/uploadedFiles/Departments/OSE/Task\\_Force\\_on\\_the\\_Environment/TFE\\_2017/Attach\\_5\\_06\\_19\\_17.pdf](https://www.smgov.net/uploadedFiles/Departments/OSE/Task_Force_on_the_Environment/TFE_2017/Attach_5_06_19_17.pdf)

## Kendall Square Ecodistrict



<https://www.arup.com/projects/kendall-square-ecodistrict>



# Adoption of smart, high-performance buildings, and deep energy efficiency upgrades will reduce electricity demand

## Boston Seaport Digital Masterplan



## City of Cambridge Municipal Facilities Improvement Plan



(c)Blind Dog Photo

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# Transition to low carbon heating sources



# Transition of building stock from natural gas based heating to electric or other fuels

Cornell Tech - The Bloomberg Center



Images credited to Iwan Baan  
<https://www.arup.com/projects/cornell-tech-the-bloomberg-center>

Hy4Heat



<https://www.arup.com/projects/hy4heat>

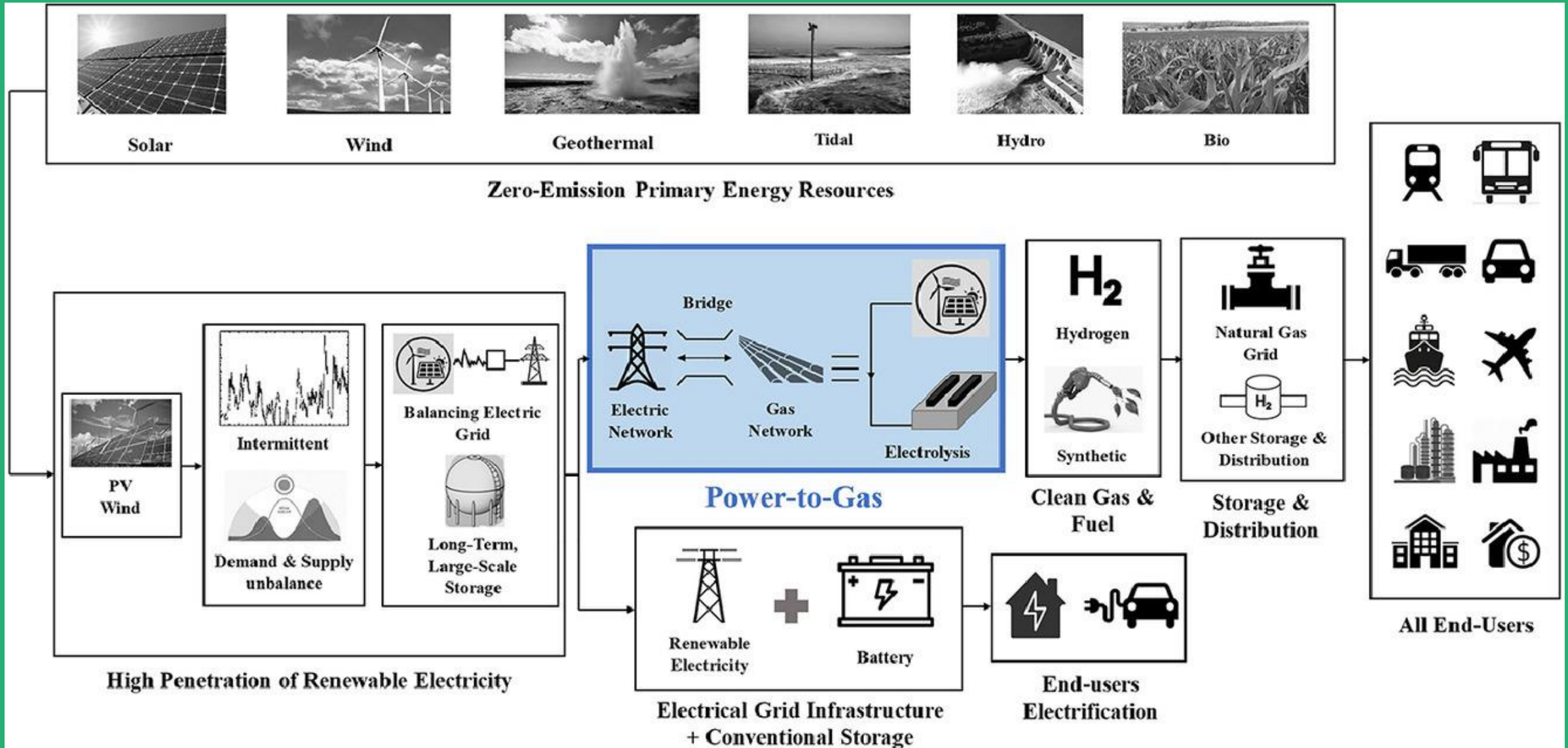
Aside:

Hydrogen as a fuel  
source





# Research from UC Irvine – Dr. Jack Brouwer

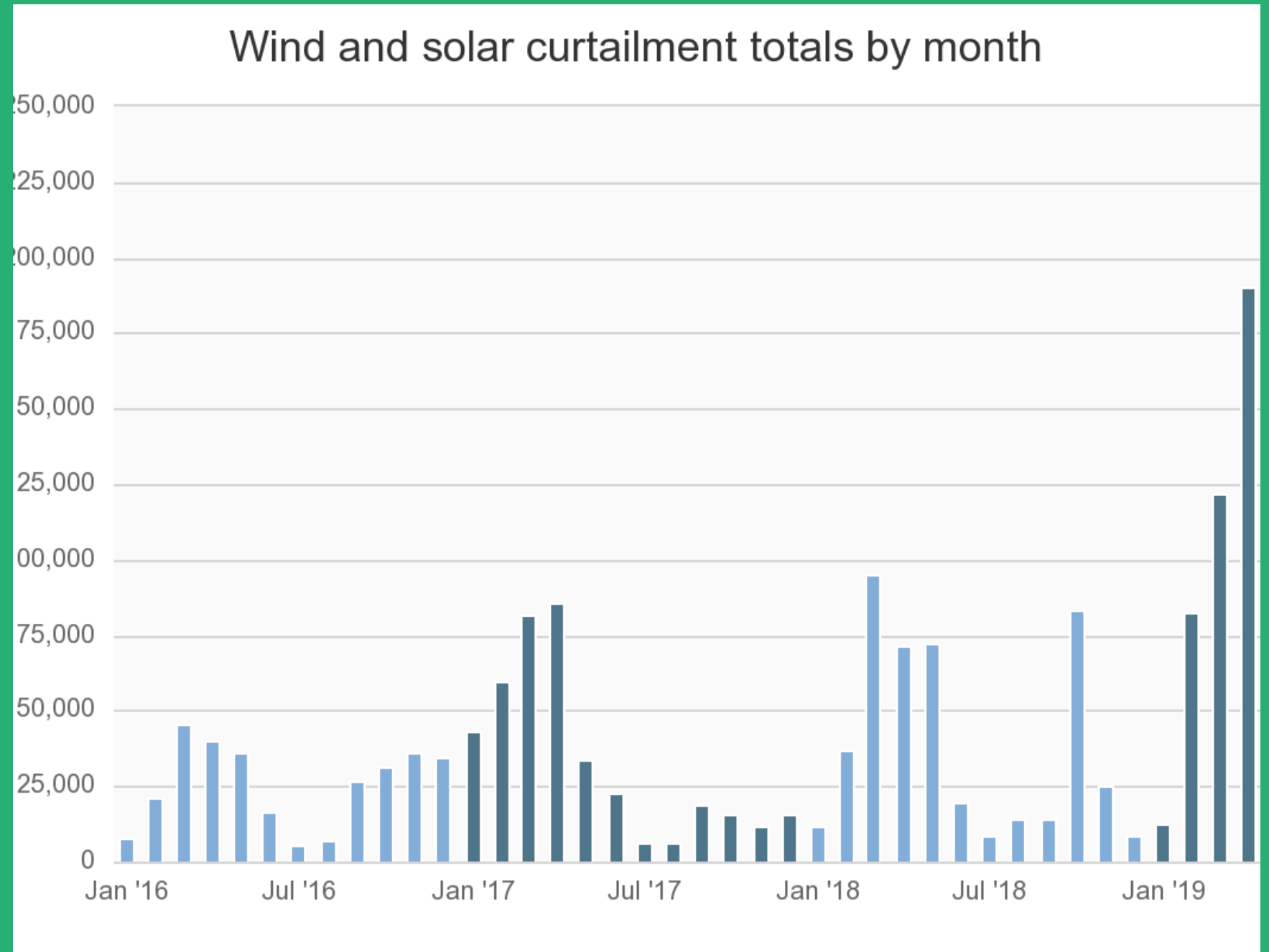


## Hydrogen research/facts

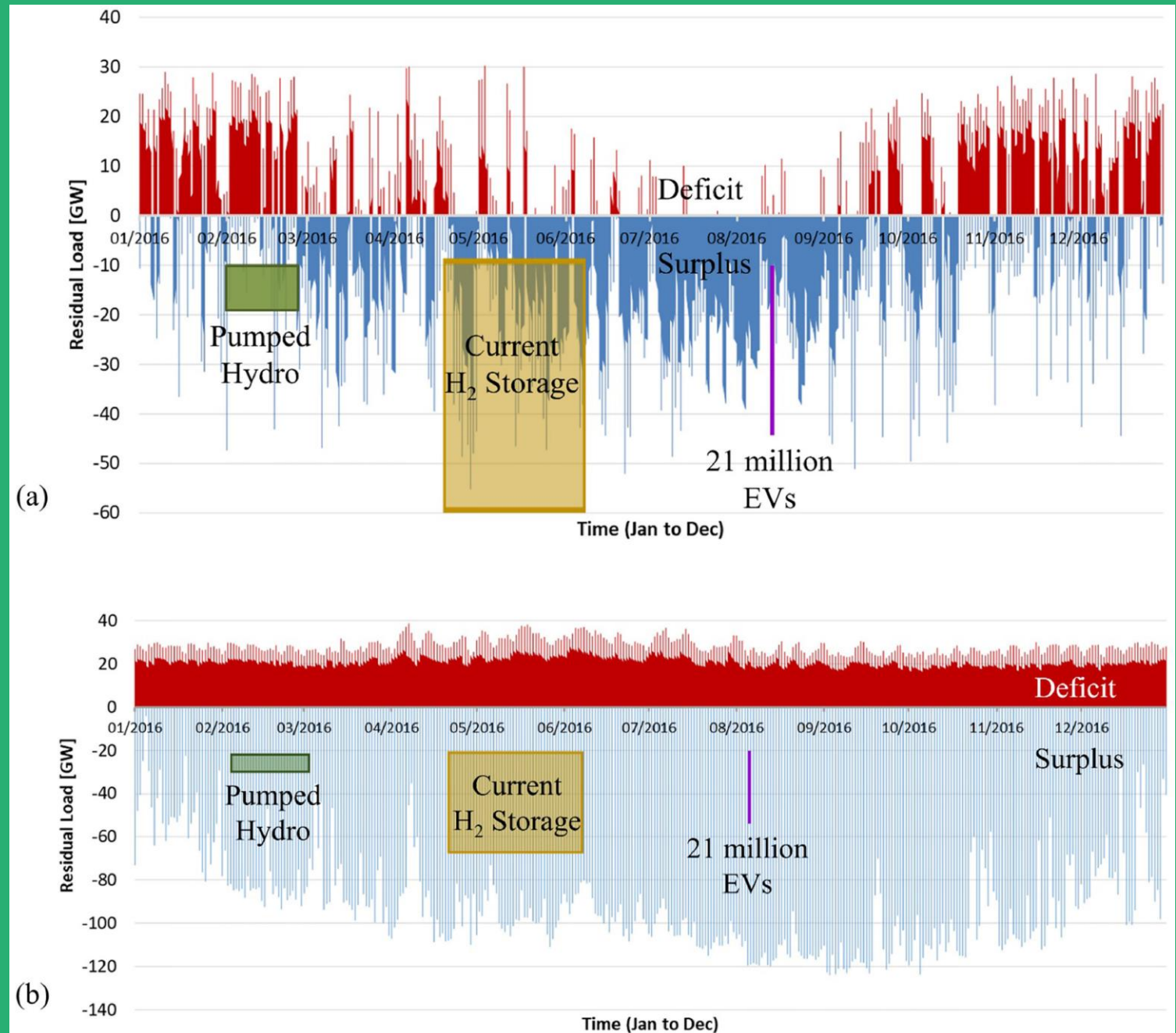
- Hydrogen can be blended (5-15%) into existing natural gas infrastructure before infrastructure and appliance replacement required. (<https://www.nrel.gov/docs/fy13osti/51995.pdf>)
- Generation of hydrogen using renewable energy can provide carbon free energy
- Hydrogen can be used to provide seasonal energy storage with higher efficiency than batteries
- Hydrogen may be a good alternative for EV's which require a daily range in excess of 200mi



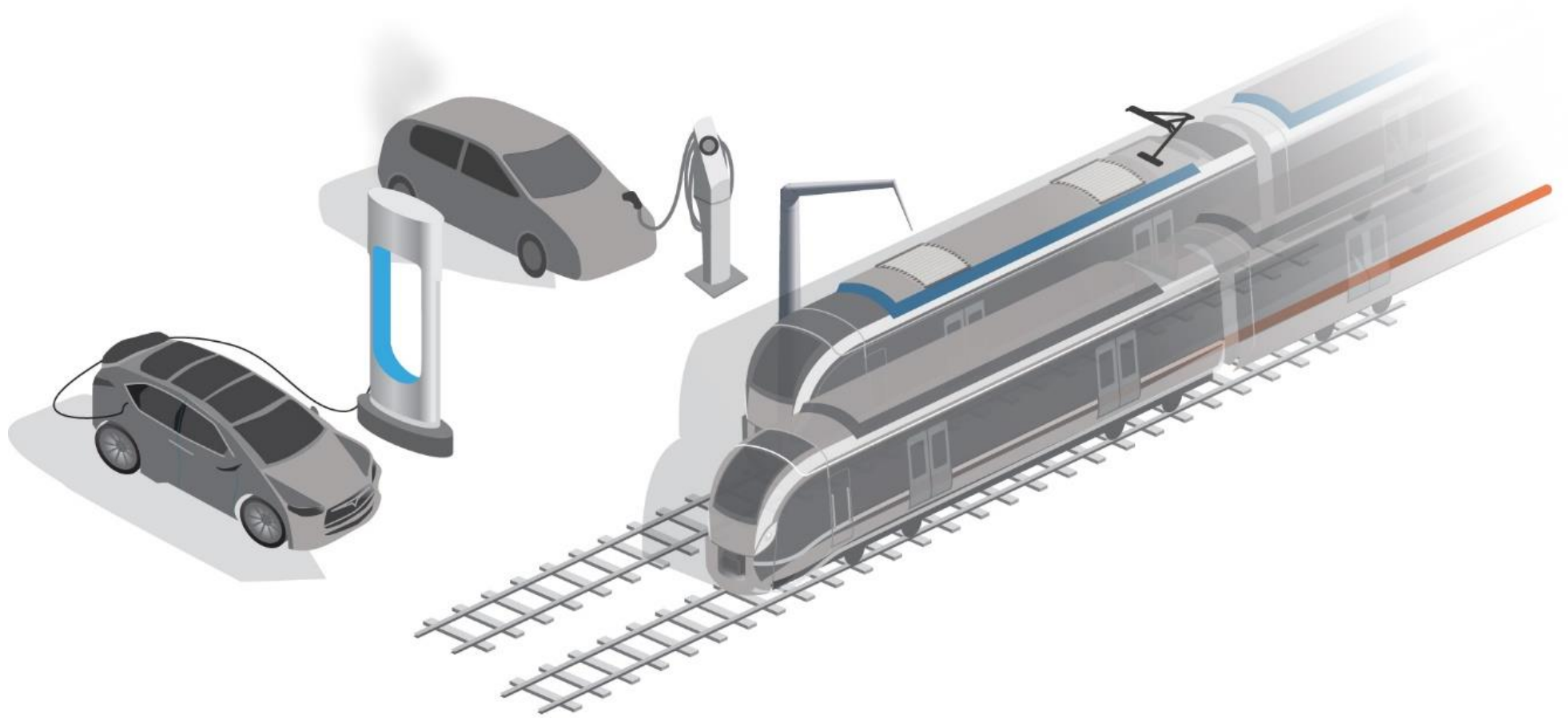
Excess renewable  
production can be  
used to generate  
hydrogen



Hydrogen can be used for seasonal energy storage



# Decarbonization and Decentralization of Transportation



Electrification of transportation along with shared ownership models and autonomy will reduce the number of vehicles required and decrease the carbon impact of transportation

Vineyard Transit Authority – Bus Electrification



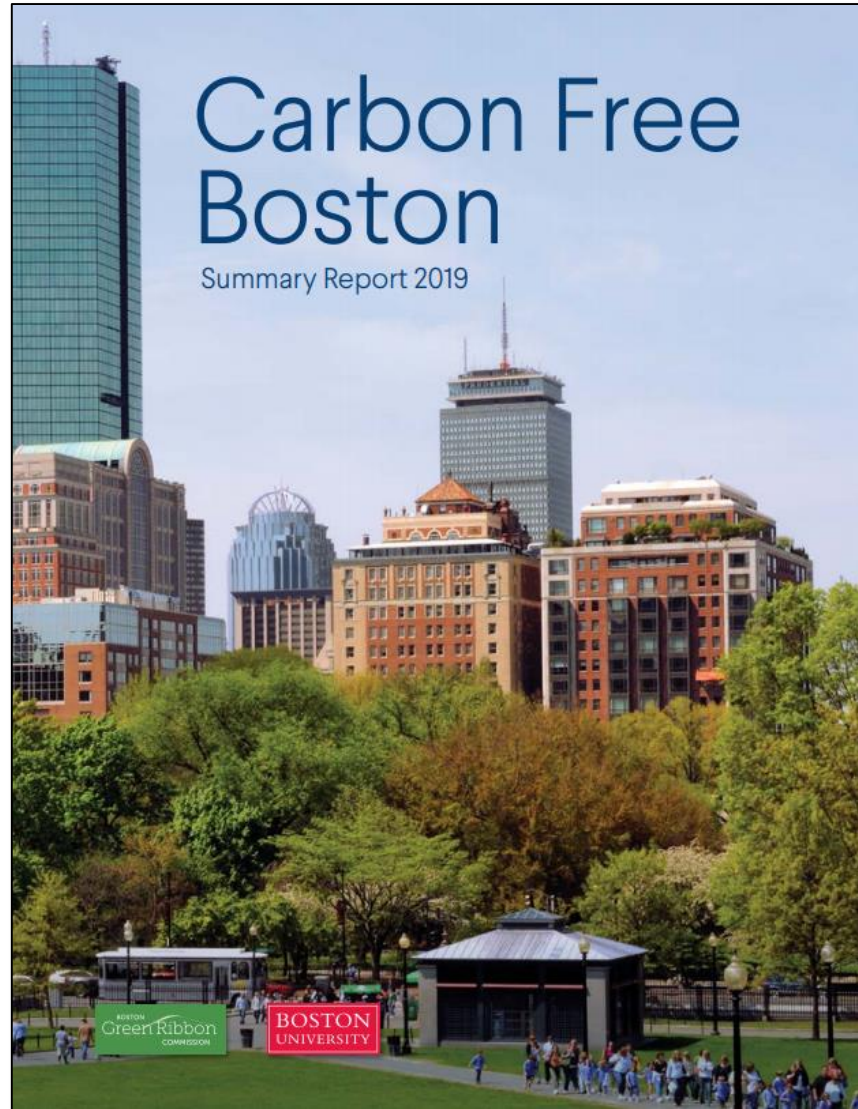
UK Autodrive



<https://www.arup.com/news-and-events/arup-led-uk-autodrive-project>



# Resources



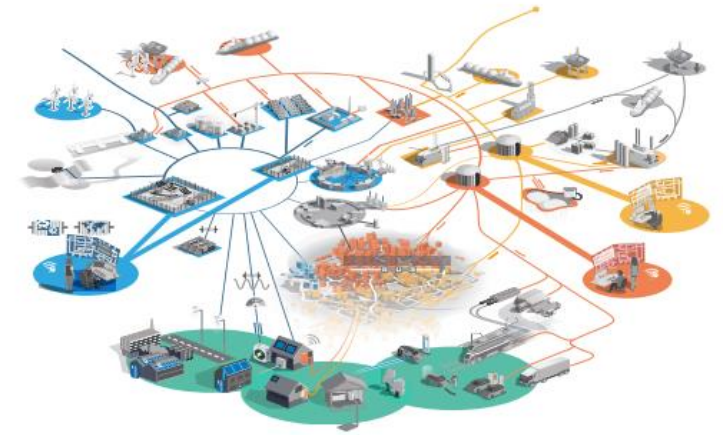
[http://sites.bu.edu/cfb/carbon-free-boston-report-released/?mc\\_cid=d10c081db9&mc\\_eid=70d3d74e5e](http://sites.bu.edu/cfb/carbon-free-boston-report-released/?mc_cid=d10c081db9&mc_eid=70d3d74e5e)

ARUP

SHAPING A BETTER WORLD

Energy systems: A view from 2035

*What will a future energy market look like?*



[arup.com/energy](http://arup.com/energy)

<https://www.arup.com/perspectives/publications/research/section/energy-systems-a-view-from-2035>



# Questions?



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