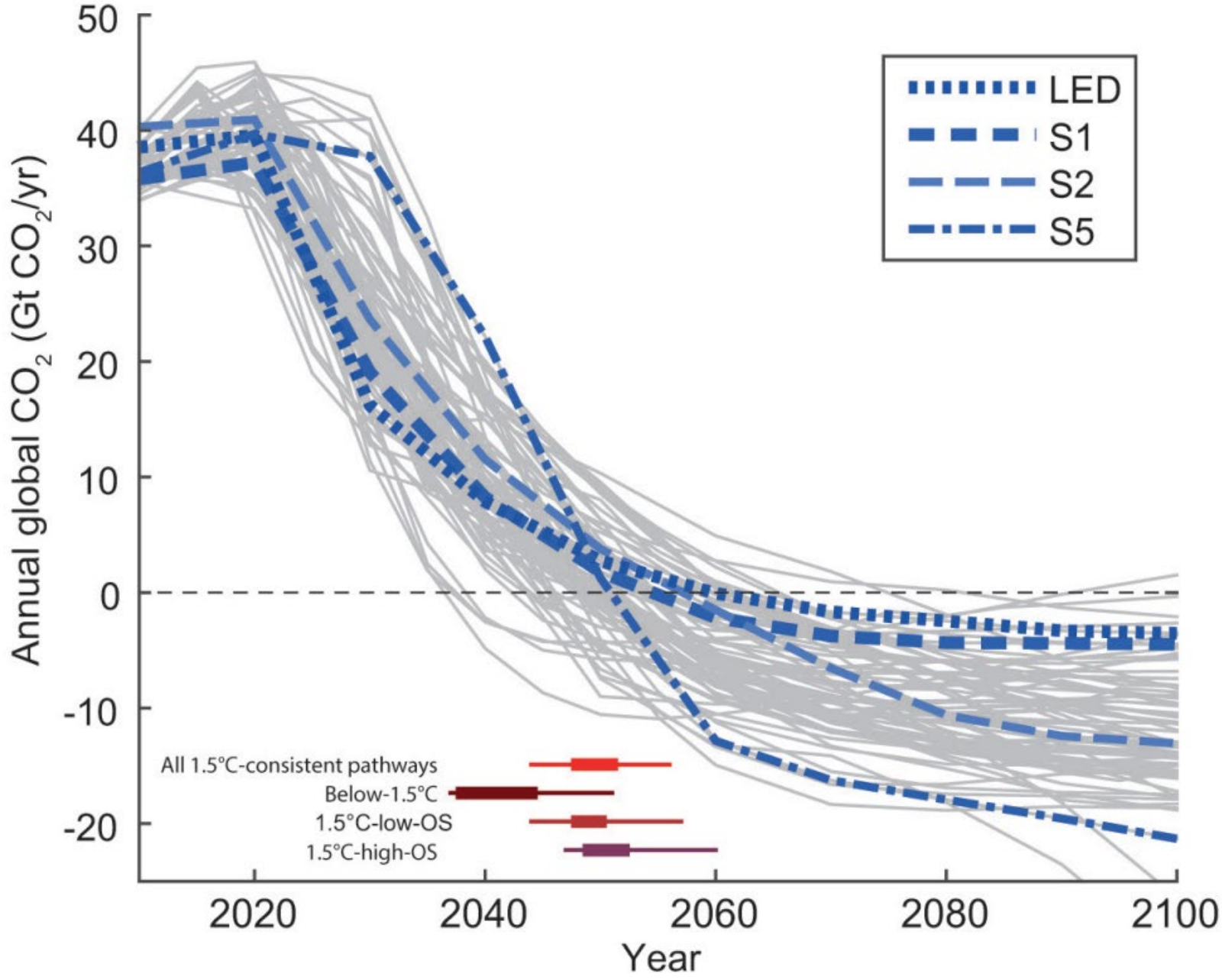
World Scientific Series in Current Energy Issues Volume 6

Energy Efficiency

Innovations: Driving Prosperity, Slashing Emissions

Henry Kelly *editor*

World Scientific


LED
S1
S2
S5
All 1.5°C-consistent pathways
Below-1.5°C
1.5°C-low-OS
1.5°C-high-OS
Annual global CO_2 ($Gt\ CO_2$/yr)
50
40
30
20
10
0
-10
-20
2020
2040
2060
2080
2100
Year

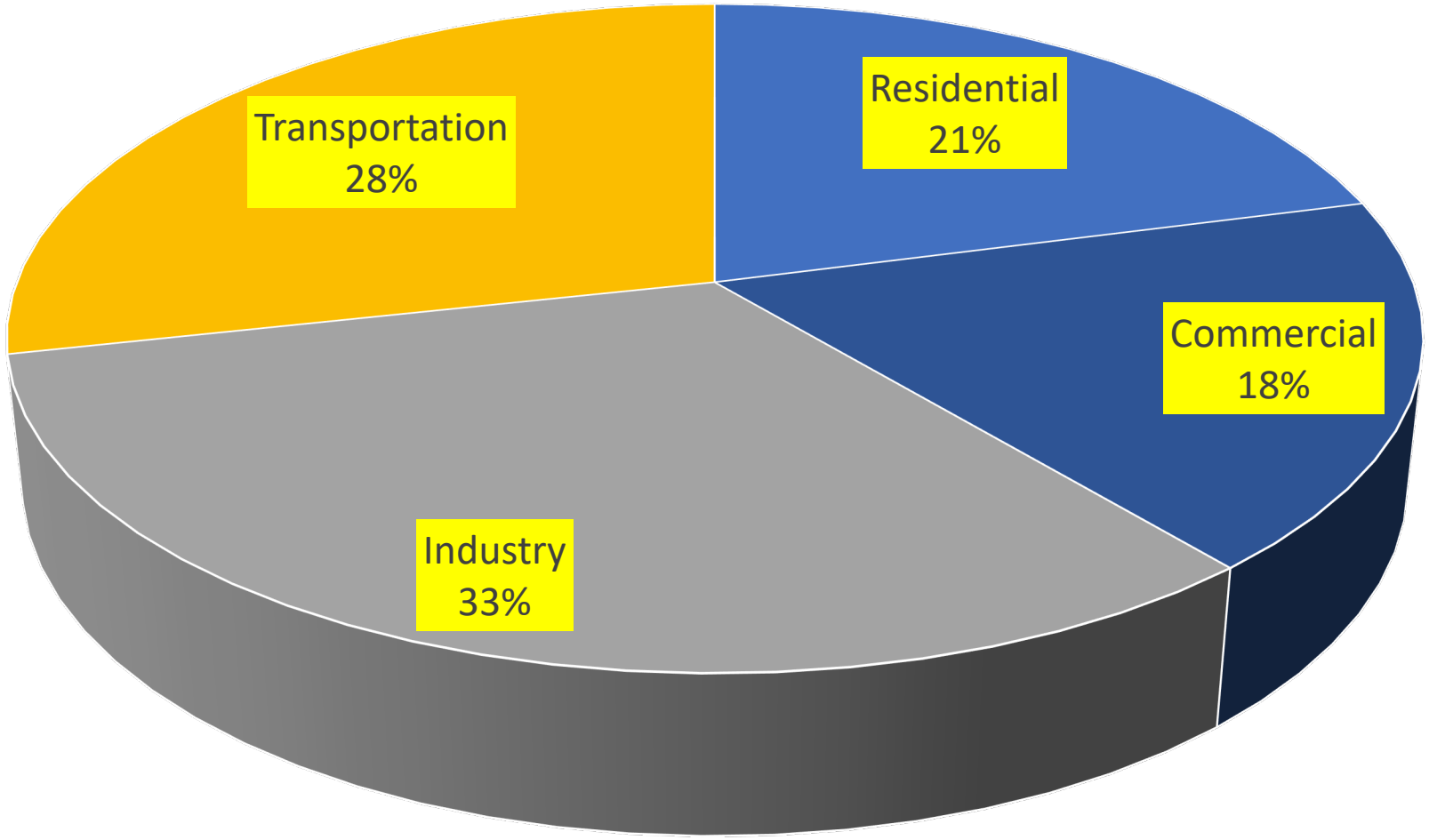
Major Themes

Systems

Electrification

Digitization

US Energy Consumption 2019



US EIA Monthly Energy Review

Systems Efficiency

Buildings as systems integrated with the environment

Transportation systems (mobility as a service)

Industrial production systems (including life cycle of materials)

Cities as systems

Electrification

Car and light truck electrification

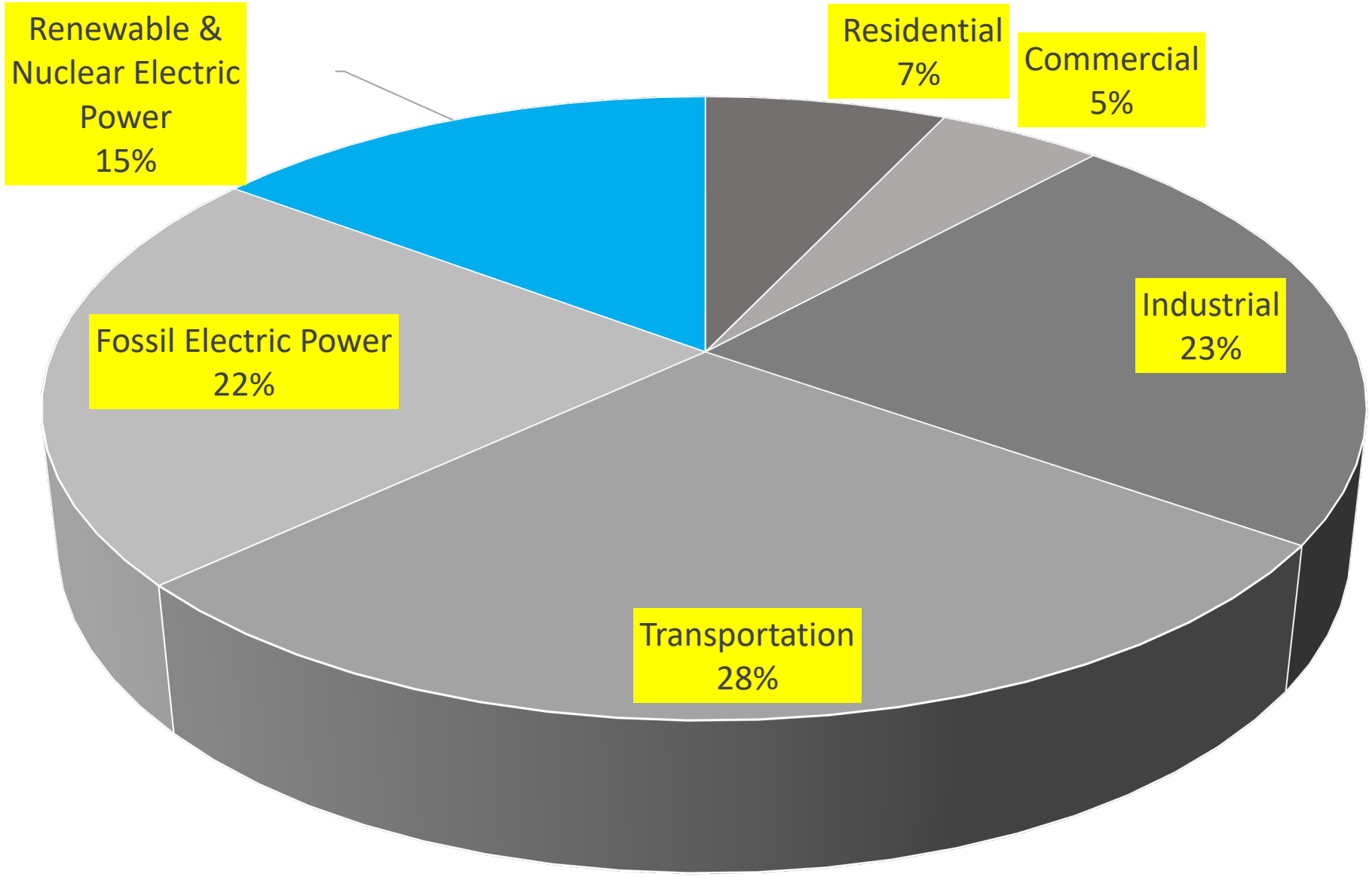
Heat pumps for low temperature heating, and cooling

Non-thermal separations and dehumidification

Industrial Process (Steelmaking)

Electrochemical/biological manufacturing

Challenges: US Primary Energy Use 2019



US EIA Monthly Energy Review

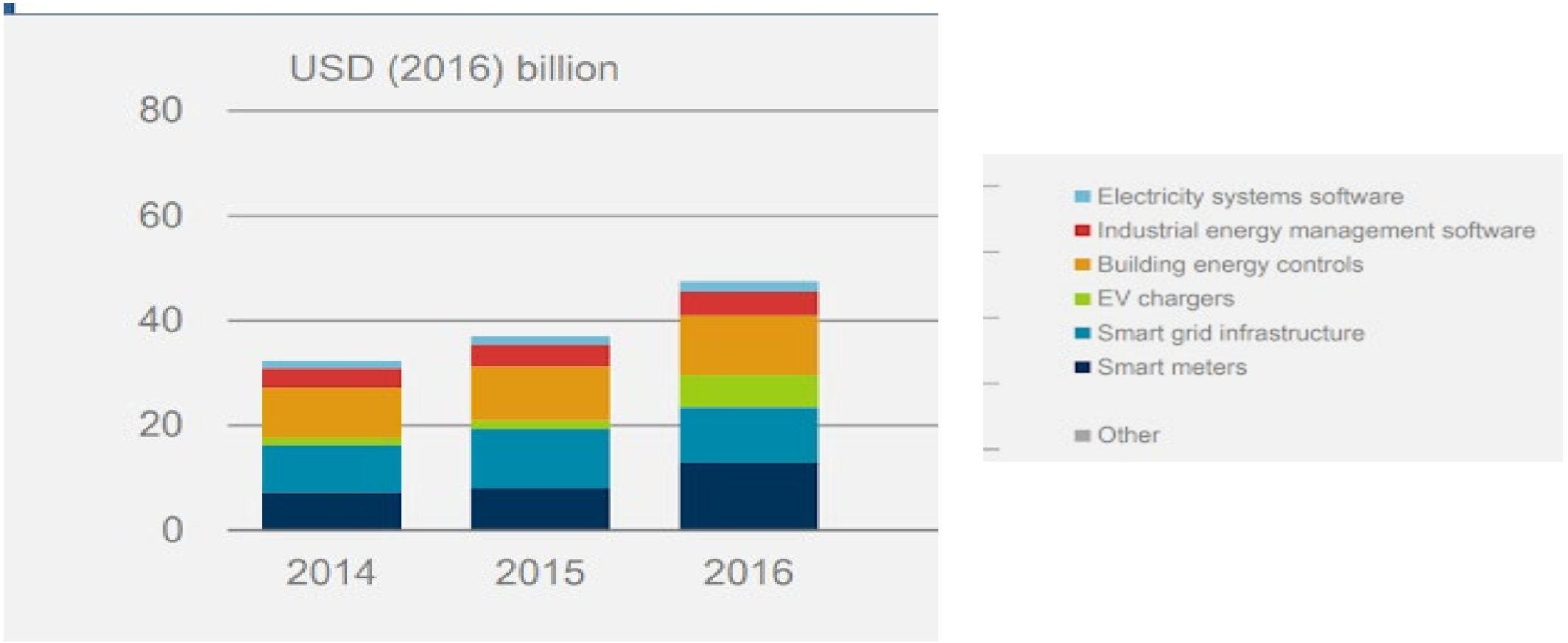
Digitization

Unprecidented control through low-cost sensors and communication

Optimization of designs, integration of designs

Optimization of operations (continuous improvement, immediate fault detection)

Digitization: Investments in digital electricity infrastructure and software (IEA)



Industrial energy

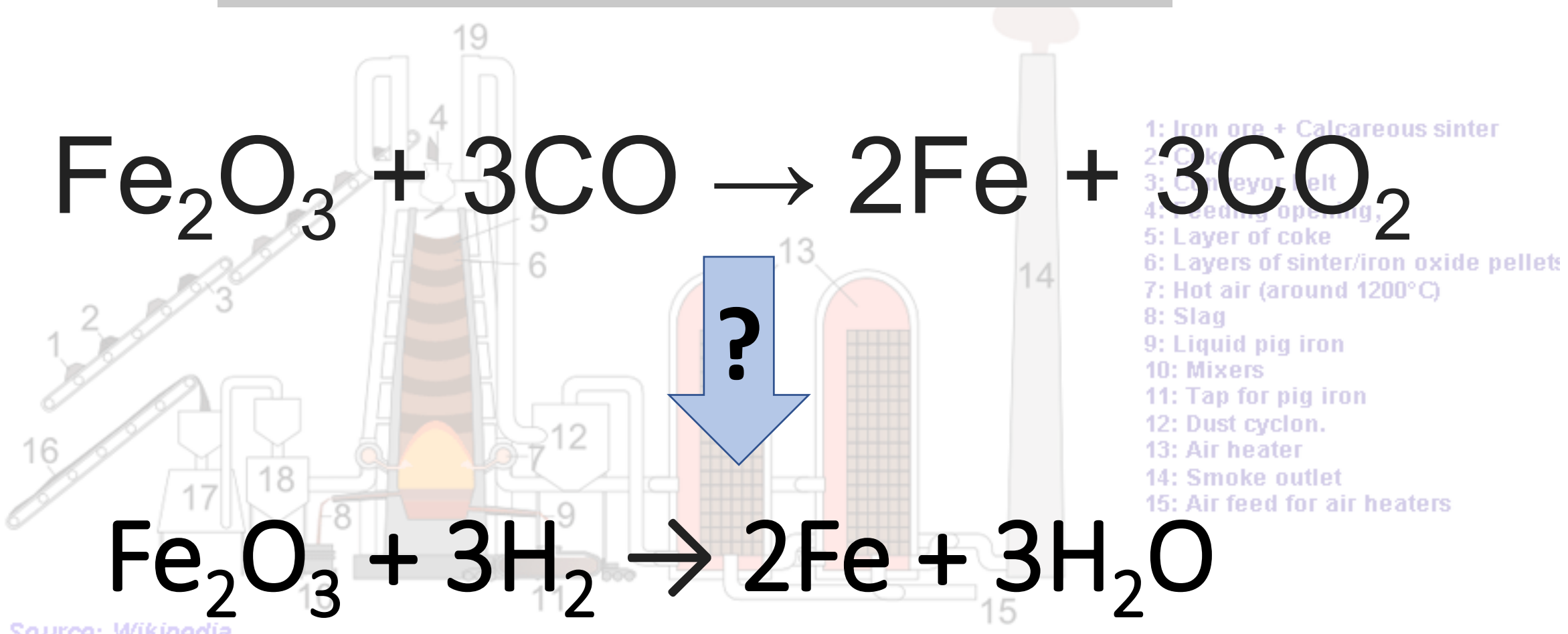
- **Revolution in industrial processes** (hydrogen for steel, biomanufacturing for chemicals, carbon capture)
- **Efficient Use of Materials** (improved function per pound, simulation based design improvements)
- **New Tools for Designing Materials** (computational design, biomimetics)
- **Circular Economy** (efficient disassembly, design for recycling)
- **Material Substitution** (replace high net carbon materials)

Process Innovation

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

?

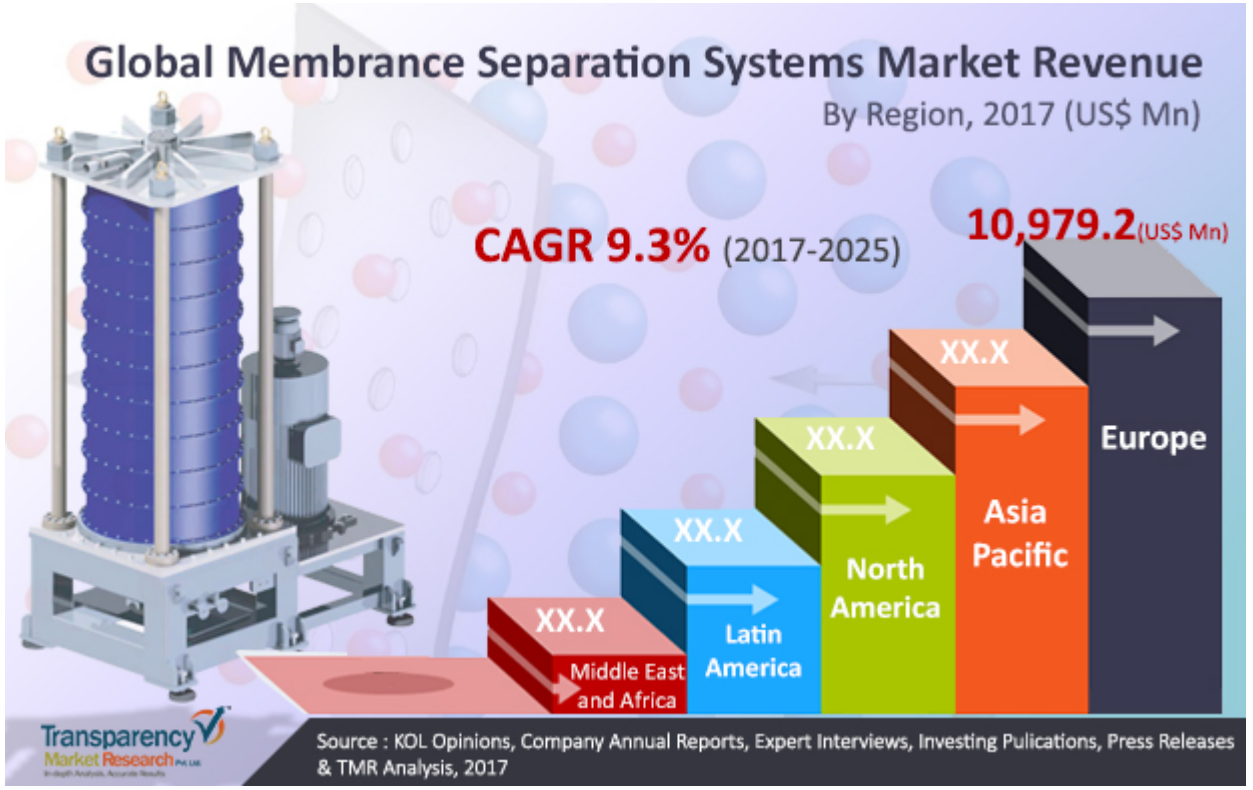
$$Fe_2O_3 + 3H_2 \rightarrow 2Fe + 3H_2O$$



Source: Wikipedia

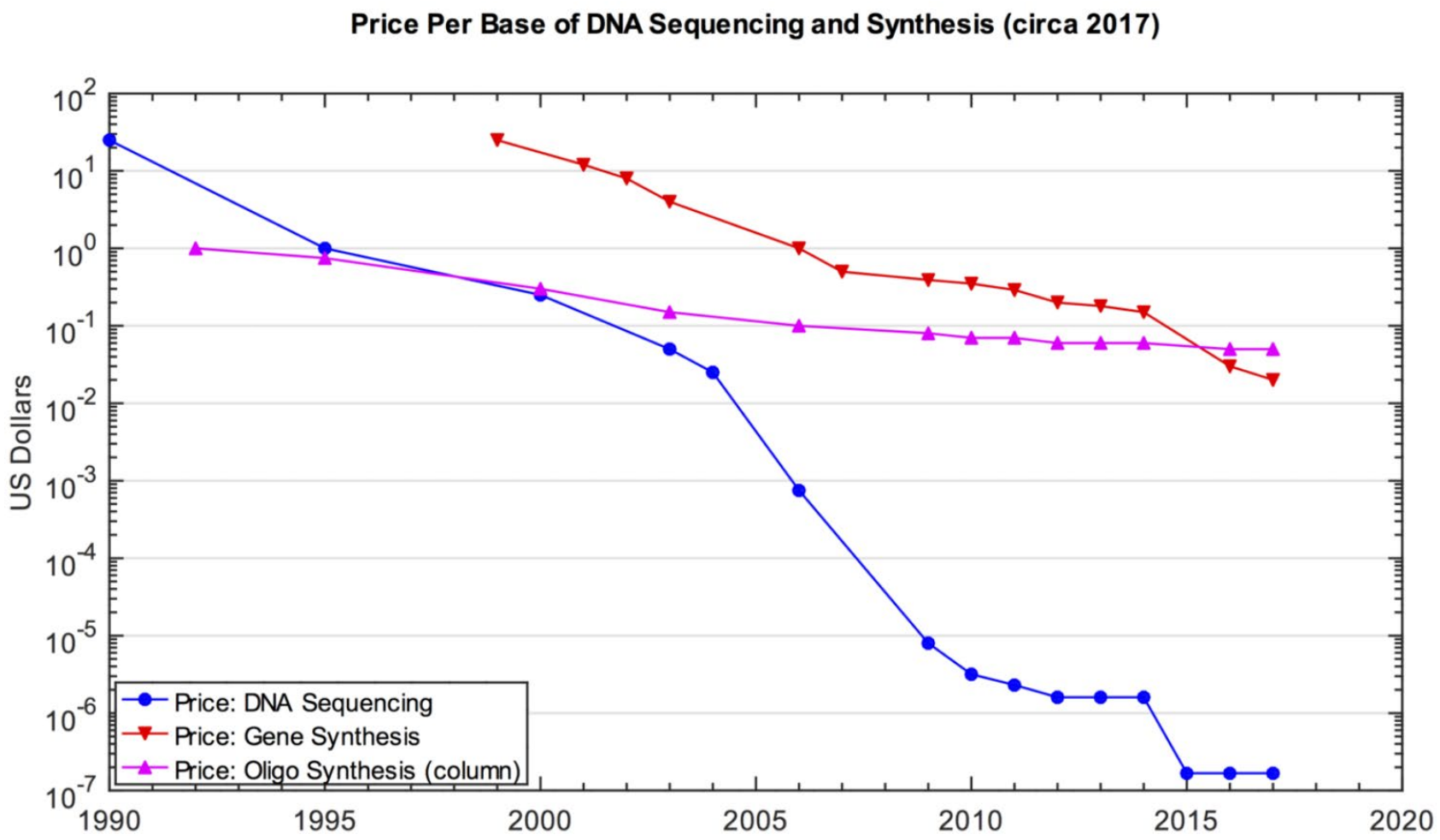
Process Revolutions: Heating, Drying, Separations

- *High efficiency Heat Pumps*
- *Membranes and advanced filtration*



Source: Transparency Market Research

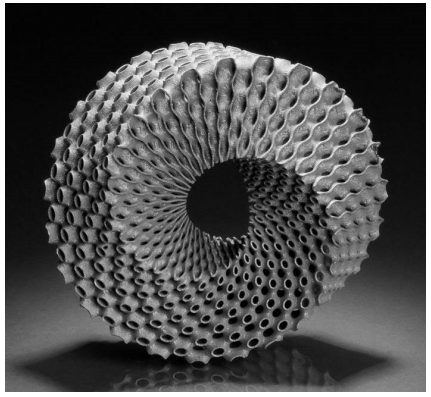
Biological Production of Chemicals

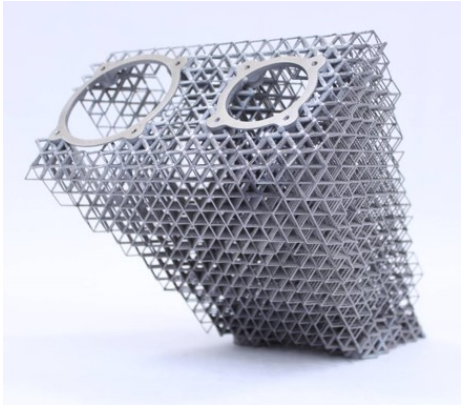


Source: Bioeconomy Capital, 2018

Systems Process Revolutions: Computer Design & Additive Manufacturing

- *They can reduce use of raw materials*. Parts can be designed to use material only where it is actually needed -savings of up to 90% are possible.
- *The production process itself can be more efficient*
- *The optimized, lightweight parts produced can increase the efficiency of vehicles, robots, and other devices using them*





Muta pagoda, built in 1056, 67m tall

Mary Ann Piette, Director, Building Technology and Urban Systems Division, LBNL

Adam Cohen, Transportation Sustainibility Research Center, University of California Berkeley

Gaudy Bezos O'Connor, Aeronautics Research Mission Directorate, NASA

Global Opportunities and Challenges in Energy and Environmental Issues in the Buildings Sector

Mary Ann Piette, Rick Diamond, Steve Selkowitz, Stephane de la Rue du Can, Tianzhen Hong, Kaiyu Sun, Paul Mathew, Iain Walker, Alan Meier, Erik Page, and Jessica Granderson, Nan Zhou, and Peter Alstone

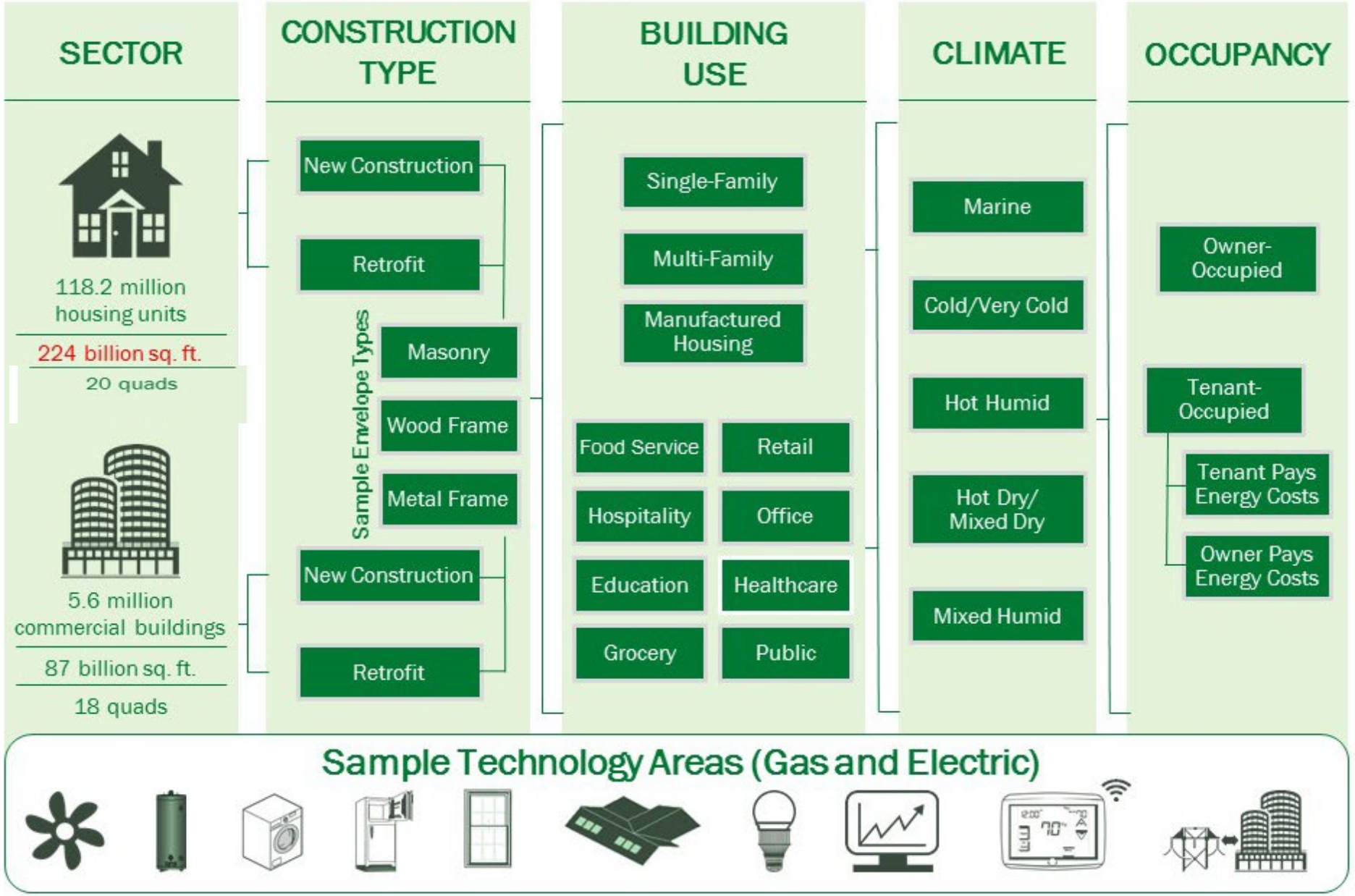
BERKELEY LAB
ENERGY TECHNOLOGIES AREA
BUILDING TECHNOLOGY & URBAN SYSTEMS DIVISION

buildings.lbl.gov
Lawrence Berkeley National Laboratory

Presentation Outline

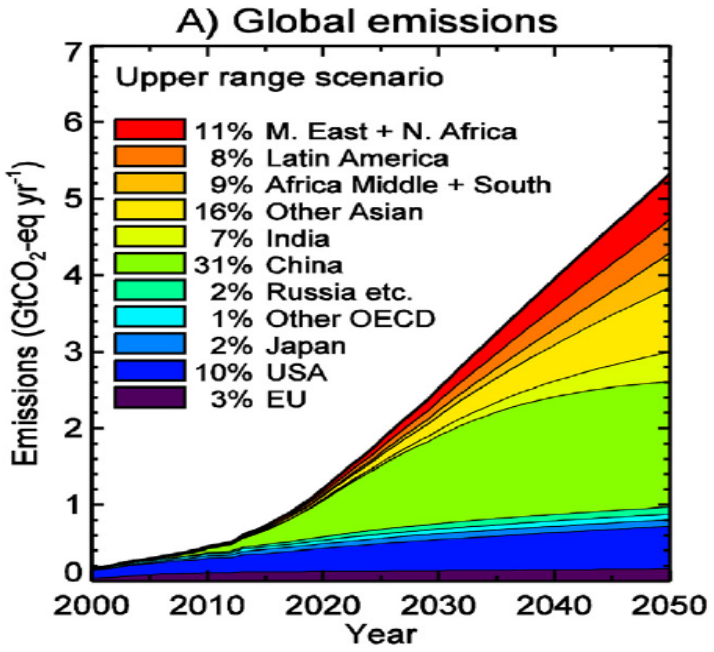
- Introduction to Buildings Sector
- Examples of Energy Efficiency Opportunities
  - Global Cooling Challenge
  - Thin Triple Window
  - Retrofits and Existing Buildings
- Grid Interactive Efficient Buildings
- Summary and Future Directions

Buildings Market is Complex – using 38 Quads in US - $380B/yr



Source:
DOE BTO

Global Cooling and Energy Efficiency

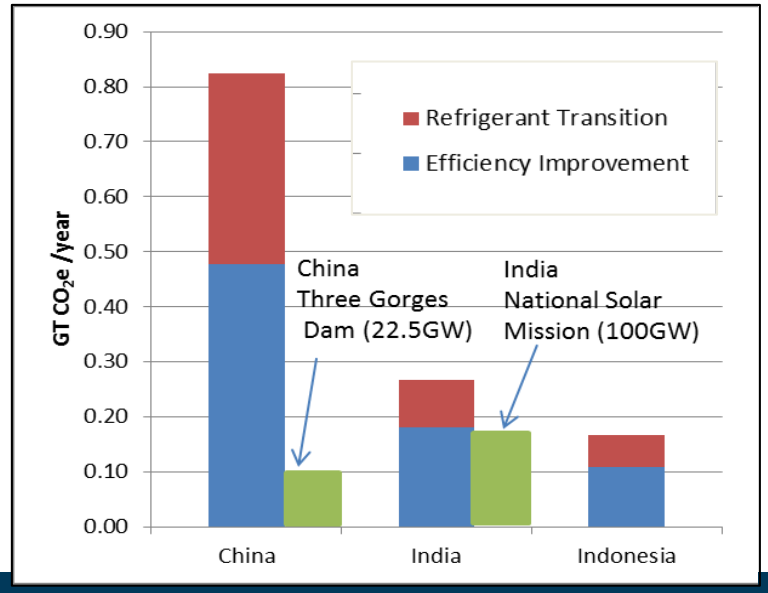


Energy and Environment

The world is about to install 700 million air conditioners. Here's what that means for the climate

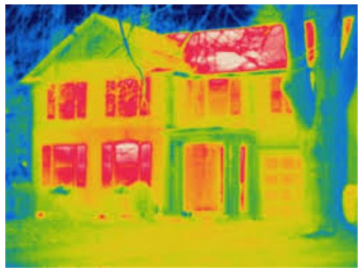
AC is fastest growing energy end-use in the world

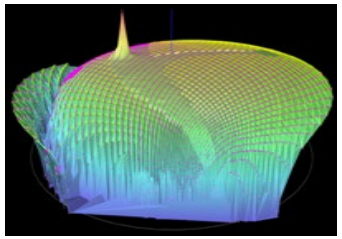
200 countries in **Kigali Amendment** of Montreal Protocol to cut GWP HFCs, eliminating ~100 Gt of CO_2 emissions (to lower global temps by up to 0.5 ºC by 2100) (Velders, 2015).



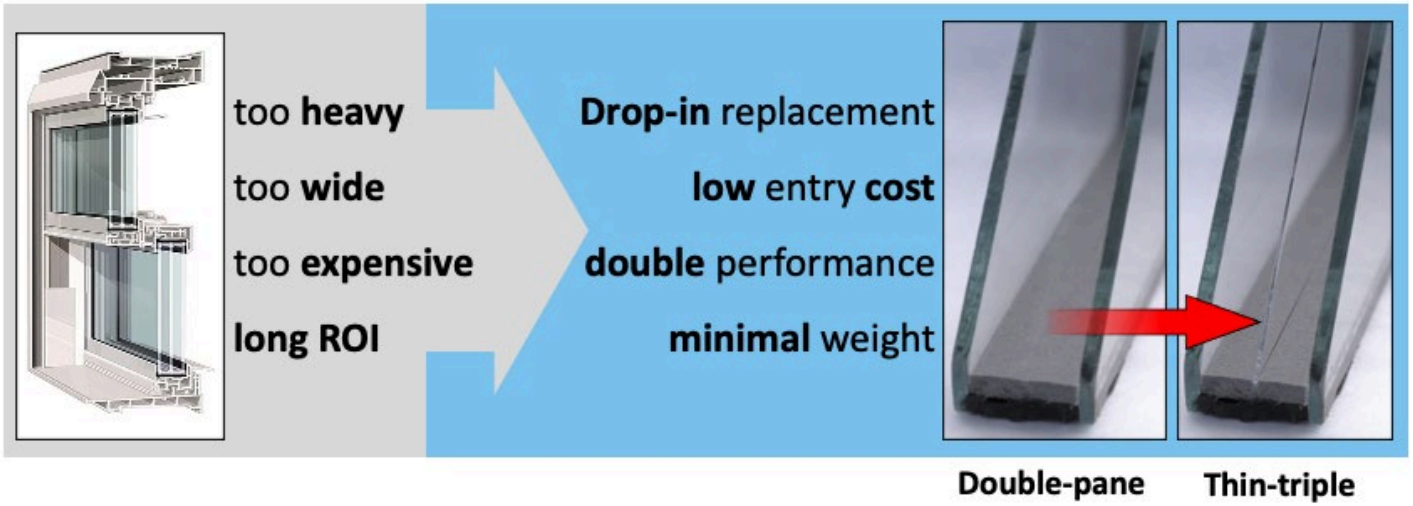
Increasing room AC efficiency 30% in tandem with **Kigali Amendment** doubles CO_2 eq emissions savings by 2030. (Shah et al, 2015).

Advanced Windows Can Reduce 2 Quads of Energy Use





Thin-triple glazing increases performance, reduces market barriers



Demonstration of Thin-Triple Windows in Disadvantaged Communities in Fresno, California.

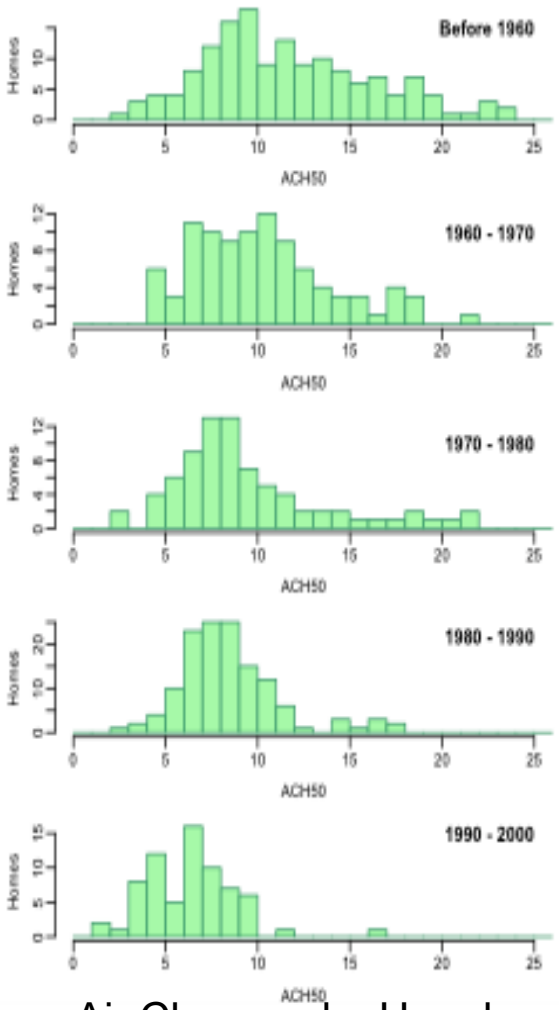
Renewal by Andersen now offering “Enhanced Triple Pane”

Andersen AW CORPORATION

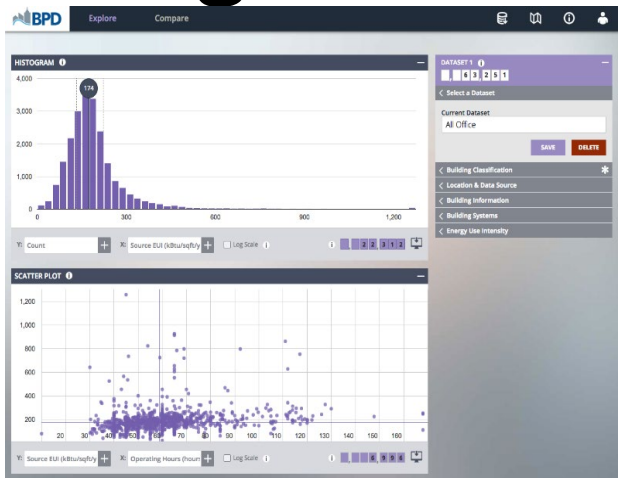
Hart, R. S. Selkowitz, and C. Curcija. 2018. Thermal Performance and Potential Annual Energy Impact of Retrofit Thin-glass Triple-Pane Glazing in US Residential Buildings. Build. Simul. (2019) 12: 79. https://doi.org/10.1007/s12273-018-0491-3

Increasing Energy Efficiency in Buildings

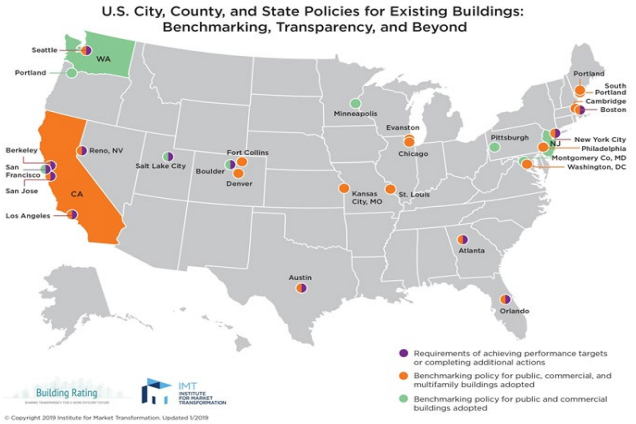
- Energy use of ventilation and health needs to be evaluated to consider indoor air quality, reduce pollutants, consider COVID and wildfire smoke.
- New homes are more efficient and tighter - Avg US House - 15 air changes per hour (ACH), new home avg - 7.
- DOE Building Performance Database allows benchmarking against > 1,000,000 buildings.
- More cities and states require disclosure laws to publish commercial building energy use.



Air Changes by Hour by Year Built

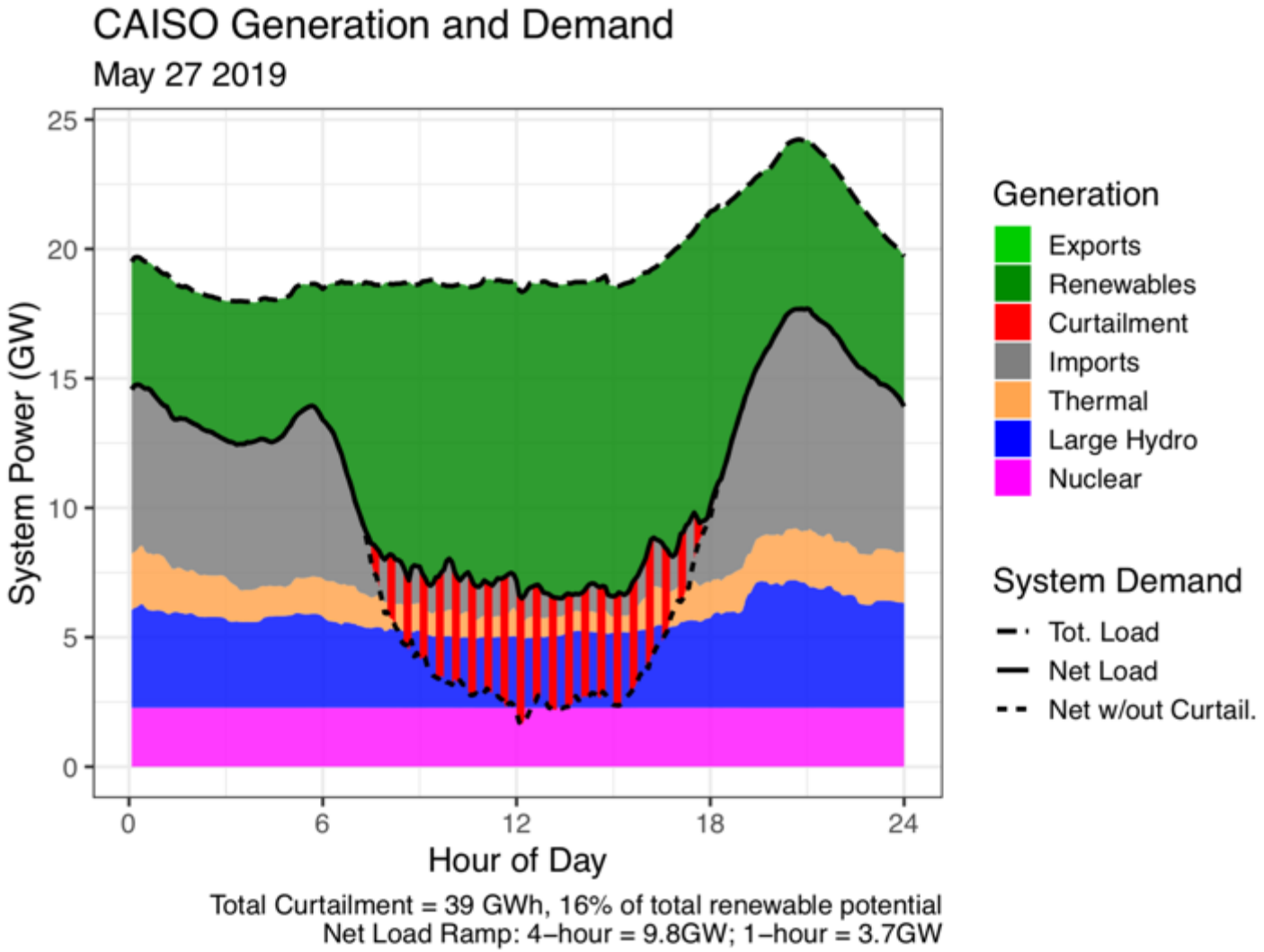


BPD User Interface



Disclosure Laws (from IMT)

Need Responsive Load to Integrate Renewbles and Manage Duck Curve



We often generate more solar than we can use.

Memorial Day 2019 was an extreme case with nearly 40 GWh curtailment.

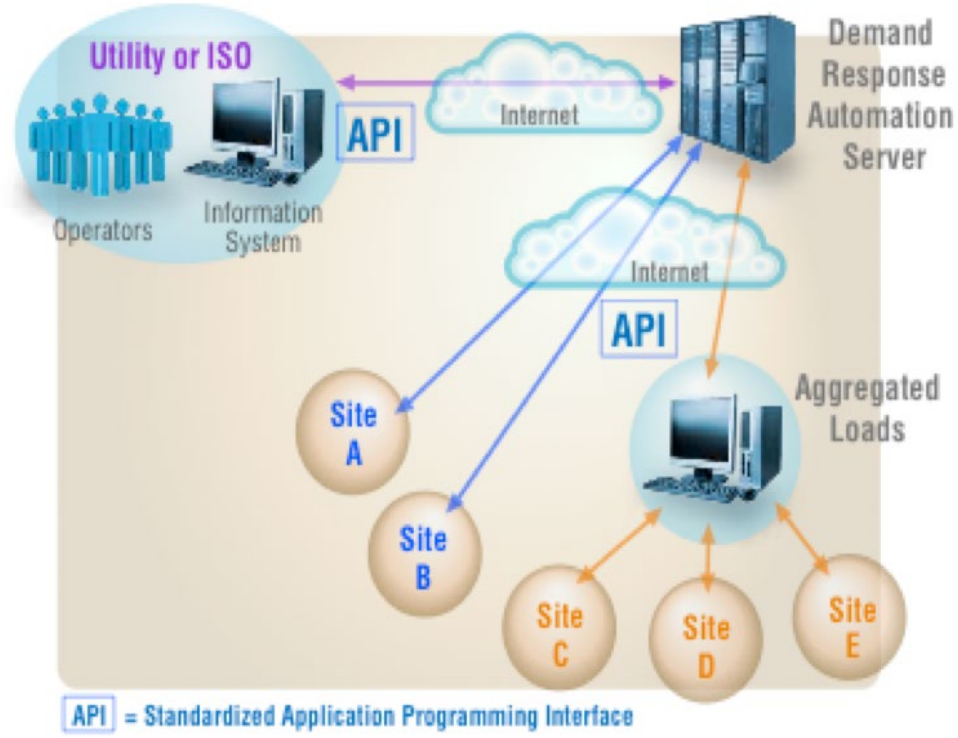
- Low demand
- Sunny day
- No exports

Future - Grid Interactive Efficient Buildings

Using less electricity is important – but when you use it can be just as important.

Sector	End-Use	Demand (GW)
Residential	AC Switch	3.4
	Water Heaters	0.3
	Thermostats	1.2
	Behavioral	0.7
Commercial & Industrial	Automated	3.7
	Customer Initiated	7.2
Mass Market	Other	1.8
Total		18.3

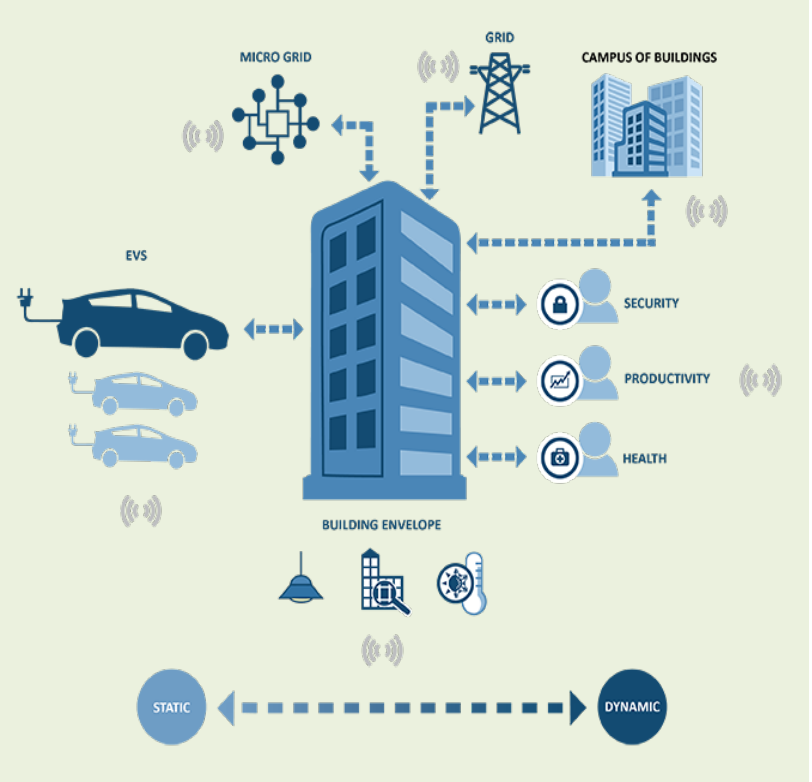
~18 GW of demand response in the US



Open Automated DR – or OpenADR provides a platform for grid signals

Summary and Future Directions

- Energy Efficiency is one of most cost effective opportunities for GHG reduction.
- Research needed on
  - *New technologies*
  - *Field measurement and cost-benefit studies*
  - *Commissioning, controls, automation, interoperability*
  - *Persistence of savings*
  - *Equity*
- Linking efficiency and demand response is synergistic in many cases



Next Generation Mobility Systems

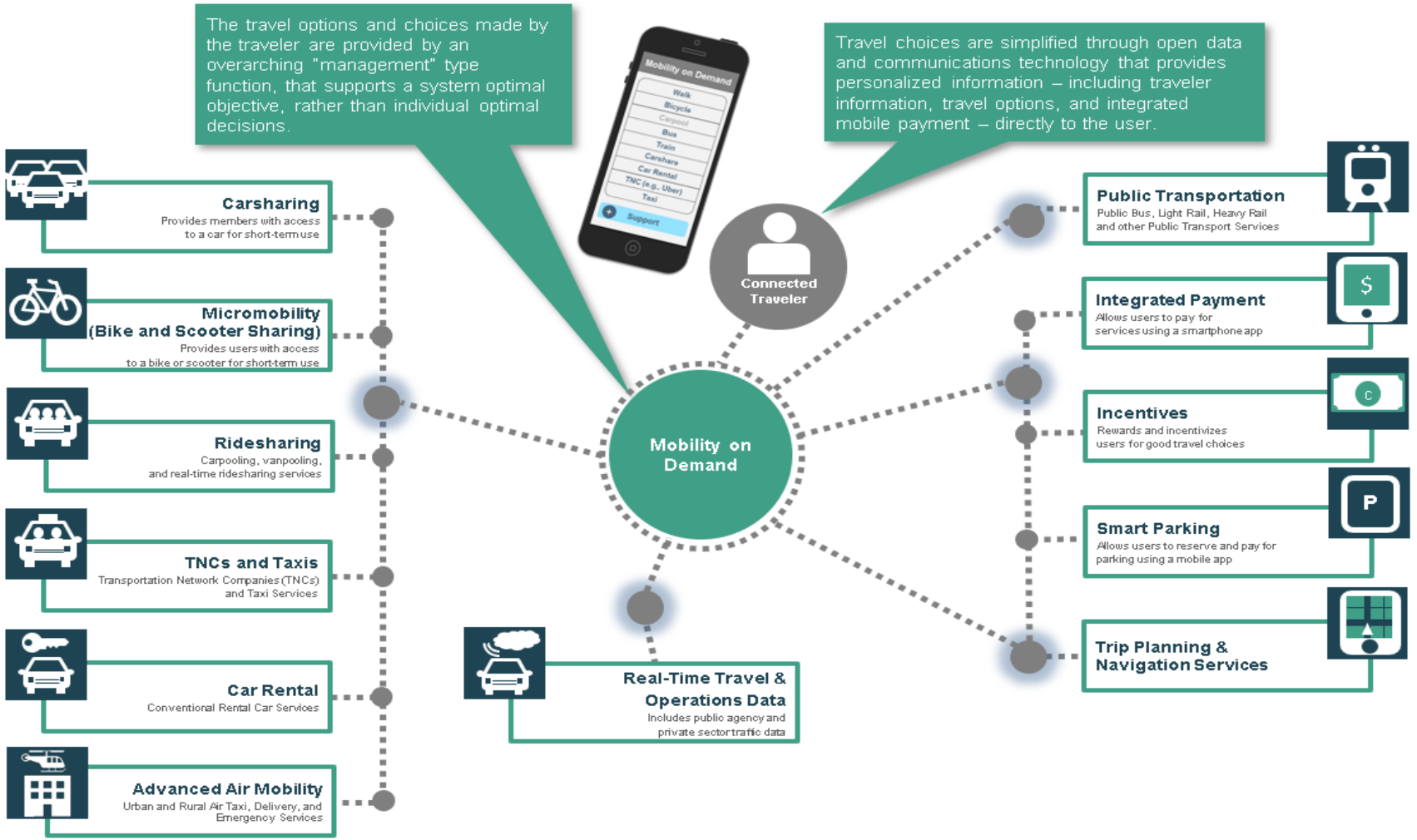
Adam Cohen
Senior Research Manager
Transportation Sustainability Research Center
University of California, Berkeley

MOBILITY ON DEMAND

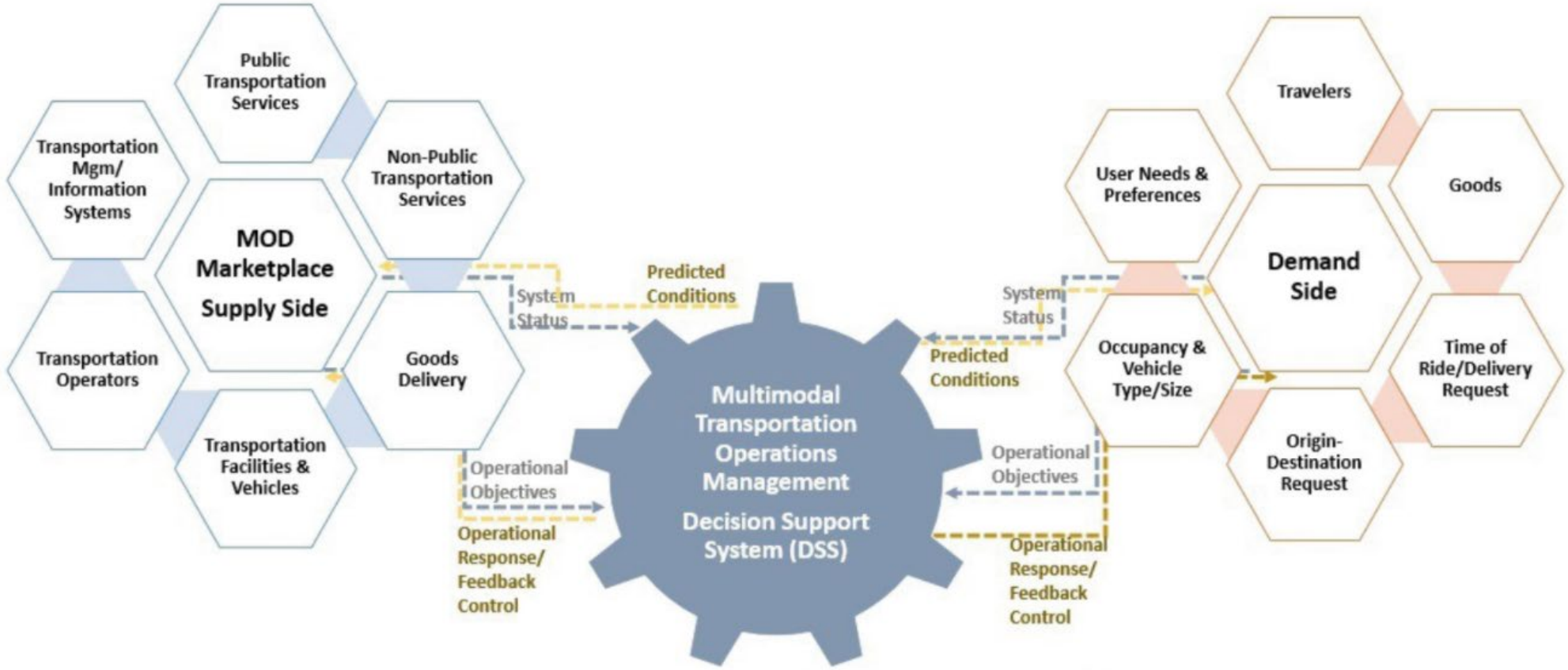
Passengers & Goods

Commodification

MOD and User-Centric Mobility



MOD Marketplace



Mobility as a Service

A concept envisioning integrated mobility where travelers can access multiple transportation modes over a single digital Interface to seamlessly plan, book, and/or pay for travel on a pay-as-you-go and/or subscription basis

Advanced Air Mobility

A broad concept focusing on emerging aviation markets and use cases (i.e., mobility, delivery, and emergency response) for urban, suburban and rural operations

Role of the Built Environment

CITY CENTER

High-density downtown/CBD employment centers and surrounding neighborhoods

SUBURBAN

Predominantly lower-density residential users with some segregated mixed uses

EDGE CITY

Medium-density employment centers outside of the urban core

EXURBAN

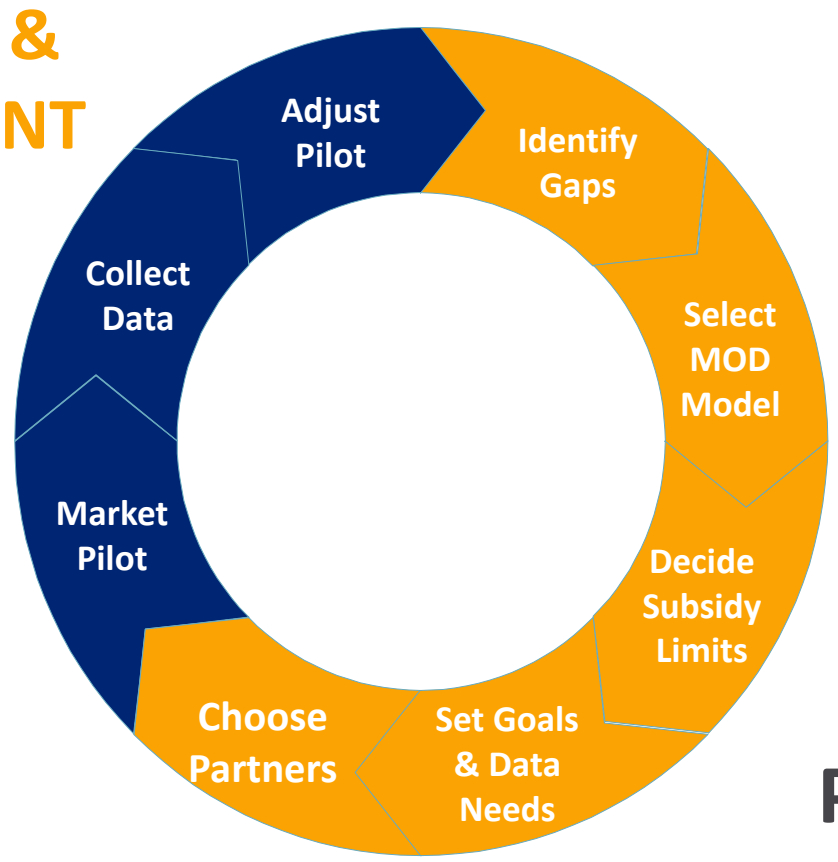
Very low-density residential uses on the urban fringe

RURAL

Typically unincorporated

Common MOD Partnerships and Use Cases

- First-and-Last Mile
- Low Density
- Off-Peak
- Paratransit
- Others …



The Pandemic Recovery and Unanswered Questions:

- How will health and economic crises impact consumer confidence, household income, travel behavior, and consumption patterns?
- Will households “de-urbanize” and move away from cities?
- Will consumers resume brick-and-mortar retail and travel after health crisis?
- What happens if a vaccine is ineffective or people refuse to take it?

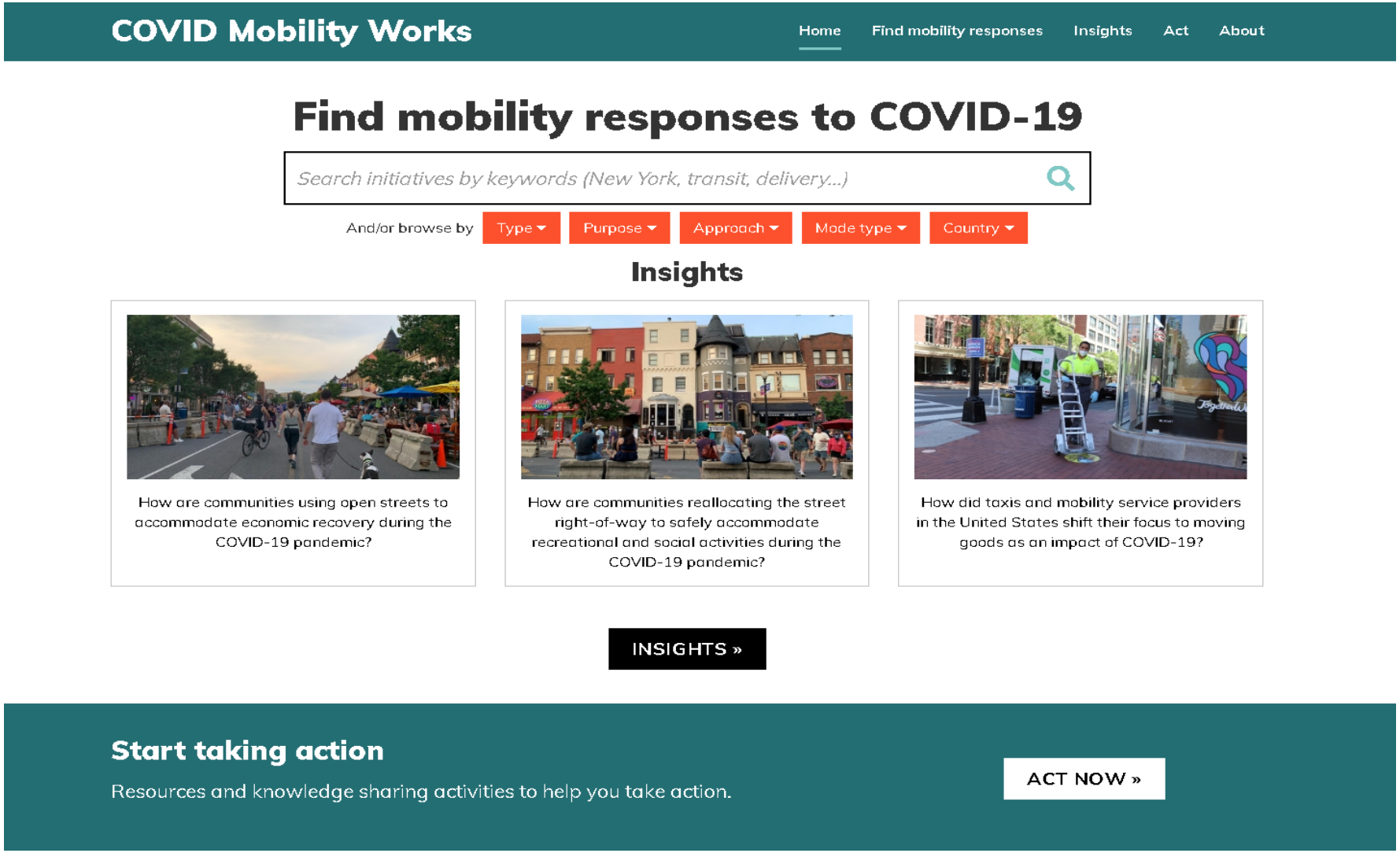
Additional Resources

A few key resources:

- ***NEW:*** USDOT MOD Planning and Implementation
- USDOT MOD Operational Concept and Primers on Shared Mobility, Equity, Smartphone Apps
- Shared mobility policy primer for the American Planning Association
- Future of Mobility strategies for Caltrans

These and other resources are available at: www.innovativemobility.org

Additional Resources



Thank you

SPECIAL THANKS TO HENRY KELLY AND BOSTON UNIVERSITY

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ISE Energy Efficiency Webinar: Innovations: Driving Prosperity, Slashing Emissions

Energy and Aviation

Gaudy M. Bezos-O'Connor
Project Manager
NASA Electrified Powertrain Flight Demonstration Project

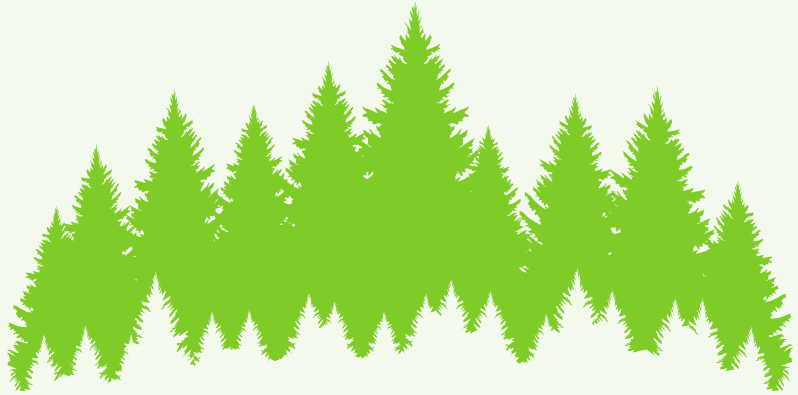
Sustainability – a Global View

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." - UN World Commission on Environment and Development

SUSTAINABILITY

SOCIETY

Meet the Mission
Value to People
Mobility
Freedom
Health



ENVIRONMENT

Meet the Mission
Protect the Planet
Protect Local Areas
Protect Ecosystems/wildlife, ….
….

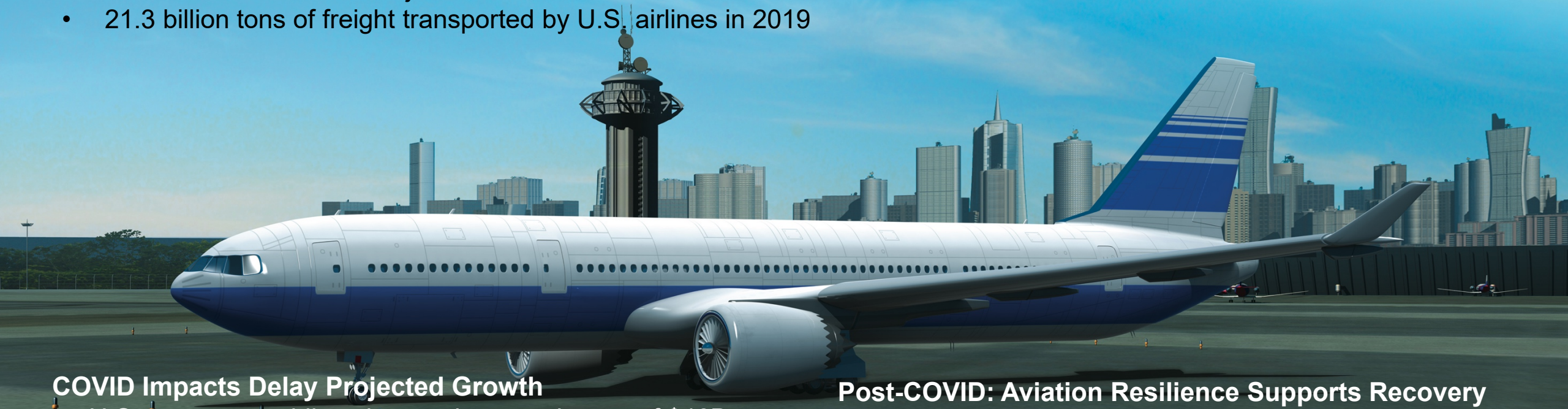
ECONOMICS

Meet the Mission
Value to Business
Profit to Shareholders
Jobs

Aviation: Vital to our economy and culture

Pre-COVID

- $78 billion positive trade balance; only U.S. industry with positive trade balance
- $1.8 trillion total U.S. economic activity
- 10.9 million direct/indirect jobs
- 21.3 billion tons of freight transported by U.S. airlines in 2019



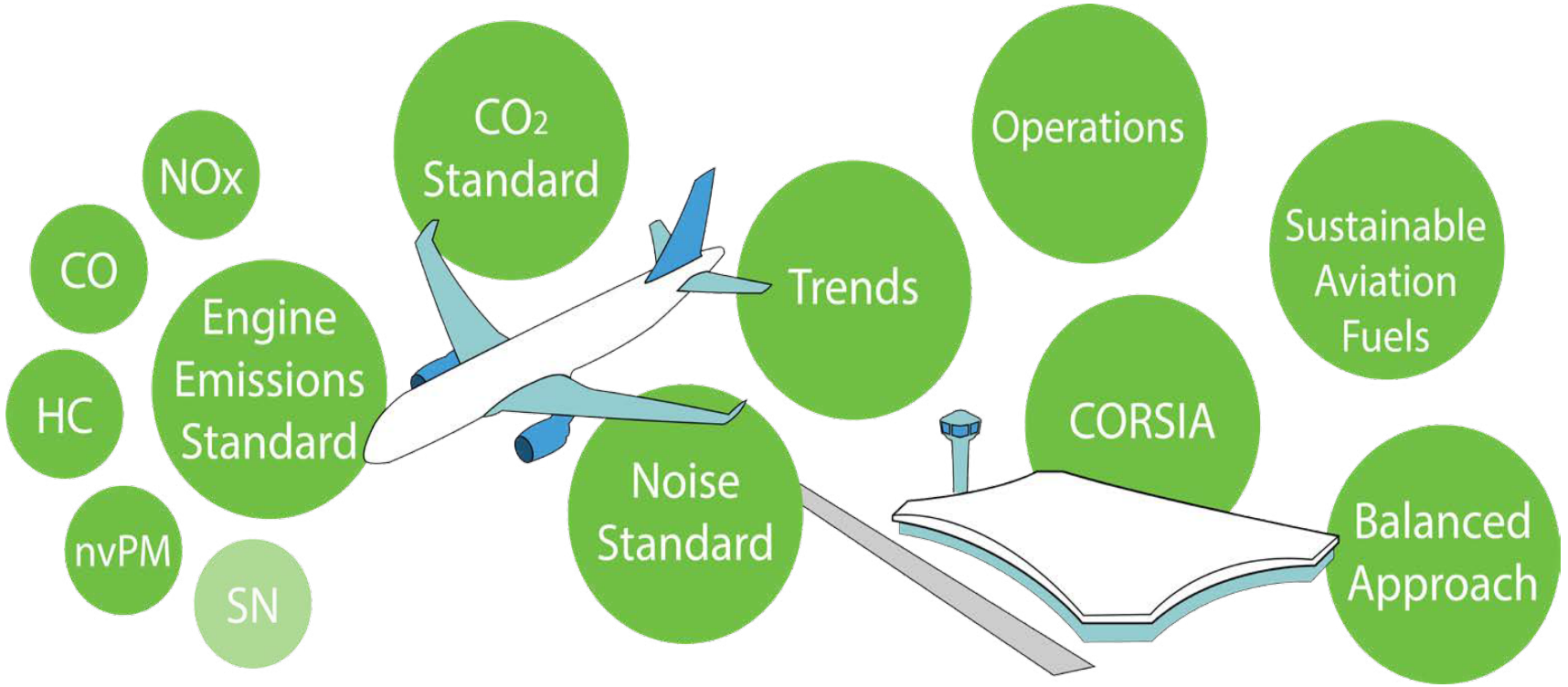
COVID Impacts Delay Projected Growth

- U.S. passenger airlines incurred pre-tax losses of $46B in 2020 ($35B net losses). But, air cargo demand reached an all-time high in 3Q 2020.
  (Airlines for America, “Impact of COVID-19 Data Updates)
- Global reduction of 2,699 million passengers (-60%)
  (ICAO, “Uniting Aviation”)
- Major disruption in new commercial aircraft production and deliveries
  Boeing Commercial Market Outlook 2020-2039

Post-COVID: Aviation Resilience Supports Recovery

- Recovery slowly begins in 2021
- Passenger numbers back to 2019 levels by 2024 at earliest, starting with domestic
  (https://www.iata.org/en/pressroom/pr/2020-11-24-01/)
- 20 years from now, world fleet will be 87% larger; needed to serve Asian markets
- Disruption also calls for new strategies for new fleets that further improve efficiency and sustainability
  (Boeing Commercial Market Outlook 2020-2039)

International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP)

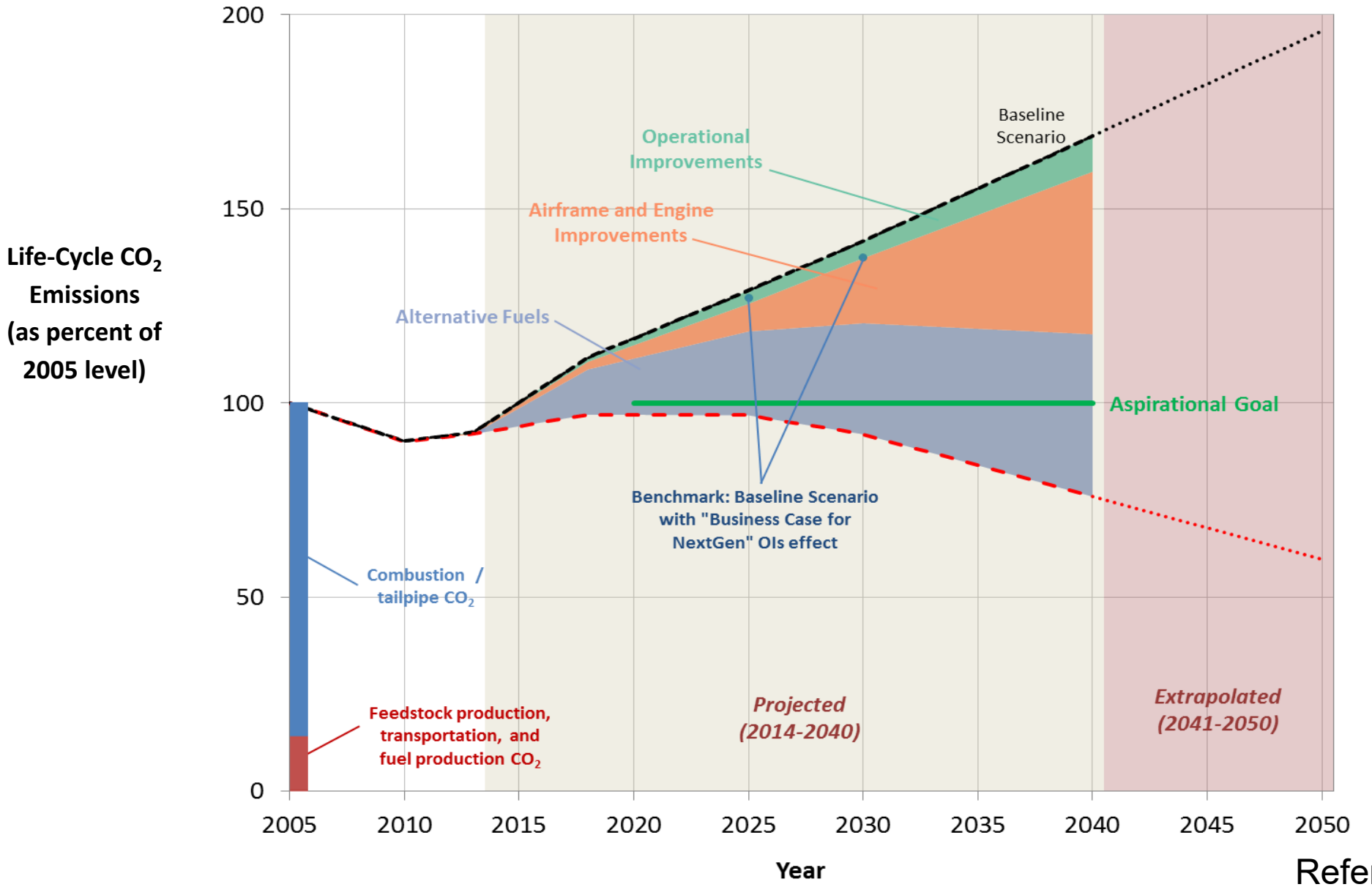


At the end of each 3-year work cycle, ICAO's CAEP conducts an assessment of future environmental trends in aviation:

- **Aircraft engine Greenhouse Gas (GHG) emissions that affect the global climate**
- **Aircraft noise**
- **Aircraft engine emissions that affect Local Air Quality (LAQ)**

Ref. Environmental Trends in Aviation to 2050 CHAPTER ONE Aviation and Environmental Outlook

Projected life-cycle CO_2 emissions impacts – aggressive system improvement scenario



Reference: ICAO 2015