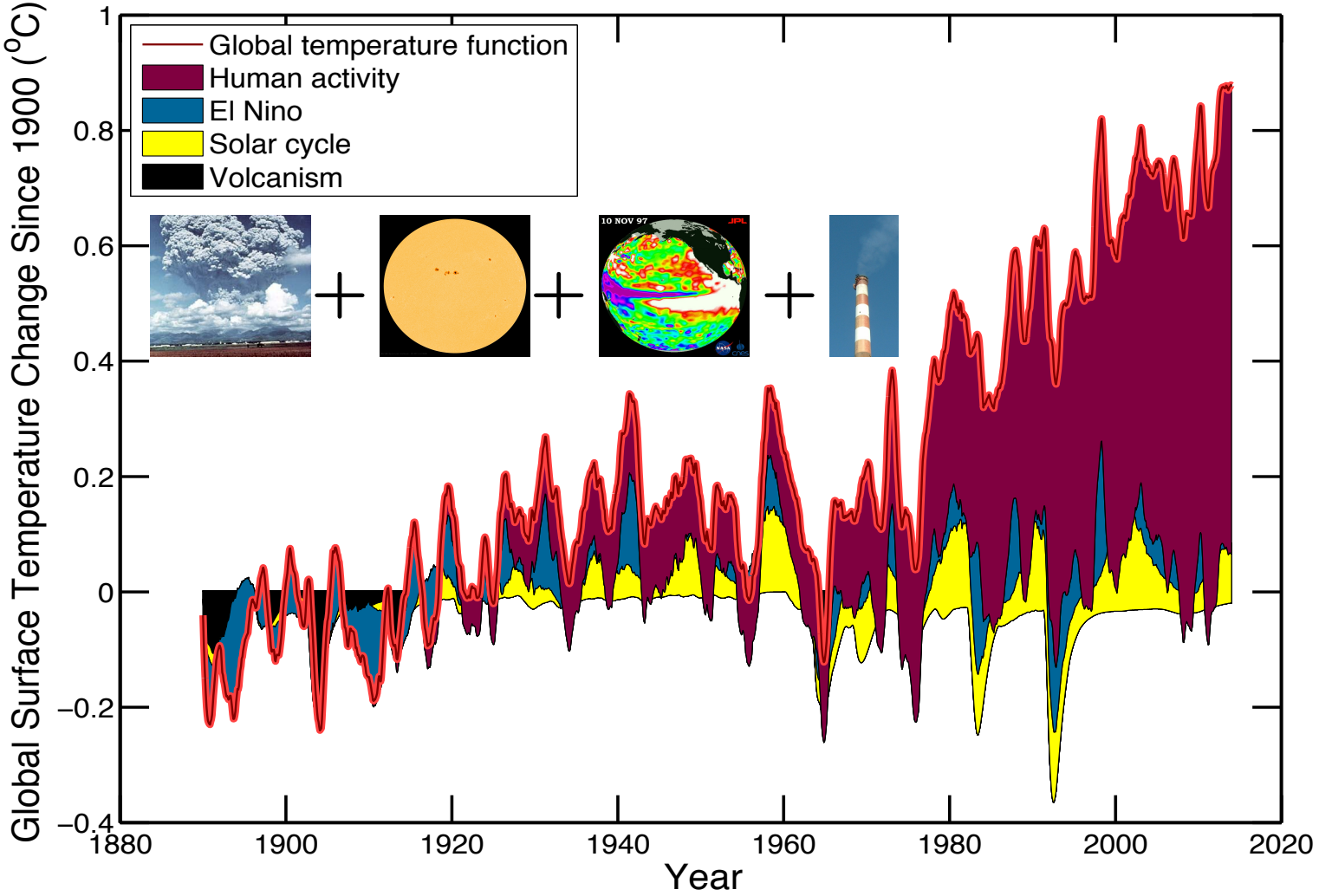
Sustainability Pioneers: Community Conversations

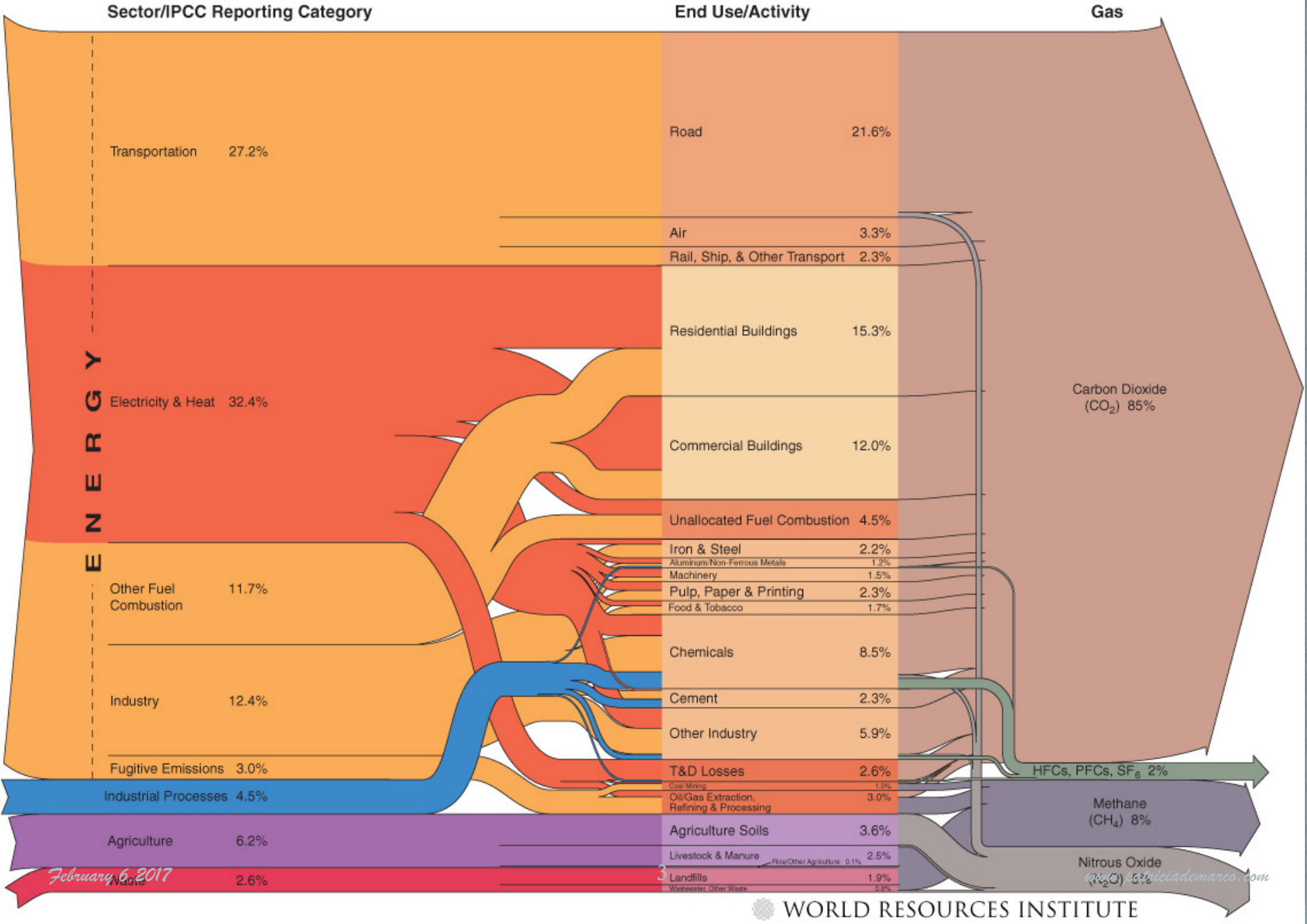
#2 The Transition from Fossil to Renewable Energy

February 6, 2017



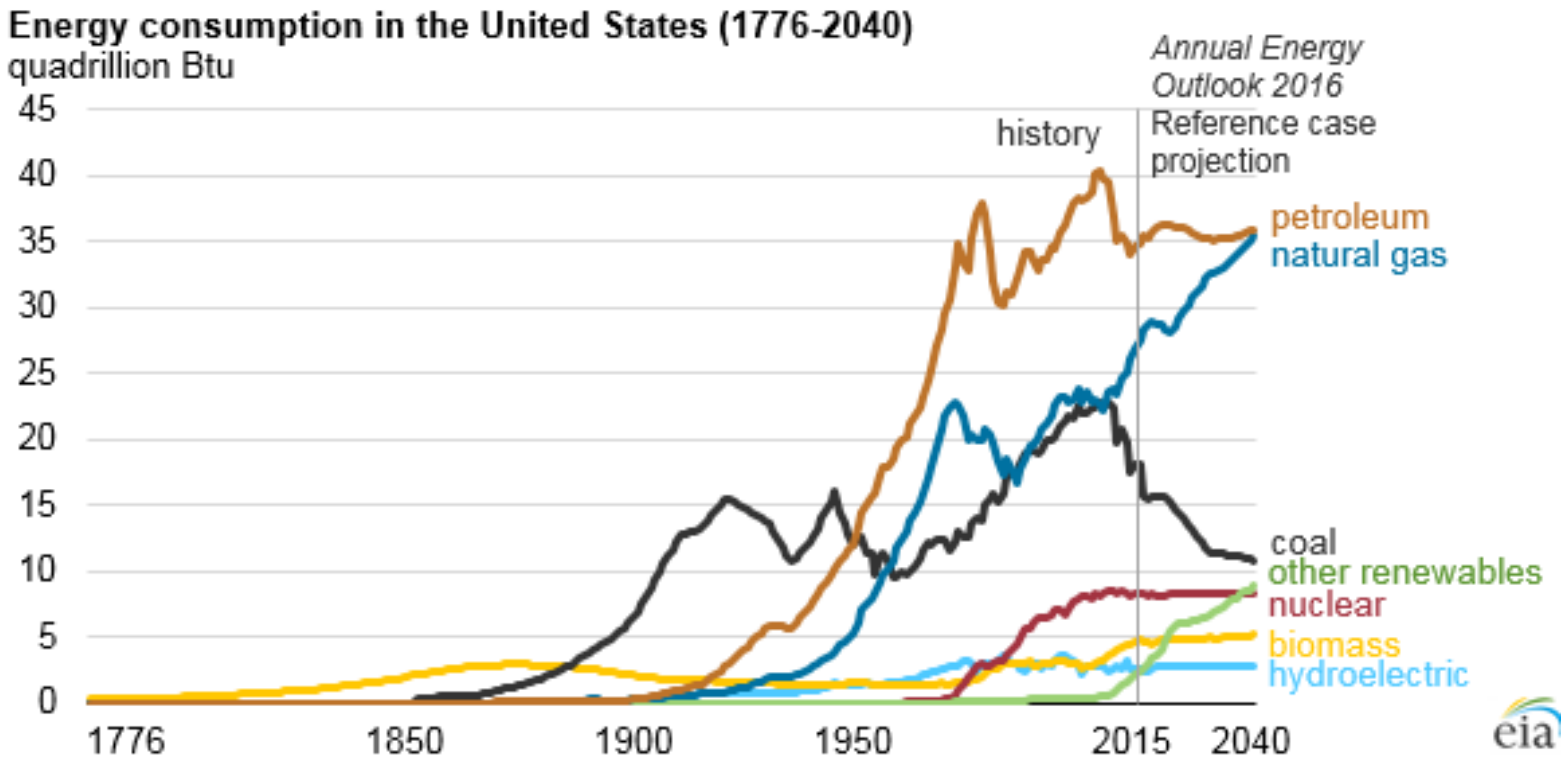
Judith L. Lean1 and David H. Rind2 How natural and anthropogenic influences alter global and regional surface temperatures: 1889 to 2006 GEOPHYSICAL RESEARCH LETTERS, VOL. 35, L18701, doi:10.1029/2008GL034864, 2008

U.S. GHG Emissions Flow Chart



WORLD RESOURCES INSTITUTE

U.S. Energy Use

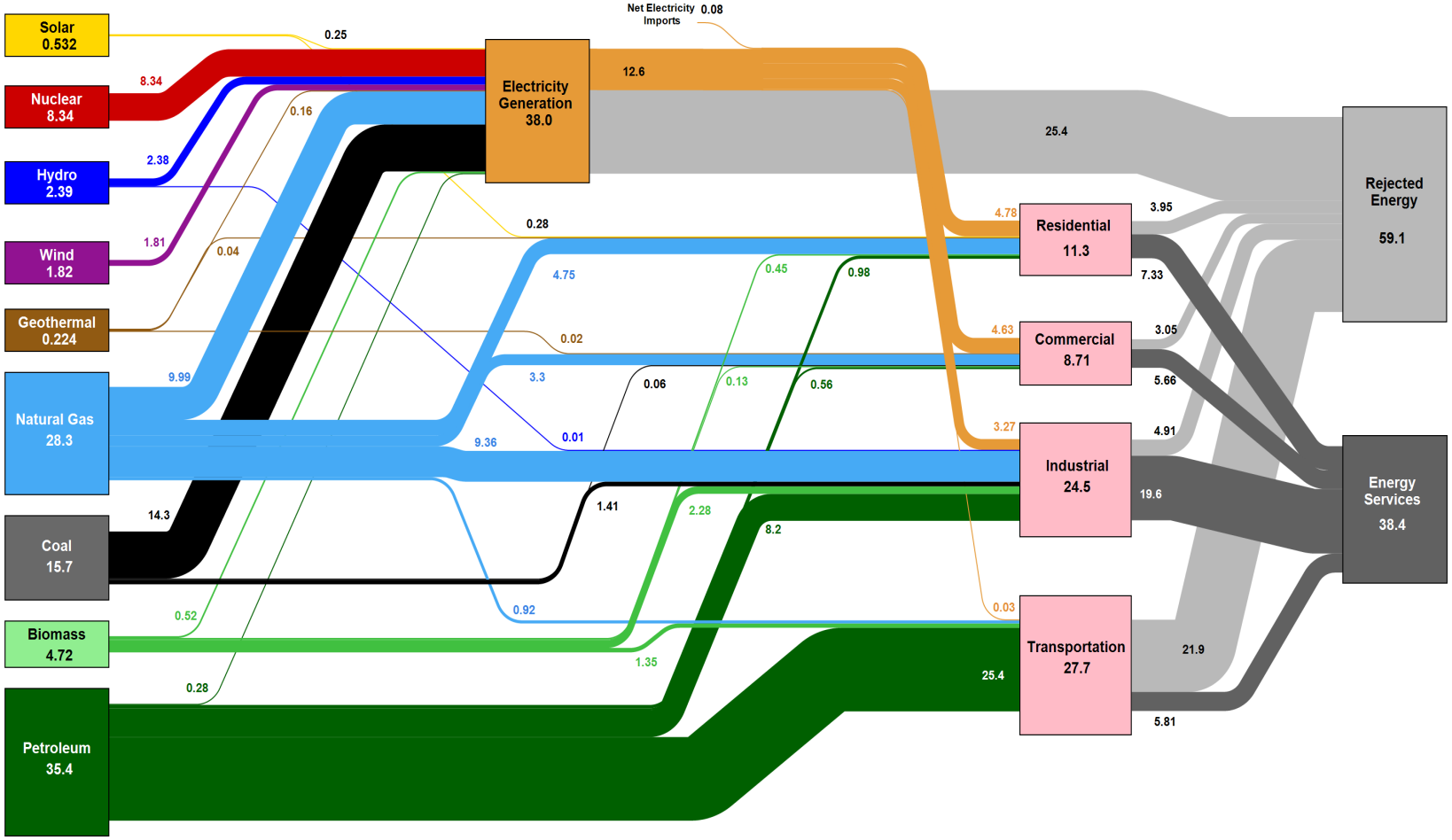


Pre-Industrial

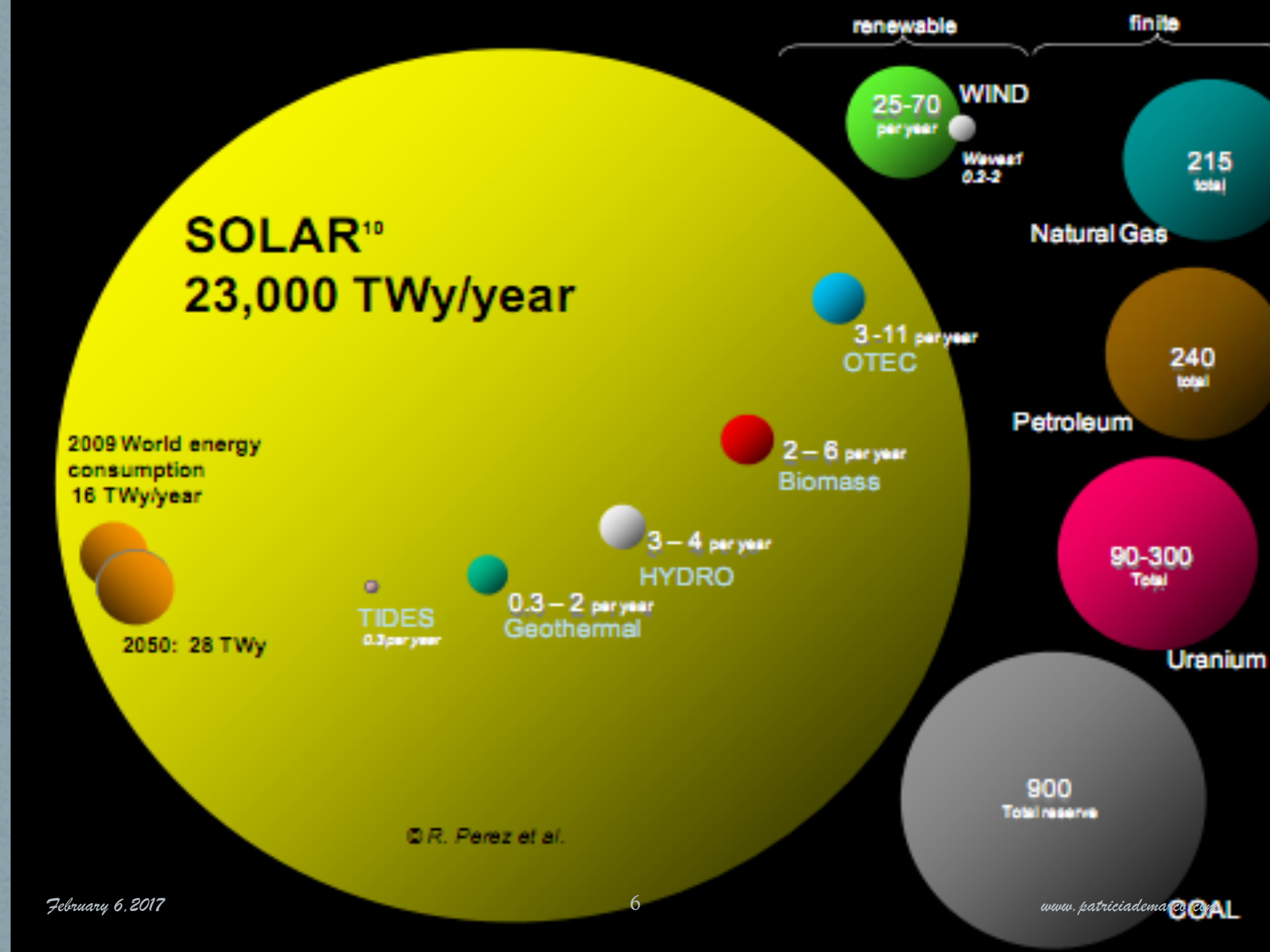
Industrial Period

Estimated U.S. Energy Consumption in 2015: 97.5 Quads

Lawrence Livermore National Laboratory



Source: LLNL March, 2016. Data is based on DOE/EIA MER (2015). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant heat rate. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent Rounding. LLNL-MI-410527


renewable
finite
SOLAR[10]
23,000 TWy/year
2009 World energy consumption
16 TWy/year
2050: 28 TWy
25-70 per year
WIND
Wave1 0.2-2
215 total
Natural Gas
3-11 per year
OTEC
240 total
Petroleum
2 – 6 per year
Biomass
3 – 4 per year
HYDRO
0.3 – 2 per year
Geothermal
TIDES 0.3 per year
90-300 Total
Uranium
900 Total reserve
COAL
R. Perez et al.

The First Energy Revolution: The Rankine Steam Engine

- **1855-** William John MacQuorn Rankine

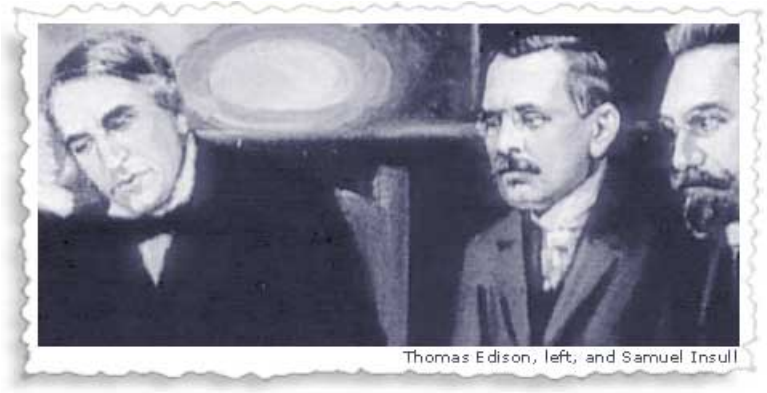
- Steam engine thermodynamics:

- 66% of fuel lost as waste heat

- Still produces 85% of electricity today

The Second Energy Revolution

- **The Public Utility Holding Company Act of 1935**
- Created Public Utilities
- Gave monopoly franchise areas
- Regulated financially (SEC) and for States control over tariffs



Thomas Edison and Samuel Insull

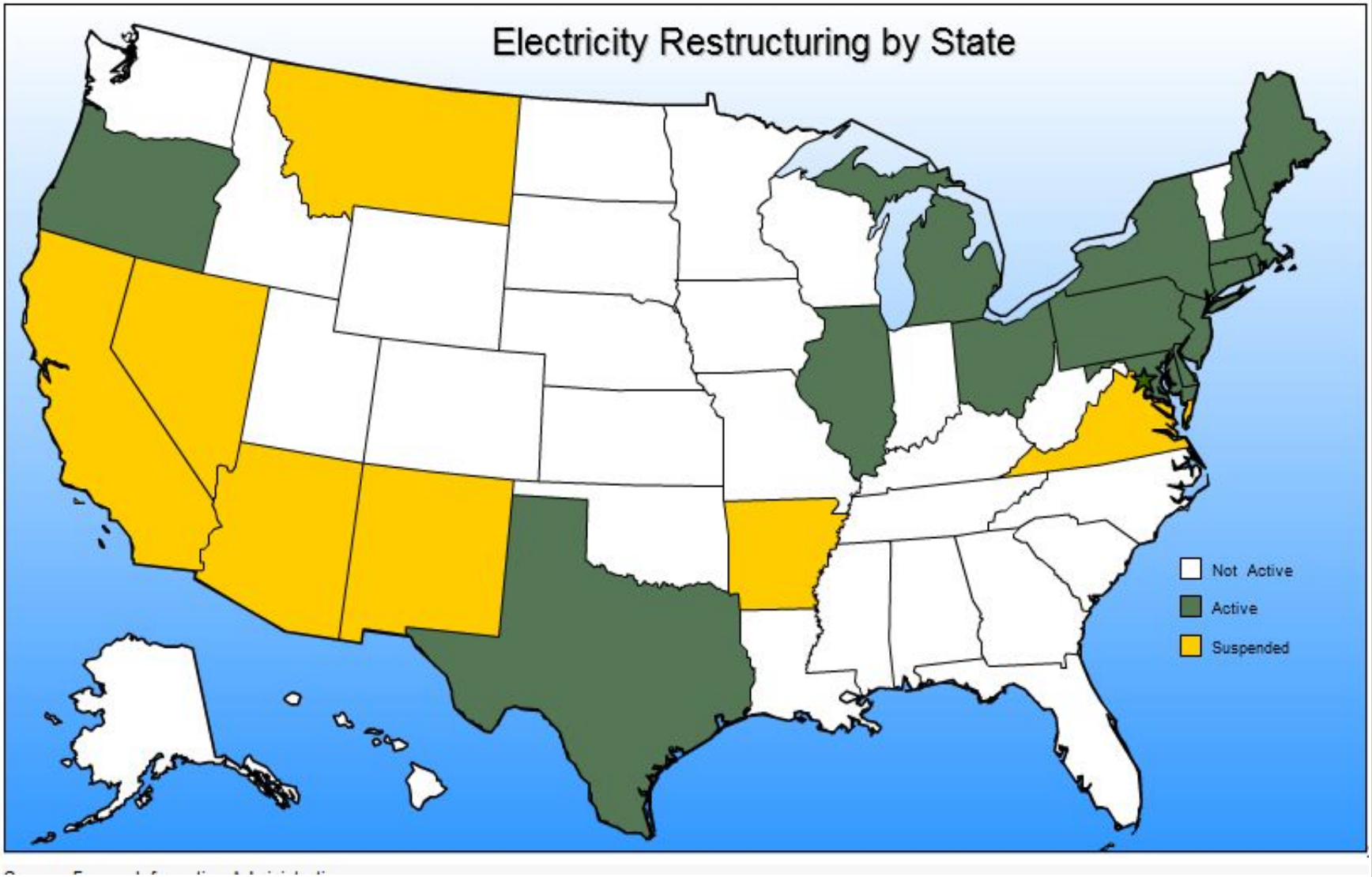
Tools for power to everyone

http://www.pbs.org/greatprojects/tour/electricnation_6.html

Rural Electrification of America

- FDR added electric power systems to The New Deal
- Municipal cooperatives for rural areas
- Tennessee Valley Authority
- Bonneville Power

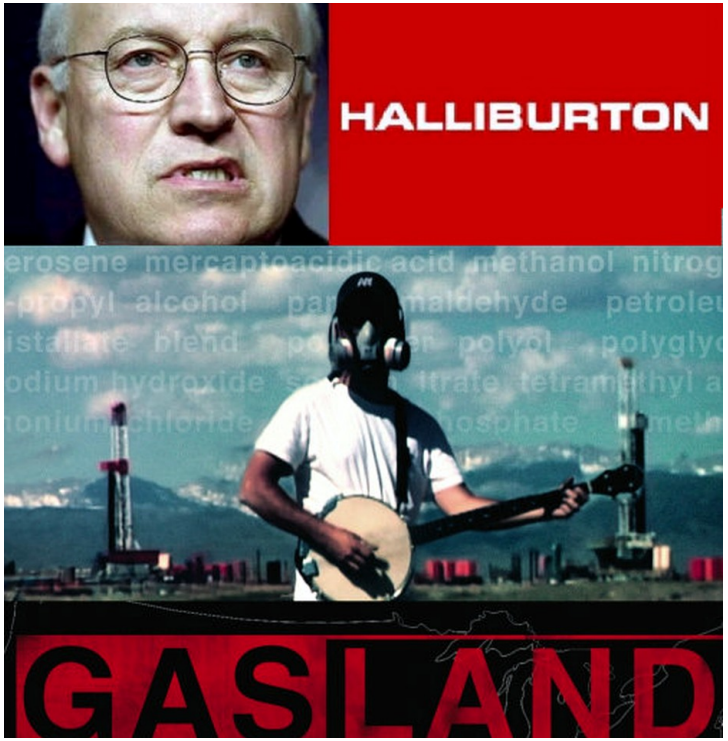
http://dspace.mit.edu/

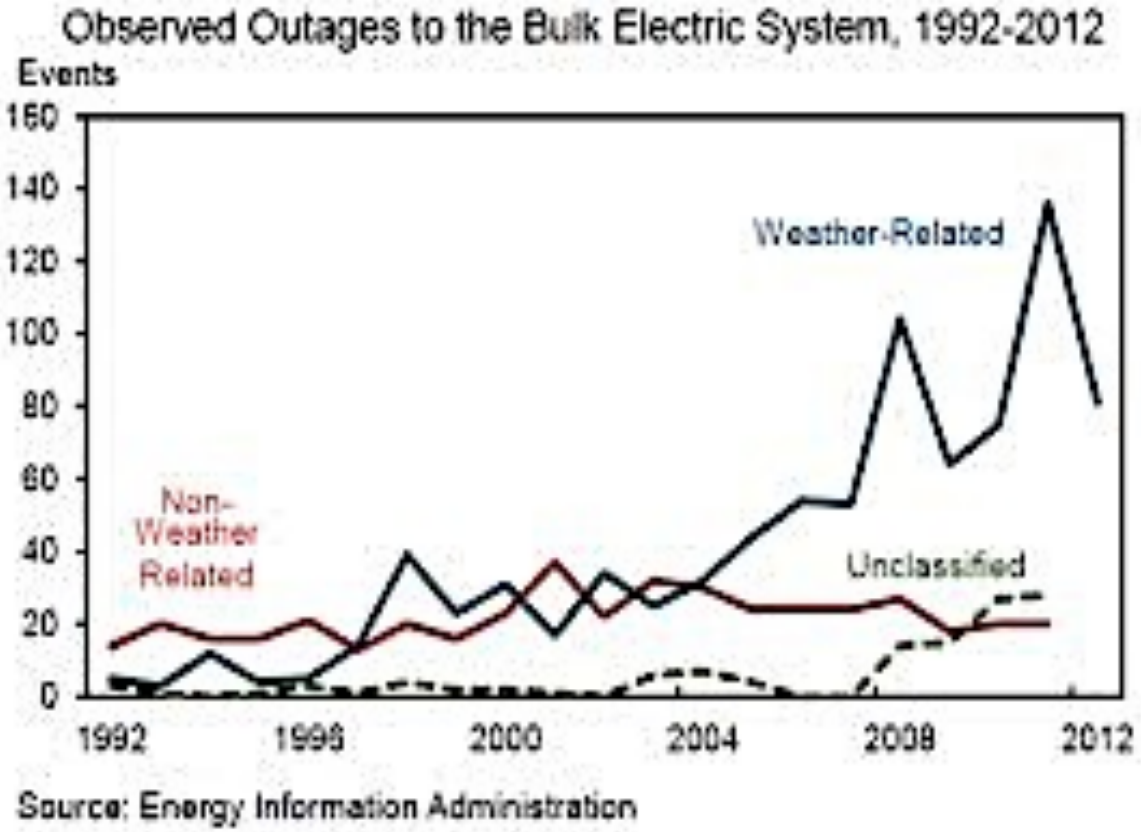


National Energy Act 1992- allowed states to de-regulate electricity

National Energy Policy Act of 2005

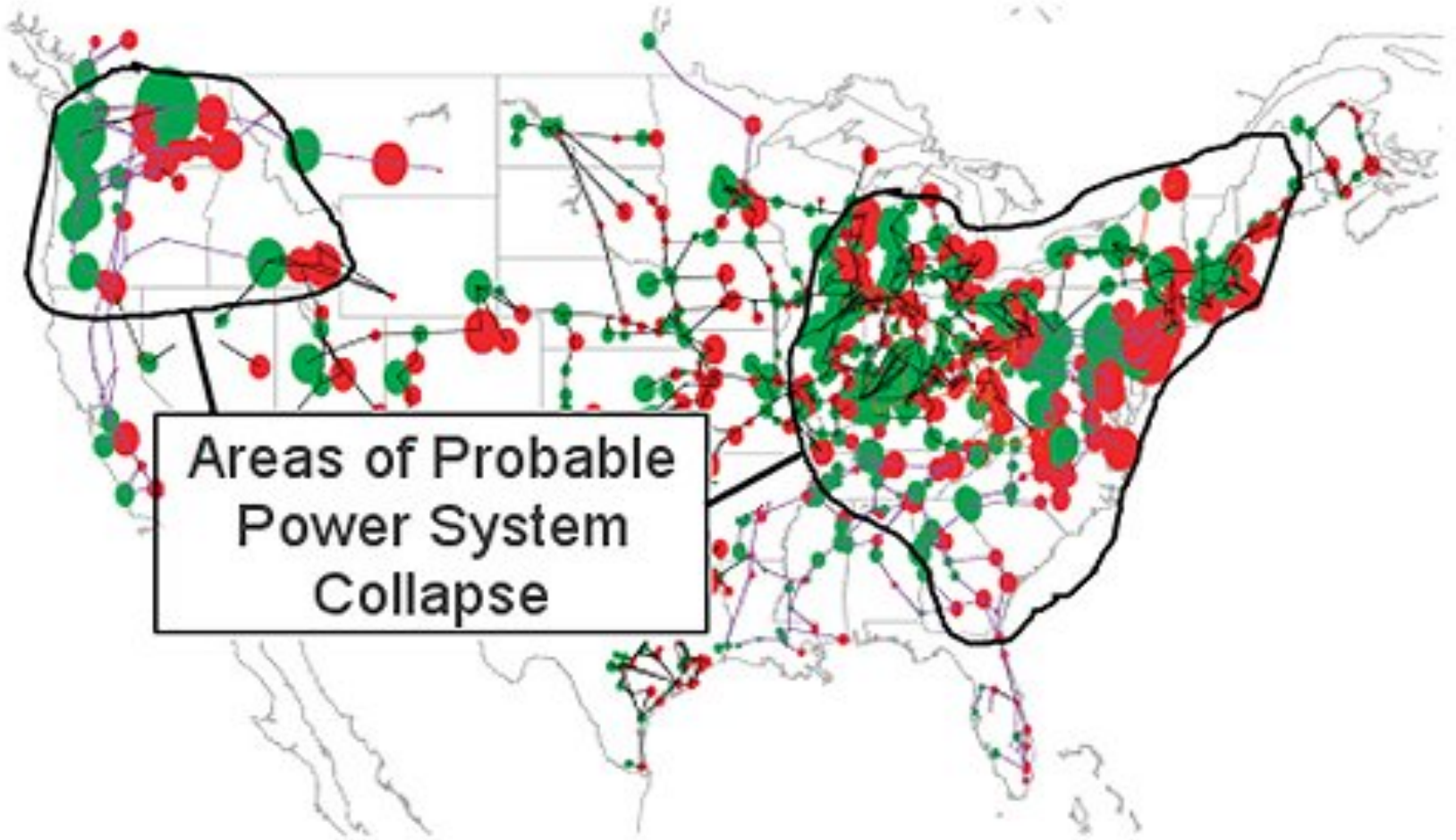
- Policy Initiative to States
- "All of the above" strategy- market driven
- "Haliburton Loophole"





Disruptive Events
of increasing frequency

Vulnerability from Interconnected Grids



http://science1.nasa.gov/science-news/science-at-nasa/2009/21jan_severespaceweather/

Rethink the Problem

How can we use the least amount of energy and natural resources to perform NECESSARY work?

- Space conditioning buildings
- Lighting & Machinery
- Transportation
- Communication
- Manufacturing

A Different Path – Nairobi, Kenya

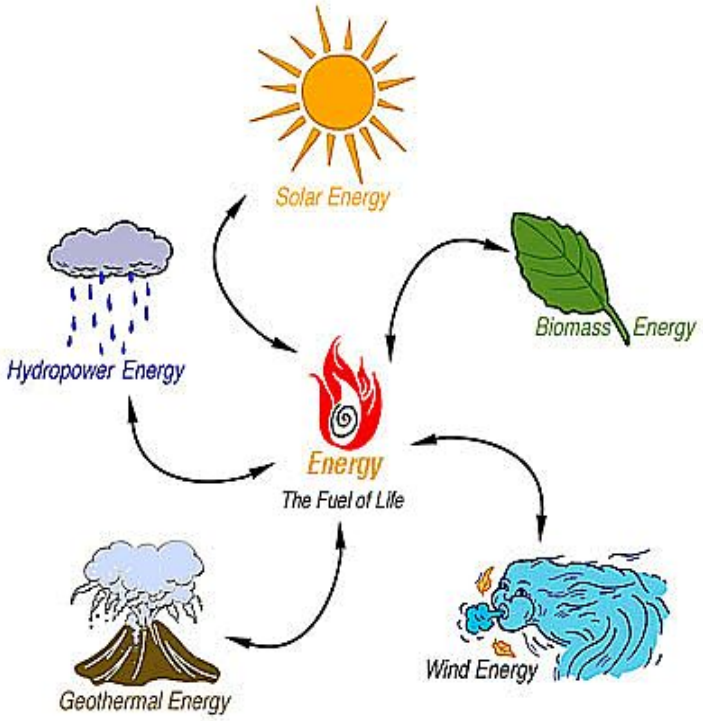
http://expressdrainage.com/details.php?ser=16%20&%20maservices=69

Re- define the Options:

- We receive from the sun over 10,000 times more energy per year than we are projected to use worldwide
- Solar (renewable) energy sources are FLOWS
- Solar energy is already distributed
- Solar energy is reliable (the sun comes up every day…)
- We have the technology to use it NOW!
- **Solar energy does not pollute compared to fossil fuels, and it is safe**

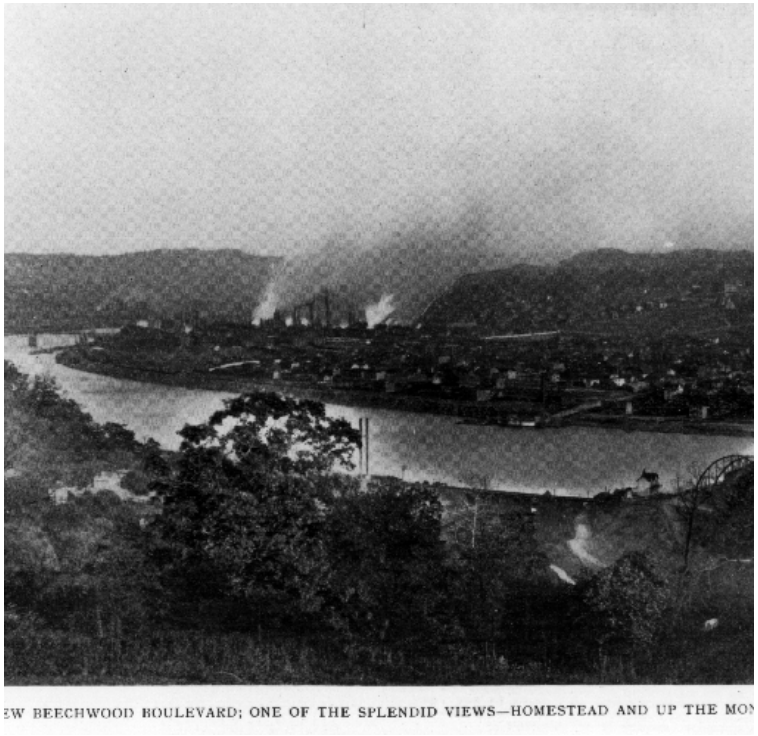
Pathway to Our Sustainable Future: Renewable Energy Systems

- Replace the 1800's technologies with renewable and sustainable energy **systems**
- Focus on meeting the **need for work,** not just replacing fuel sources.



The Third Energy Revolution

Fossil Fueled Economy



EW BEECHWOOD BOULEVARD; ONE OF THE SPLENDID VIEWS—HOMESTEAD AND UP THE MO

Sustainable Economy

Renewable Energy Systems

From Coal, Oil & Fossil Gas Combustion

To Renewable Resource Systems

Steps in the Transition

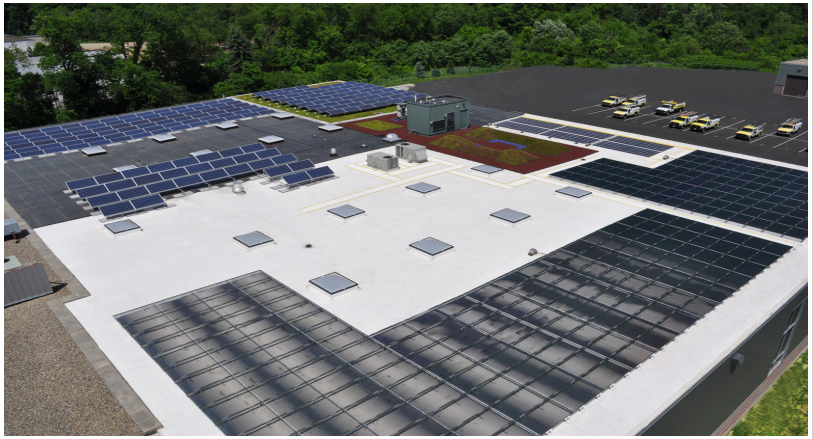
- **Rules of the Road**

Horse and buggy collision
With horseless carriage 1869

- Roads were paved
- Traffic signal system deployed
- Vehicles were licensed
- Fuel stations replaced horse shoe stalls

- **Distributed generation?**

Scalo Solar in Crafton PA



- Utility interface
- Insurance and financing issues
- Zoning issues
- Building codes
- Safety standards

System Solutions

- Address the technology to displace fossil fuels
- Build the infrastructure to support new systems

- Electricity
- Transportation

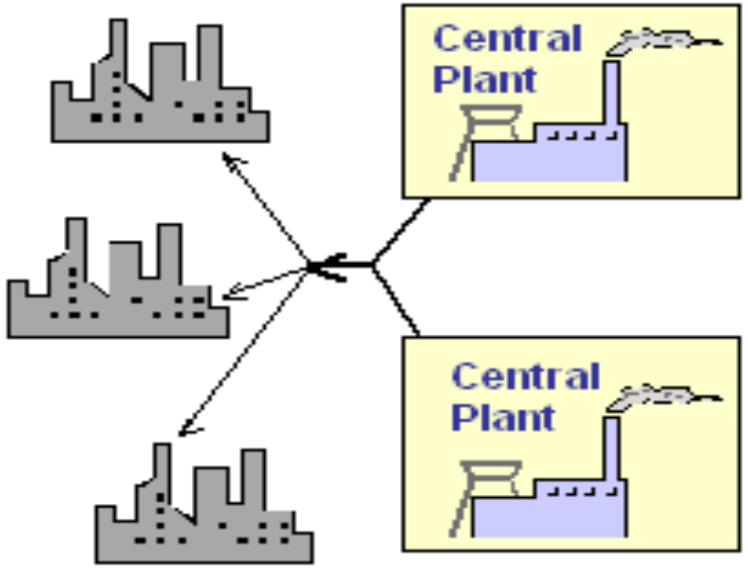
Energy Solutions by Design

- Reduce the need for transportation
  - Walk-able communities
  - Telecommunication
  - Public transit ; “Uber” and dispatched vans

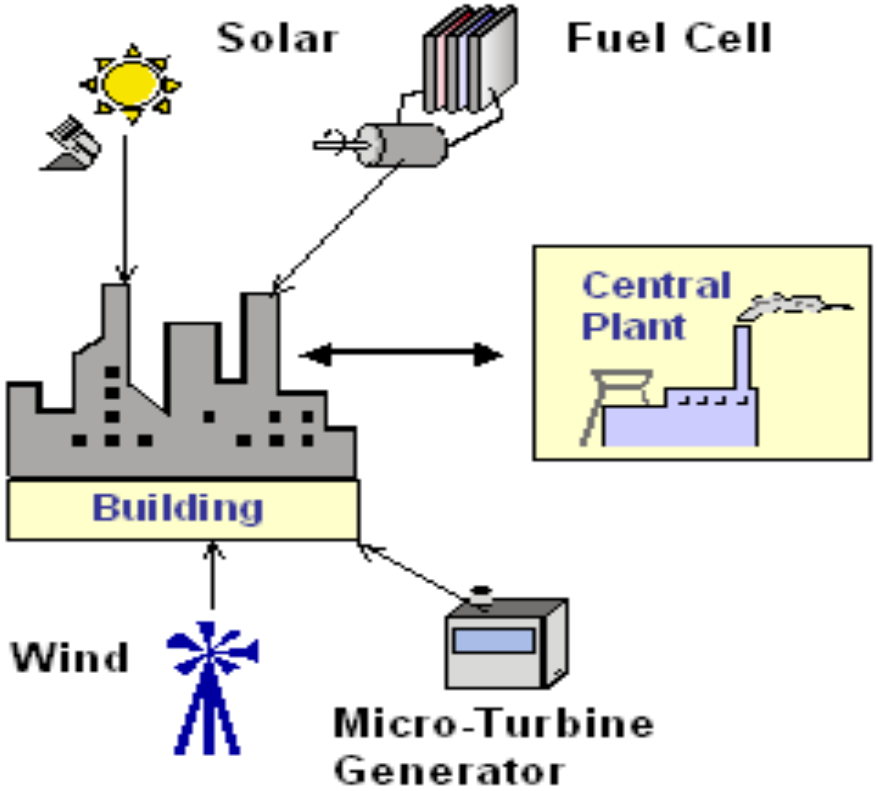
- Combine energy systems to work together
  - Buildings as power generators
  - Micro-grids

CENTRAL vs. DISTRIBUTED GENERATION

Central Generation



Distributed Generation

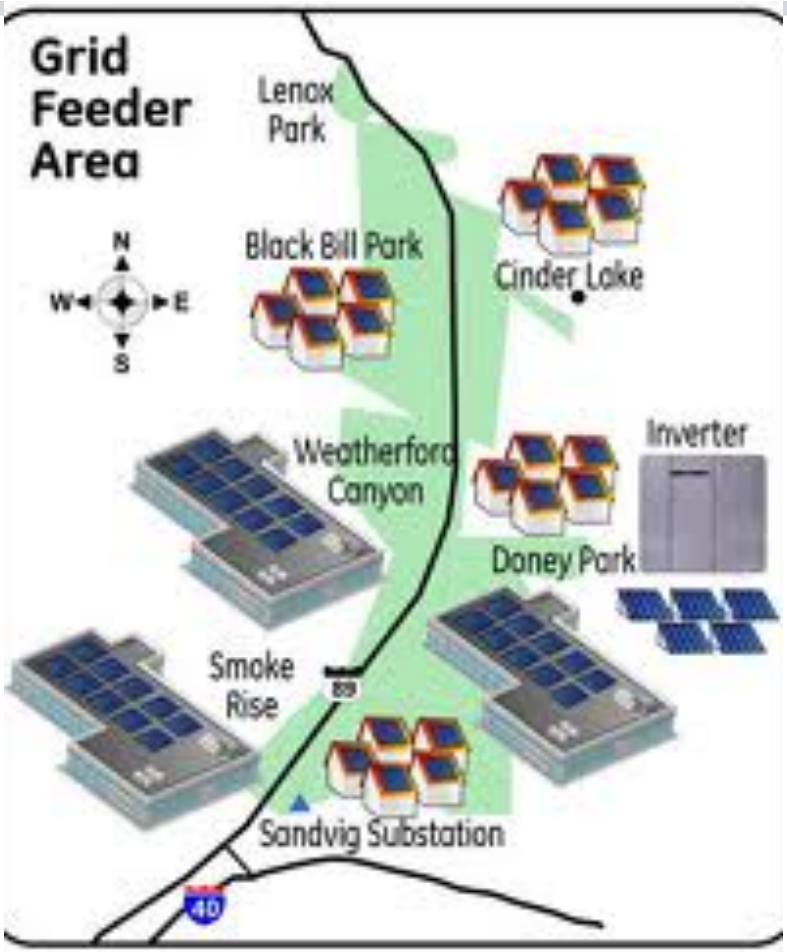


NET ZERO HIERARCHY

NET ZERO IS A FORCE MULTIPLIER

Where it is working already:

- Utility-owned distributed generation on customer rooftops, such as the Arizona Public Service Community Power Project
- **Requires Net metering tariff and Investment Tax Credit**



Where it is working already:

- Solar services co-ops such as Cooperative Community Energy, CA

. www.energy.gov/sunshot

THE SAN FRANCISCO ENERGY CO-OP

Power is Everyone's Business

Net Zero Energy Buildings

Deerfield Illinois Zero Net Energy retail operation

Passive solar living building

- Phipps Conservatory illustrates green roofs
- Passive solar design
- Active solar collectors
- Water conservation
- Earth tubes
- Fuel cell back up system

Net Zero Campus

Chatham University Eden Hall Campus

Sustainable Communities

Eco-Village- Ithaca, New York

Structurally Integrated PV

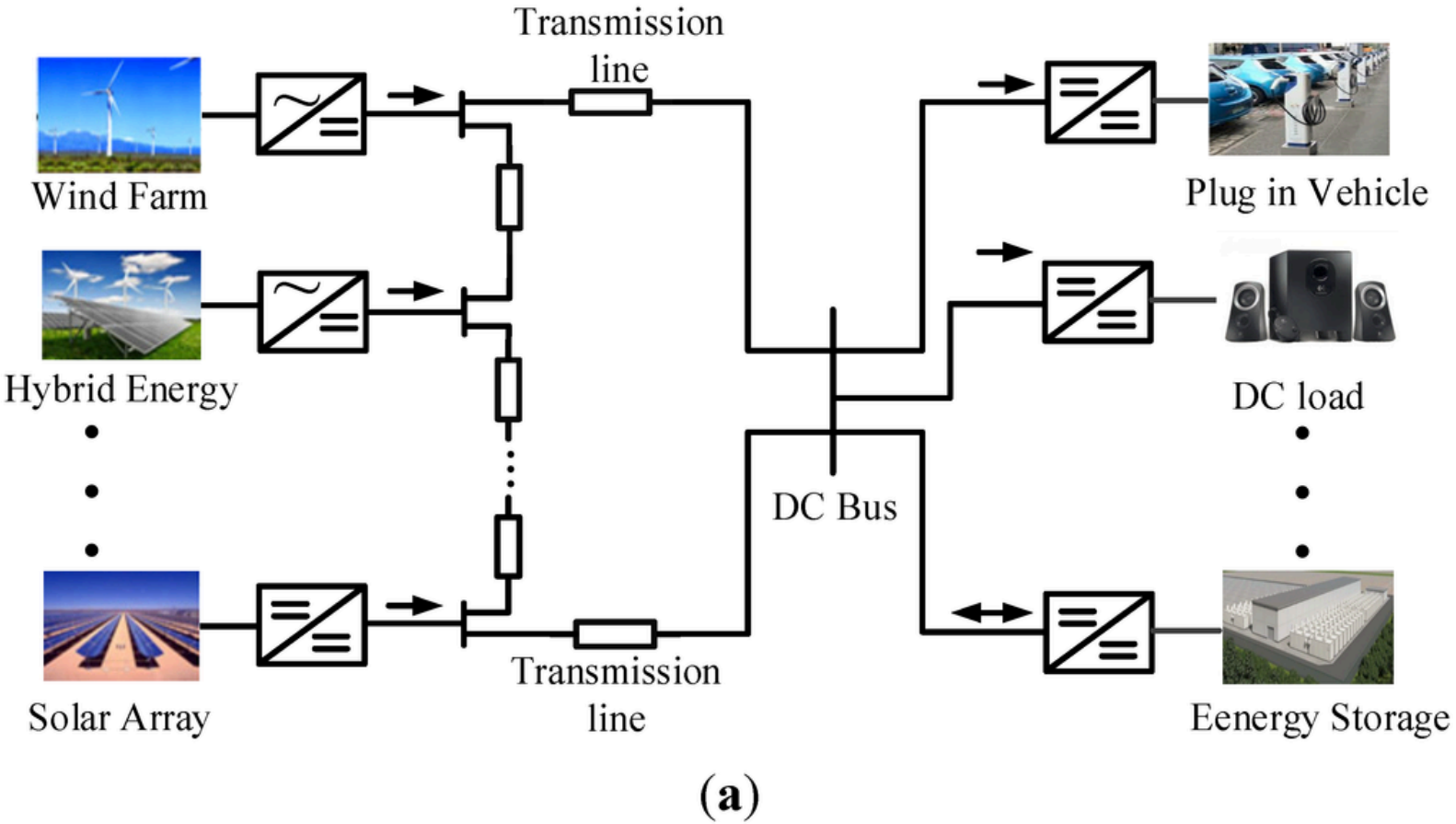
- integrating solar electricity into the design of a building or structure so that the solar components also serve as structural or design elements.

Curtain wall

PV Window walls

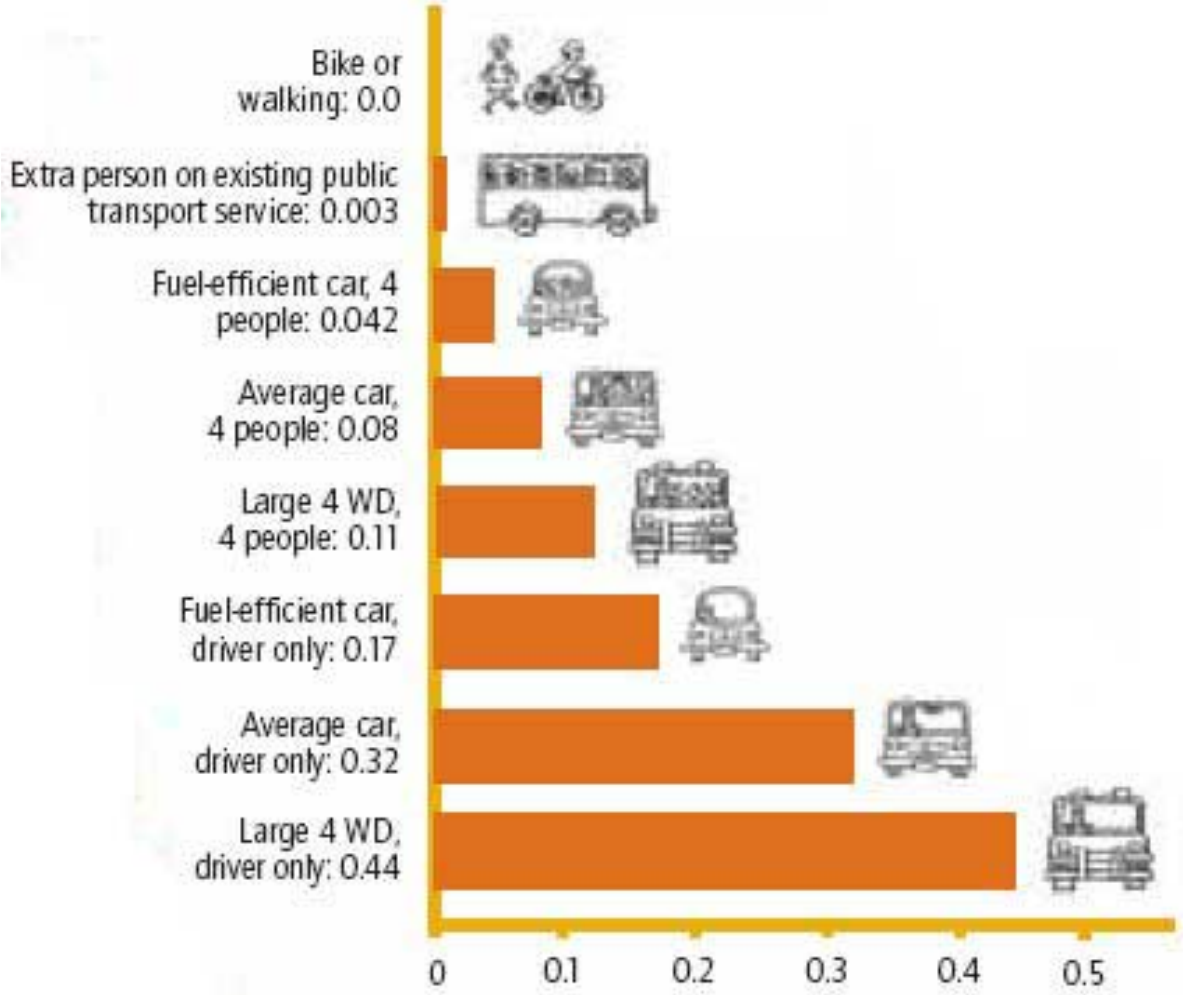
PV Awnings

Micro-grids on DC Electricity



Liu et.al. Energies. 2015, 8(5), 3591-3605

Emissions from Transportation Modes



www.environment.gov

Solar electric connections

University of Iowa parking PV and charging station

Cars as solar storage!

Fred Kraybill's EV connected to PV house system

Choices and Values

View of Coal River Mountain from nearby Kayford Mountain
which has been ravaged by a 10,000 acre strip mine.

Coal for 20 years

www.pdwv.org Progressive Democrats of West Virginia

Power 150,000 homes indefinitely

Residential Energy?

Fracking in Baldwin CA

WindStax in Pittsburgh

Transition from Steel to High Tech took 30 years

Brownfields now see a new fate

The Sustainability Pioneers Stories

- From Haze to Sun
- It Takes A Village