Comparison Among Three Studies

Presented to

DOE Electricity Advisory Committee

July 12, 2011

L.T.Papay

Comparison Among Three Studies

1. Roadmap 2050: a practical guide to a prosperous, low carbon Europe (ECF) 2010 - RM 2050

2. America's Energy Future (National Academies) 2009 - AEF

3. California's Energy Future: Reducing GHG emissions 80% below 1990 (CCST) 2011 - CEF

Comparison Among Three Studies: Goals

1. RM 2050: Establish a fact base to achieve 80-90% reduction in GHG below 1990 levels by 2050 for Europe and other developed economies and understand implications for the next 5-10 years.
2. AEF: Provide transparent and authoritative estimates of the current contributions and future potential of existing and new energy supply and demand technologies, impacts and costs, focusing on the next two decades.
3. CEF: Achieve the GHG goals set forth in AB 32 and the Governor's executive order, S-3-05 that would result in an 80% reduction below 1990 levels by 2050.

Comparison Among Three Studies: Scope

1. RM 2050: (a) greater achievement in EE, (b) substantial fraction of light duty transportation must be electrified, (c) a substantial fraction of load must be dispatchable; and (d) grid policies and interconnections are needed for renewables.
2. AEF: (a) greater EE, (b) alternative transportation fuels, (c) renewable electric power generation, (d) natural gas and advanced coal-fired power generation with CCS, (e) nuclear power and (f) electric power transmission, distribution, control and storage.
3. CEF: (a) control electricity demand thru EE and DSM, (b) transportation - electrification/H2, (c) decarbonize electricity/balance load and (d) decarbonize transportation fuels

Comparison Among Three Studies: Methodology

1. RM 2050: stipulate minimum desired outcomes and derive plausible pathways to achieve them (back casting).
2. AEF: look at technological options within three time "buckets:" 2010-2020, 2020-2035 and 2035-2050 with most emphasis on the first bucket.
3. CEF: (a) existence proof: can it be done, and what needs to change to allow us to get there and (b) focus on technology, GHG emissions and other impacts, not economics

Comparison Among Three Studies: Conclusions - RM 2050

1. Addresses GHG emissions across all sectors w/ emphasis on the power sector.
2. An 80% GHG reduction => 95-100% decarbonized power sector
3. Need to maintain grid reliability; tradeoffs among transmission capacity, backup generation and operating costs; smart grid measures evaluated by allowing load balancing in the system.
4. Robust pathways; not dependent on future technology breakthroughs; diversified resources; mix of technologies; not cost optimized.
5. Addresses implications of electrification in buildings and transport, but not with the same rigor (conservative approach)

Comparison Among Three Studies: Conclusions - AEF

1. With a sustained national commitment, we could obtain substantial energy-efficiency improvements, new sources of energy, and reductions in greenhouse gas emissions through the accelerated deployment of existing and emerging energy-supply and end-use technologies

2. Substantial reductions in greenhouse gas emissions from the electricity sector are achievable over the next two to three decades through a portfolio approach involving the widespread deployment of energy efficiency; renewable energy; coal, natural gas, and biomass with CCS; and nuclear technologies.

Displacing a large proportion of petroleum as a transportation fuel to achieve substantial greenhouse gas reductions over the next two to three decades will also require a portfolio approach involving the widespread deployment of energy efficiency technologies, alternative liquid fuels with low CO_2 emissions, and light-duty vehicle electrification technologies.

Comparison Among Three Studies: Conclusions - AEF

3. The deployment of existing energy-efficiency technologies is the nearest-term and lowest-cost option for moderating our nation's demand for energy, especially over the next decade

4. There are many promising options for obtaining new supplies of electricity and changing its supply mix during the next two to three decades, especially if carbon capture and storage (CCS) and evolutionary nuclear technologies can be deployed at required scales. However, the deployment of these new supply technologies is very likely to result in higher consumer prices for electricity.

Comparison Among Three Studies: Conclusions - AEF

5. Expansion and modernization of the nation's electrical transmission and distribution systems (i.e., the power grid) are urgently needed.

6. Petroleum will continue to be an indispensable transportation fuel through at least 2035

7. To enable accelerated deployments of new energy technologies starting around 2020, and to ensure that innovative ideas continue to be explored, the public and private sectors will need to perform extensive research, development, and demonstration over the next decade.

8. A number of barriers could delay or even prevent the accelerated deployment of the energy-supply and end-use technologies described in this report. Policy and regulatory actions, as well as other incentives, will be required to overcome these barriers.

Comparison Among Three Studies: Conclusions - CEF

1. We can achieve 80% cuts in emissions and still meet our energy needs.

2. We can get ~60% of the cuts with technology we largely know about

   - Technology in use today or in demonstration.

   - Deployment will depend more on policy.

3. We can get the rest of the cuts to 80% below 1990, but this will require new technology innovation and development

Comparison Among Three Studies: What Have We Learned?

1. No impediments to getting started, but we must get started NOW.

   - Existing infrastructure is valued in $ trillions

   - Turn over of assets is measured in decades

2. A portfolio approach is necessary, including a modern, 21st century grid.

3. Deployment and integration are key; policy and regulatory actions as well as other incentives will be required to overcome these barriers.

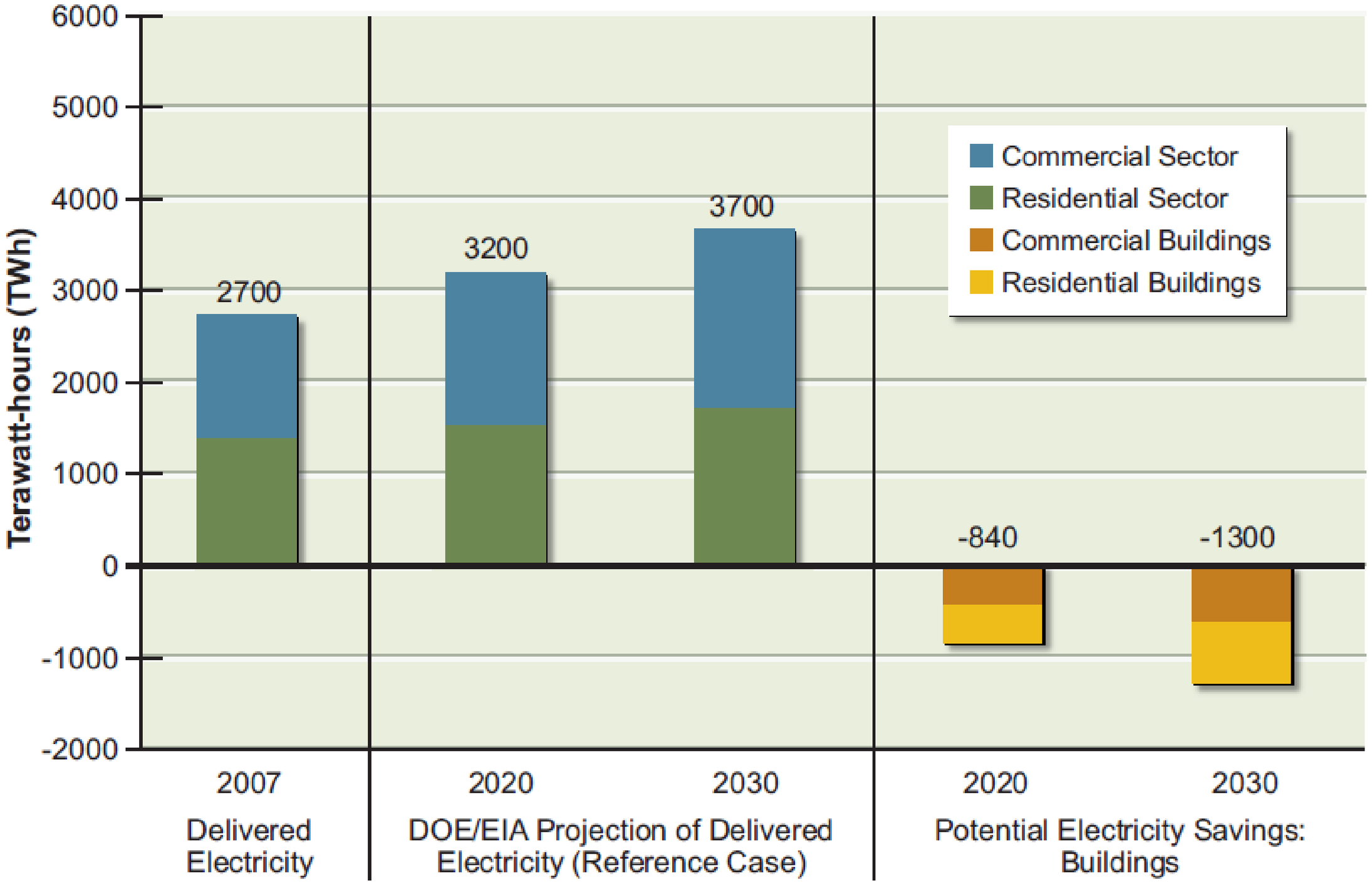
4. However to get 80% below 1990 GHG levels by 2050 will require new technology innovation and development.

5. Need to stay the course (Fukushima Daiichi as an example)?

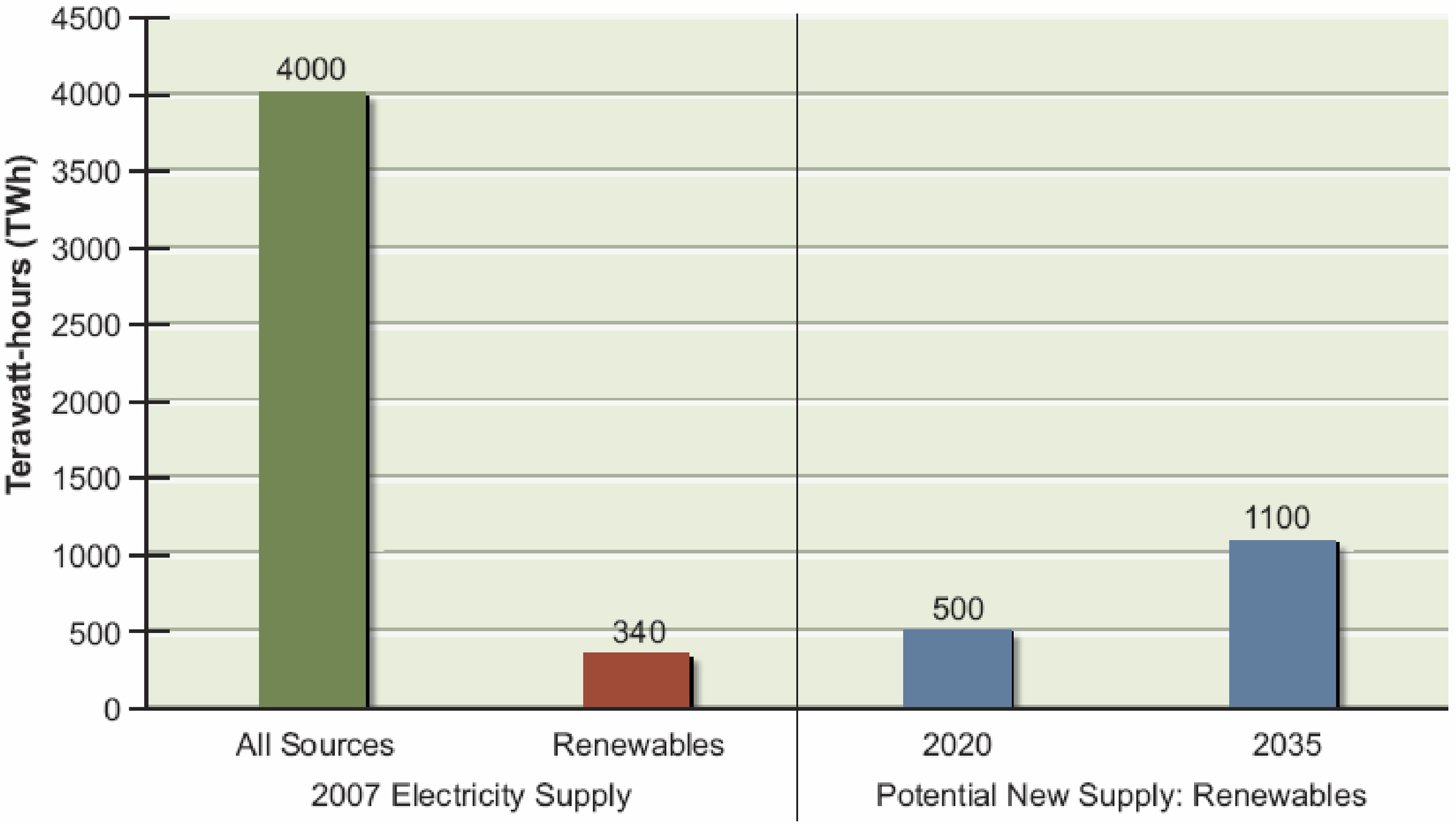
2.

BACKUP CHARTS

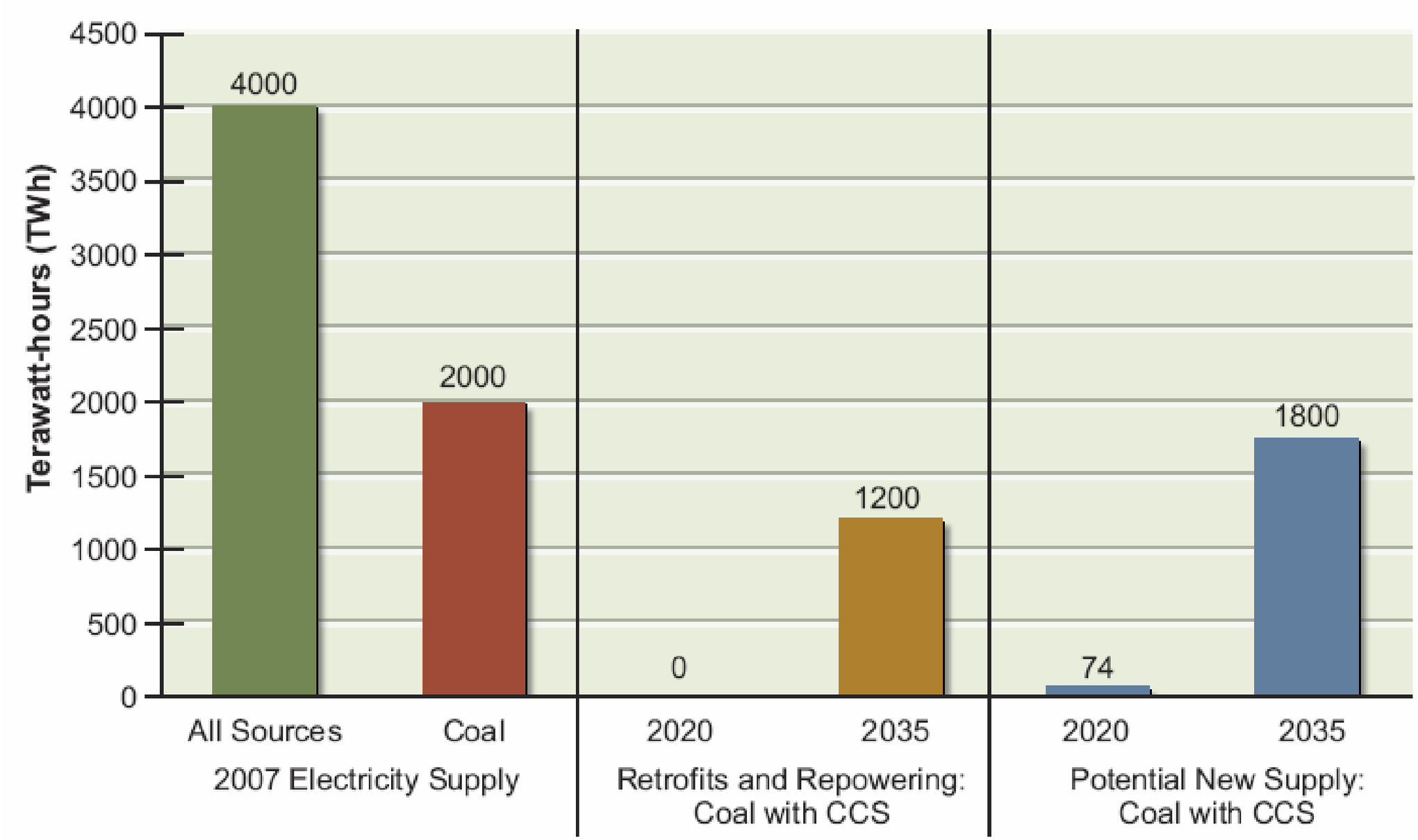
Potential Electricity Savings in Commercial and Residential Buildings, 2020 and 2030



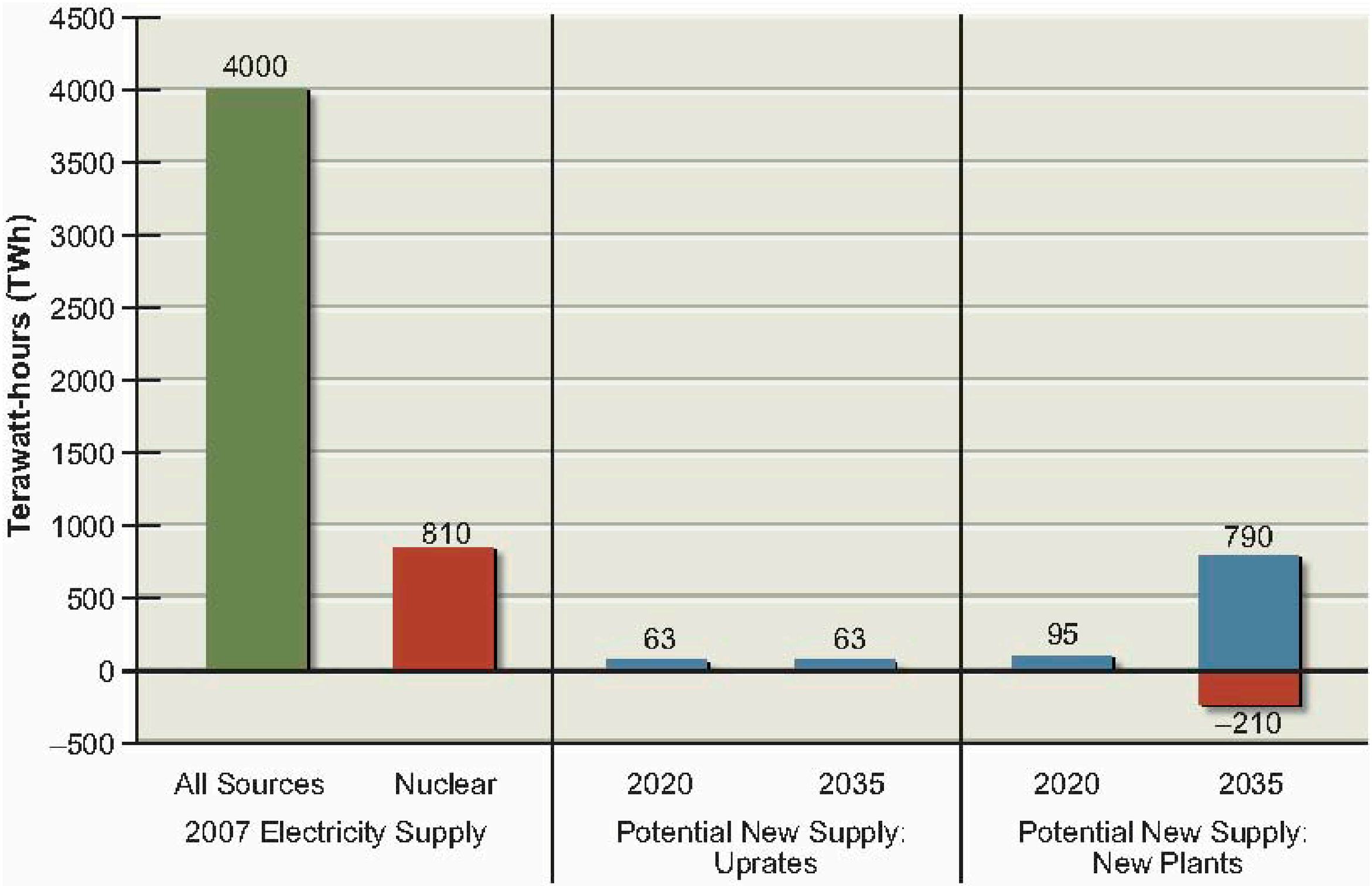
Prospects for Renewable Electric Power in the U.S.



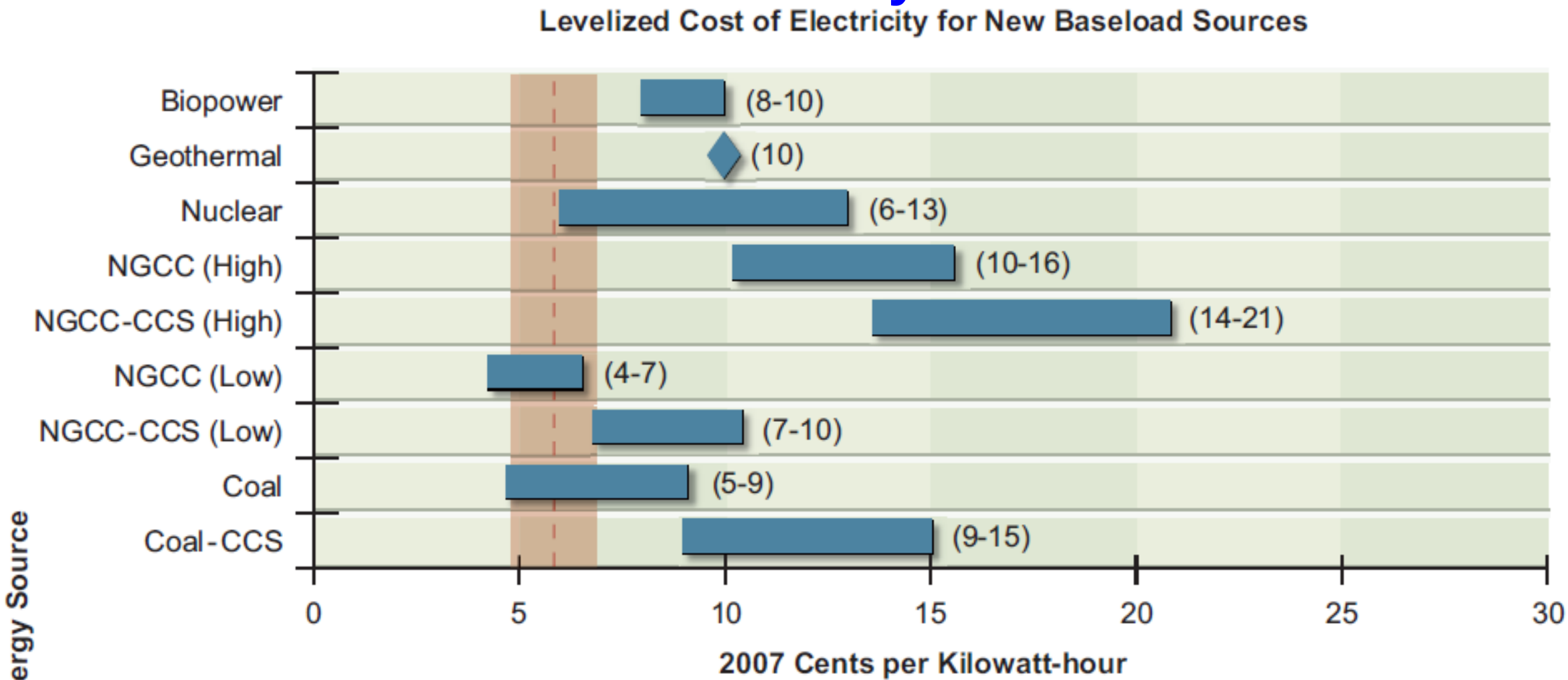
Future of Coal with Carbon Capture and Sequestration: Retrofits and New Supply

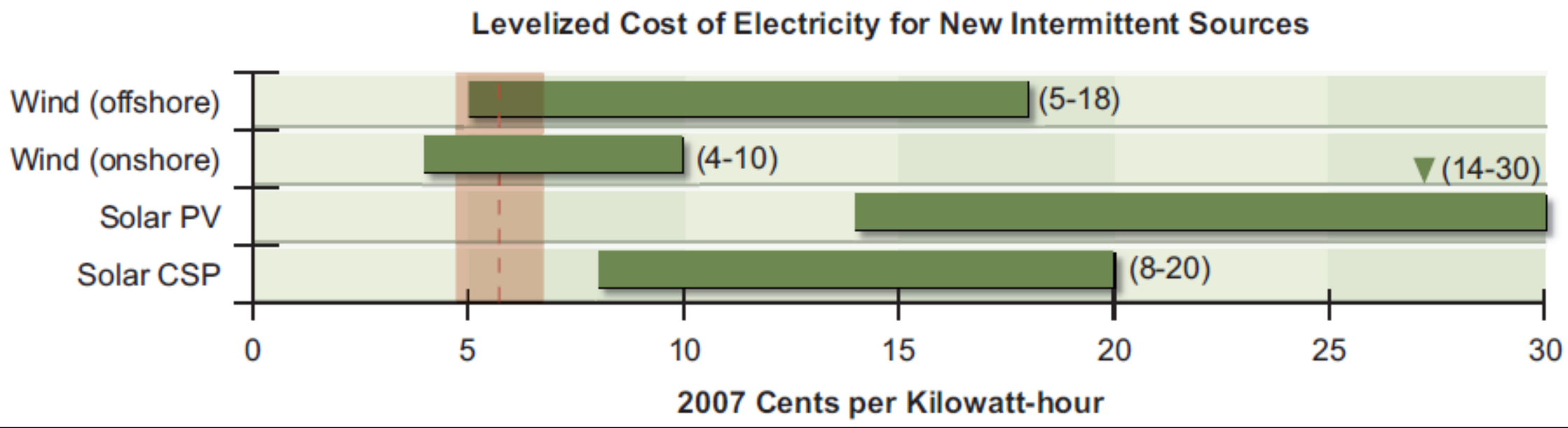


Prospects for Nuclear Power in the U.S.



Levelized Cost of Electricity Generation





Moving Toward the "Smart Grid"

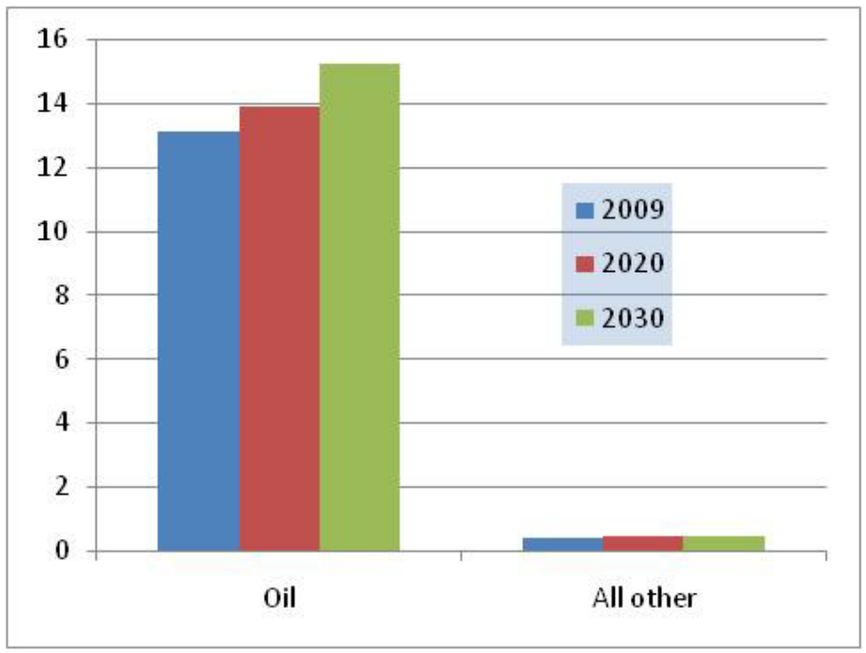
- Deploy advanced communication and control to facilitate improved reliability and security
- Enable more efficient use of distributed generation sources over much wider areas
- Deploy advanced metering
- Accommodate higher penetration of intermittent sources such as wind and solar
- Increase dispatchable energy storage
- Utilize load management and improved ability to control end-use demand

Finding 5: Continued Dependence on Oil

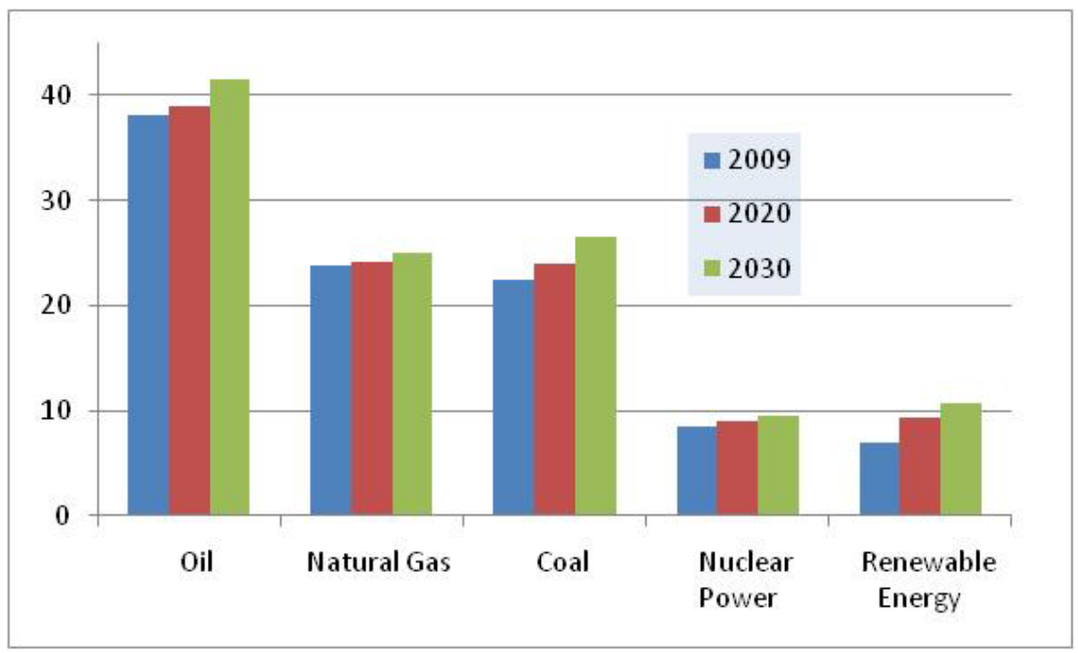
Petroleum will continue to be an indispensable transportation fuel through at least 2035.

EIA Reference Case through 2030

Transportation
Million barrels of gasoline equivalent per day



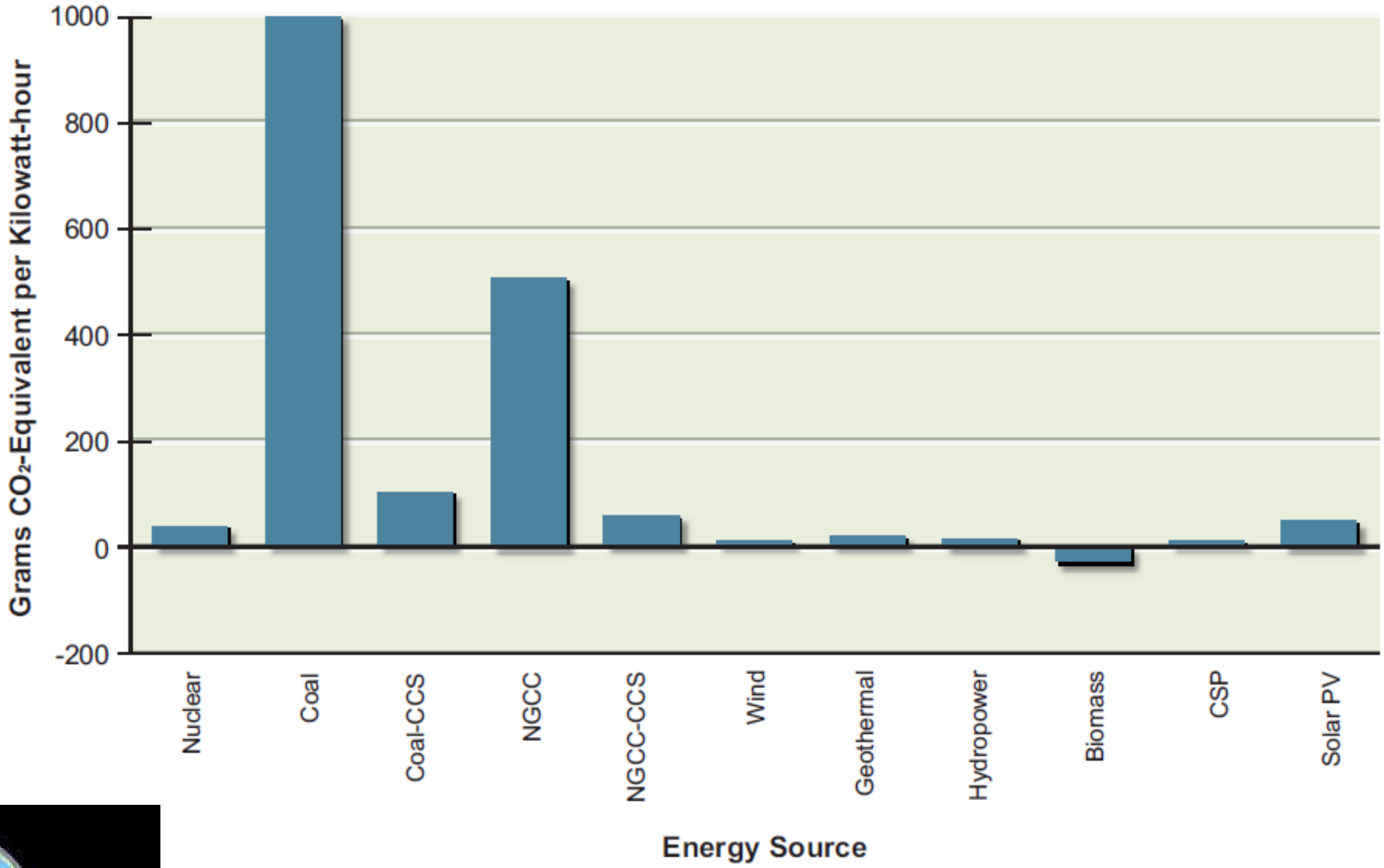
Total Energy
Quadrillion Btu per year



Million Barrels of Gasoline Equivalent Per Day	Current	2008	2020	2035
Cellulosic Ethanol		0	0.5	1.7
Coal to Liquids with CCS		0	0	3
Coal-and-biomass-to-Liquids		0	0	2.5

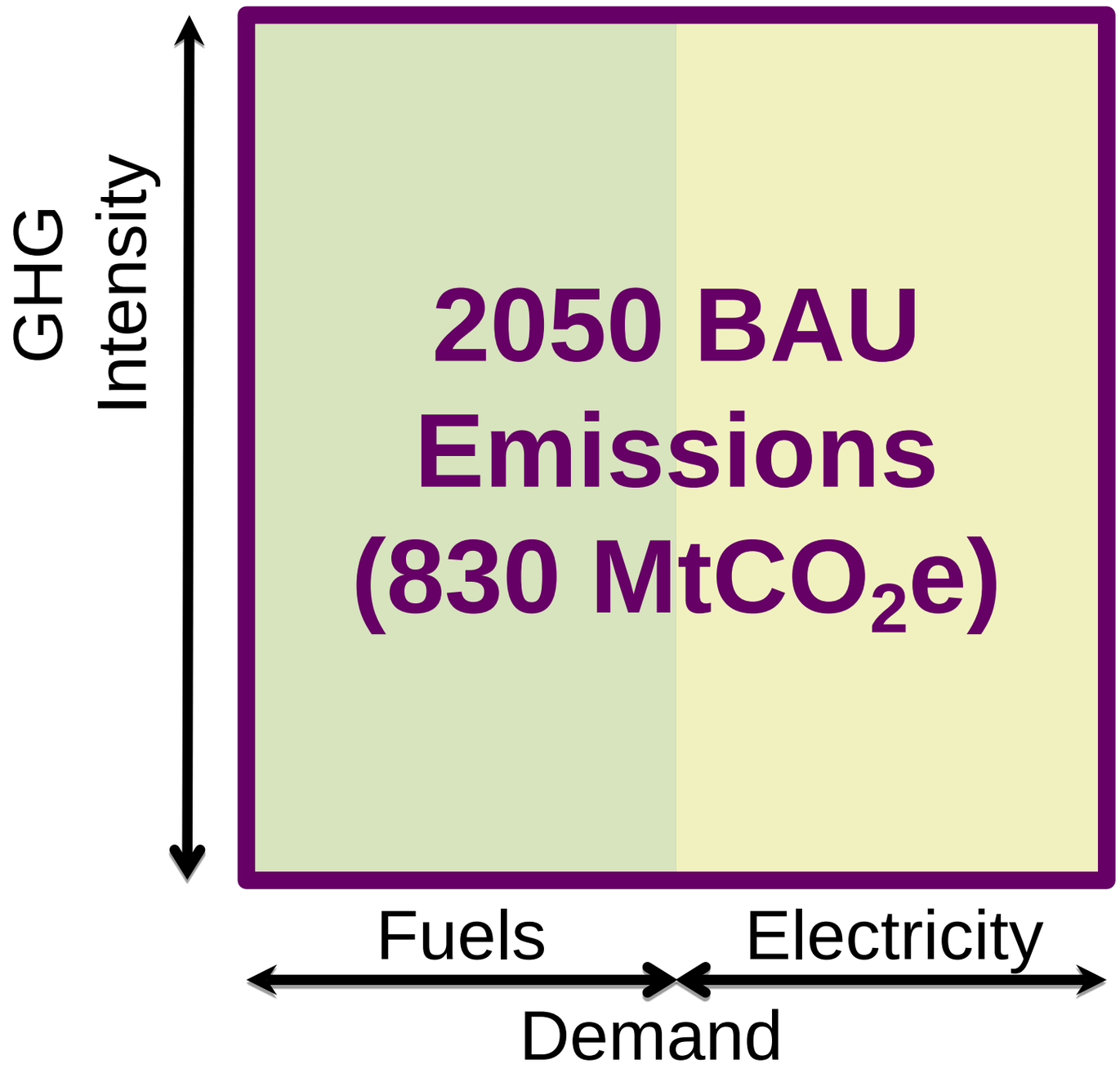
Reminder: Estimates are not additive

Estimated Life-Cycle Greenhouse Emissions from Electricity Generation Technologies

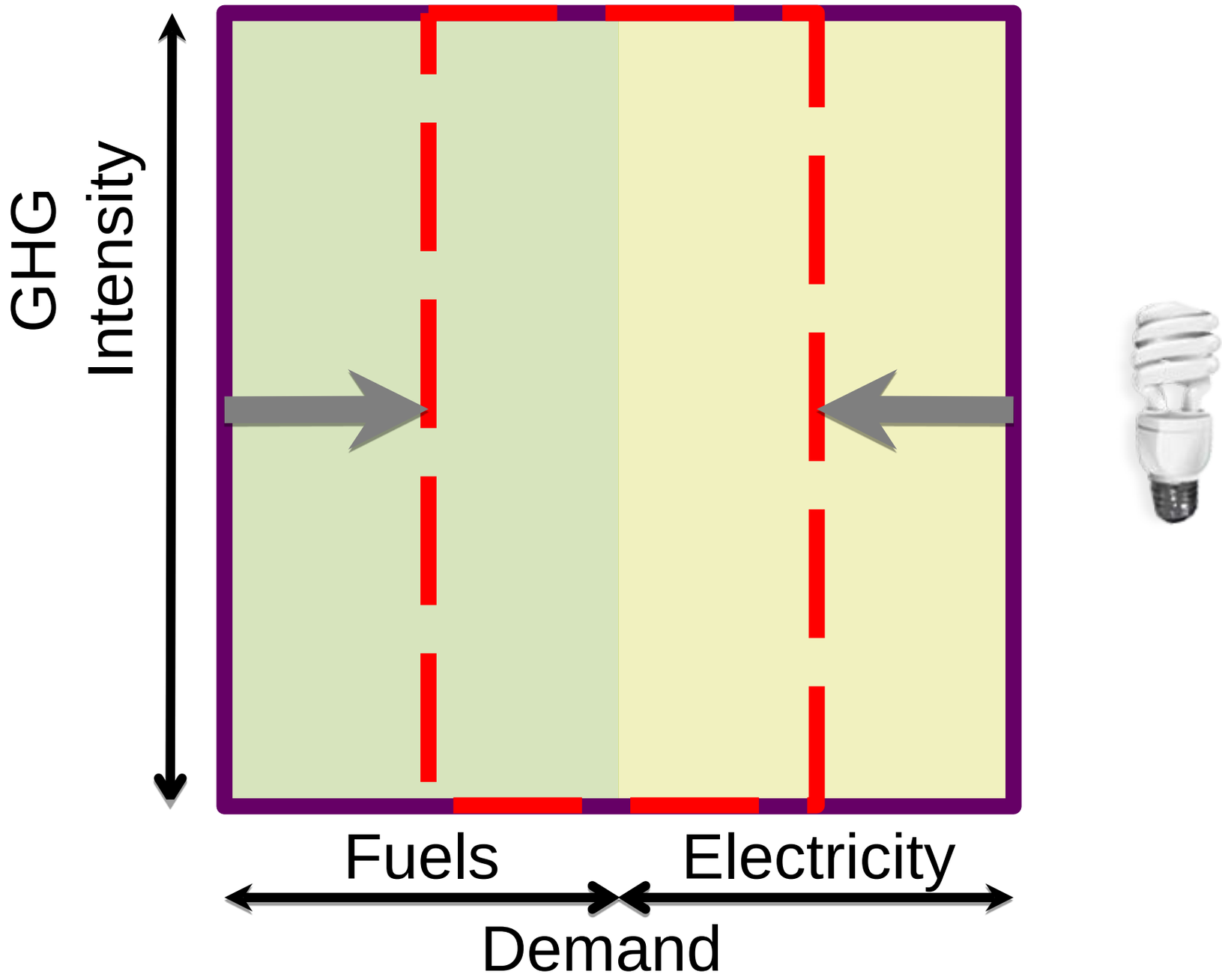


Four Actions to Reduce Emissions

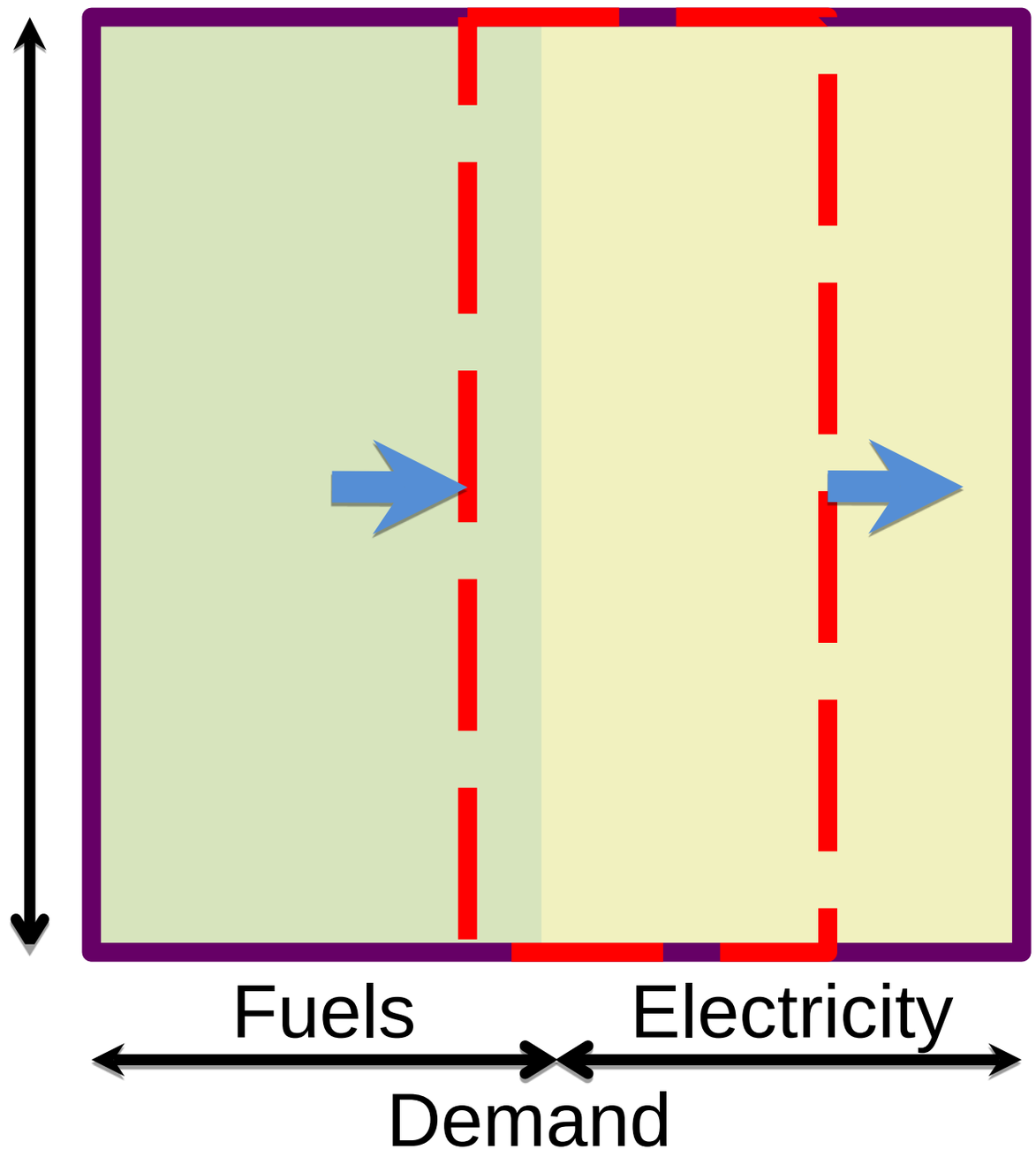
GHG Intensity-Demand Diagram



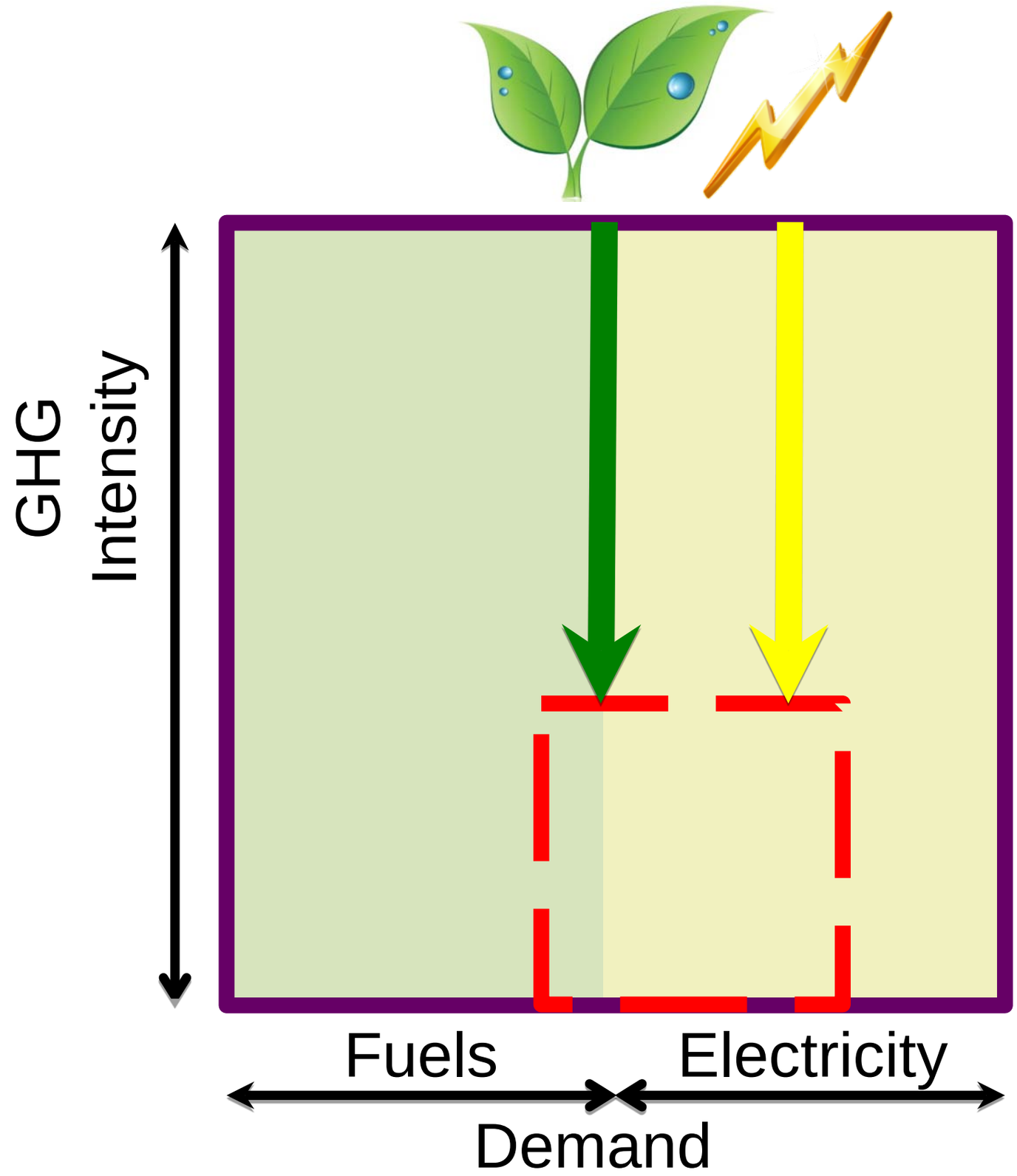
1. Efficiency



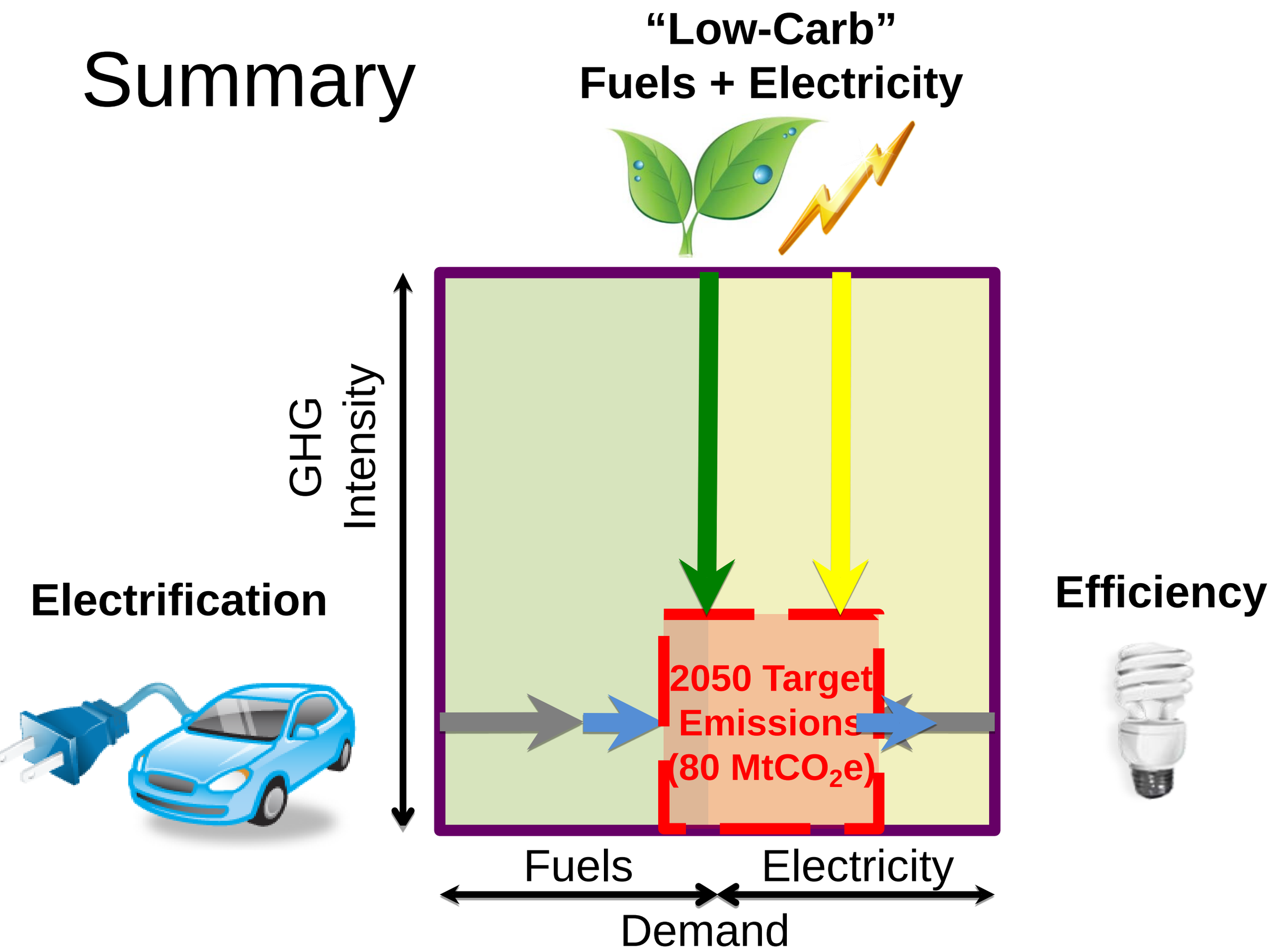
2. Electrification



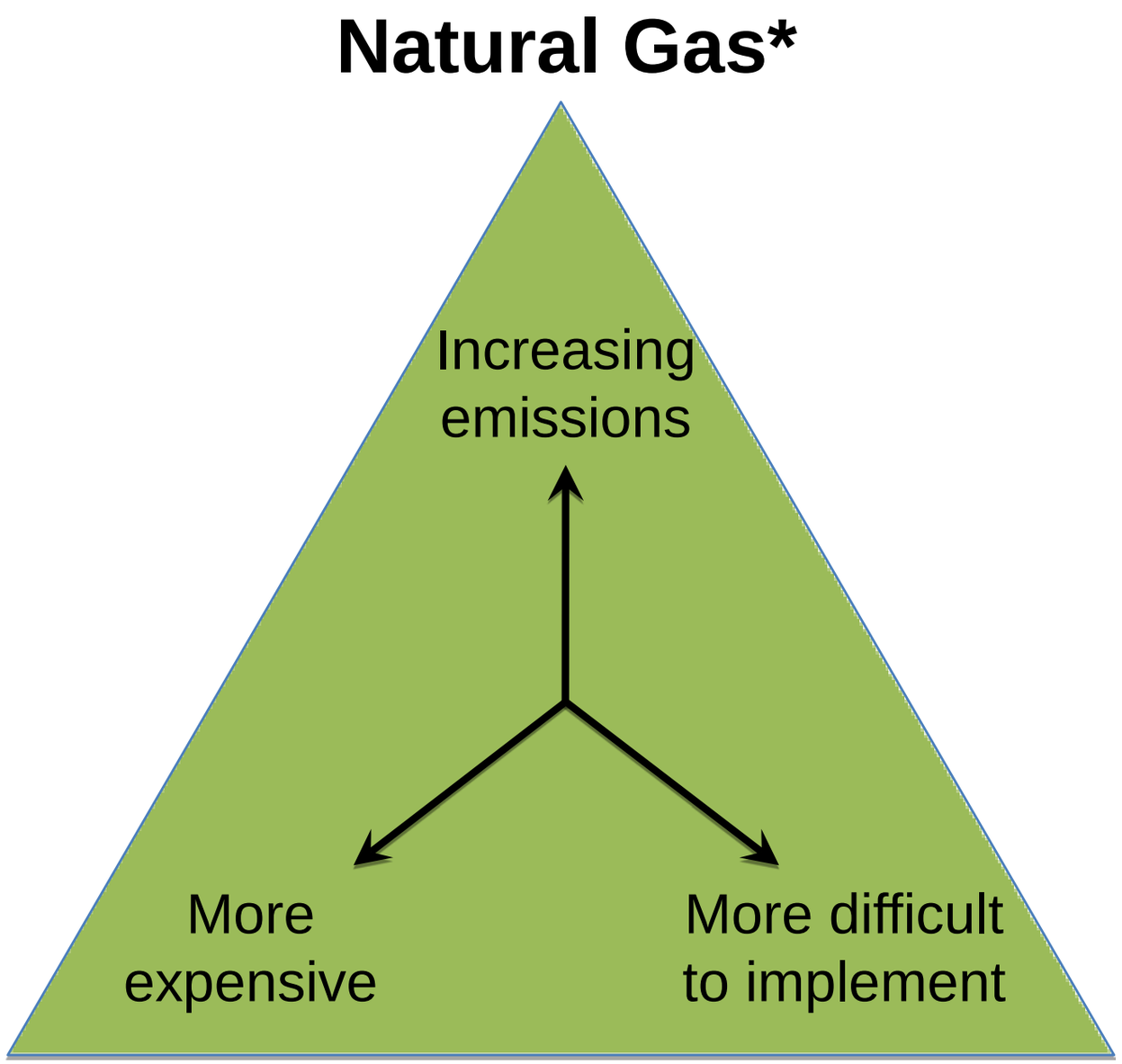
3 + 4. “Low-Carb” Fuels + Electricity



Summary


"Low-Carb"
Fuels + Electricity
GHG Intensity
Electrification
Efficiency
2050 Target Emissions (80 MtCO2e)
Fuels
Electricity
Demand

Load balancing can add emissions:



** May be possible with CCS in future*