Electricity Life-Cycle Analysis:
Issues, Results, and Case Simulations:

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University of Chicago

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Outline

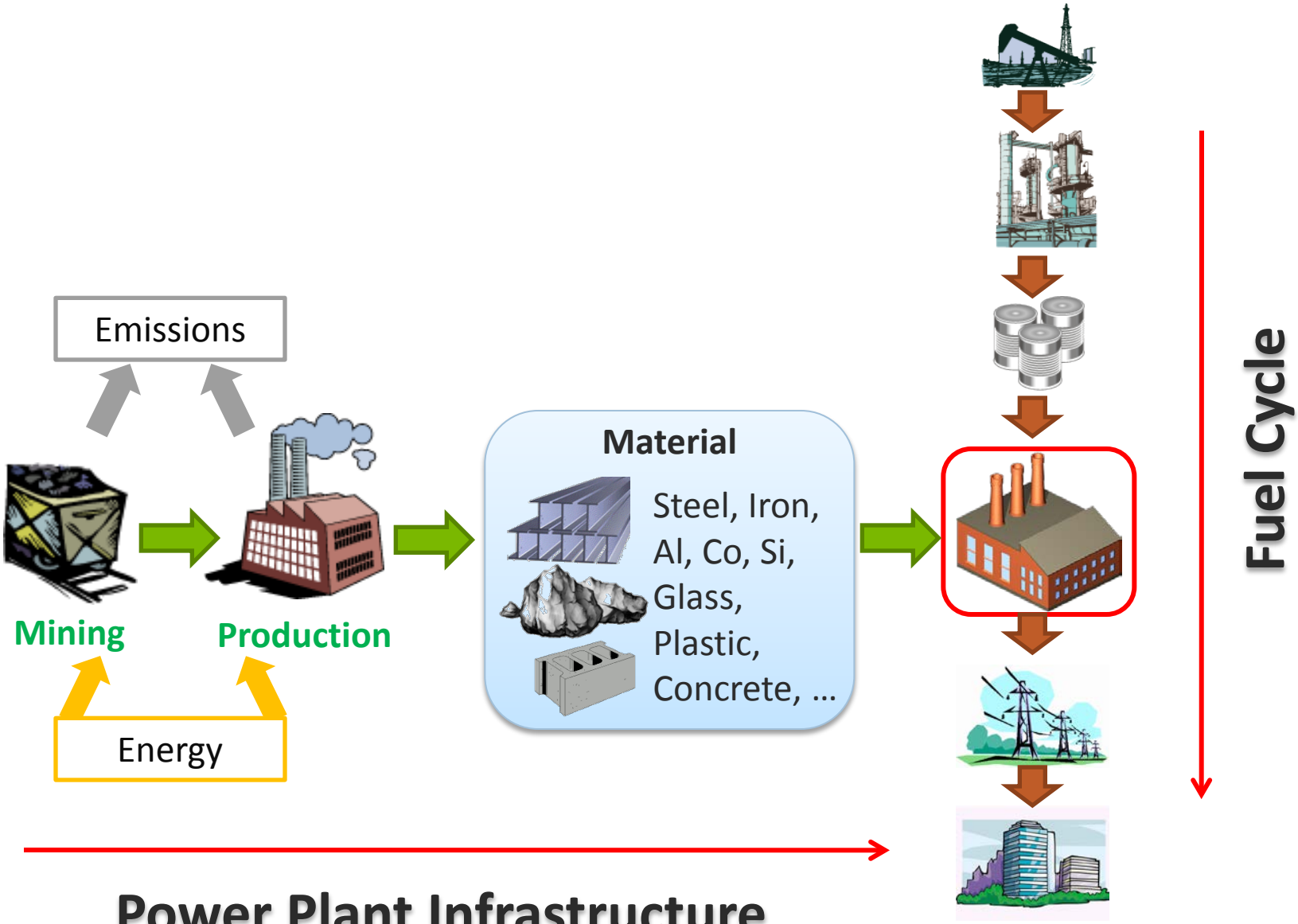
- Electricity generation (fuel cycle)
- Plug-in hybrid electric vehicles (WTW analysis)
- Electricity generation (infrastructure)

Supporting Document: Journal Article and Technical Reports

A. Elgowainy, J. Han, L. Poch, M. Wang, A. Vyas, M. Mahalik, A. Rousseau, 2010, "Well-to-Wheels Analysis of Energy Use and Greenhouse Gas Emissions of Plug-In Hybrid Electric Vehicles," http://greet.es.anl.gov/publication-xkdaqgyk

J. Sullivan, C. Clark, J. Han, M. Wang, 2010, "Life-Cycle Analysis Results of Geothermal Systems in Comparison to Other Power Systems," http://greet.es.anl.gov/publication-geothermal_and_other_power

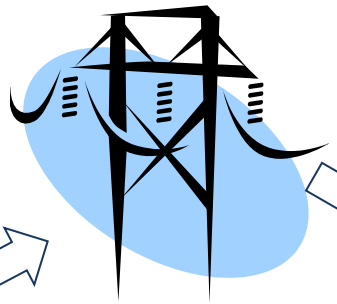
GREET Fuel Cycle and Power Plant Construction



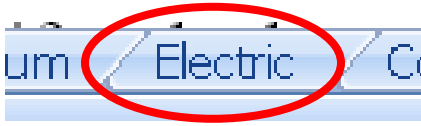
Electricity Generation Fuel Cycle Key Stages:

Fuels

T&D



Electricity



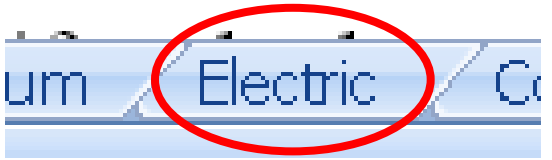
Power Plant
(fuel conversion, infrastructure)

Upstream
(recovery, processing, T&D)

Electricity Generation Technology Mix:

- By fuel type and generation technology
  - NG: steam, simple combustion, CC
  - Coal: steam, IGCC
  - Nuclear: LWR
  - Oil: steam cycle
  - Biomass: steam, IGCC
  - Renewable: geothermal, wind, solar, hydro
- By region
  - U.S. average
  - California
  - Northeastern
  - User defined (specific)
- By application
  - Stationary applications (process use)
  - Transportation (marginal) applications (e.g., EVs)

Electricity



Electric sheet in GREET

9.2) Electricity Generation Mix

9.2.a) Selection of Electricity Generation Mix for Transportation Use

Mix for transportation use	1	1 -- U.S. Mix	4 -- User Defined Mix	7 -- Nuclear Power Plants (transportation only)
Mix for stationary use	1	2 -- NE U.S. Mix	5 -- NG Power Plants (transportation only)	8 -- Hydro Power Plants (transportation only)
		3 -- CA Mix	6 -- Coal Power Plants (transportation only)	9 -- NGCC Turbine (transportation only)

Electricity Generation Technology Mix:

GREET uses EIA projections for future generation mixes in different regions (AEO 2011)

U.S. Mix: Stationary Use

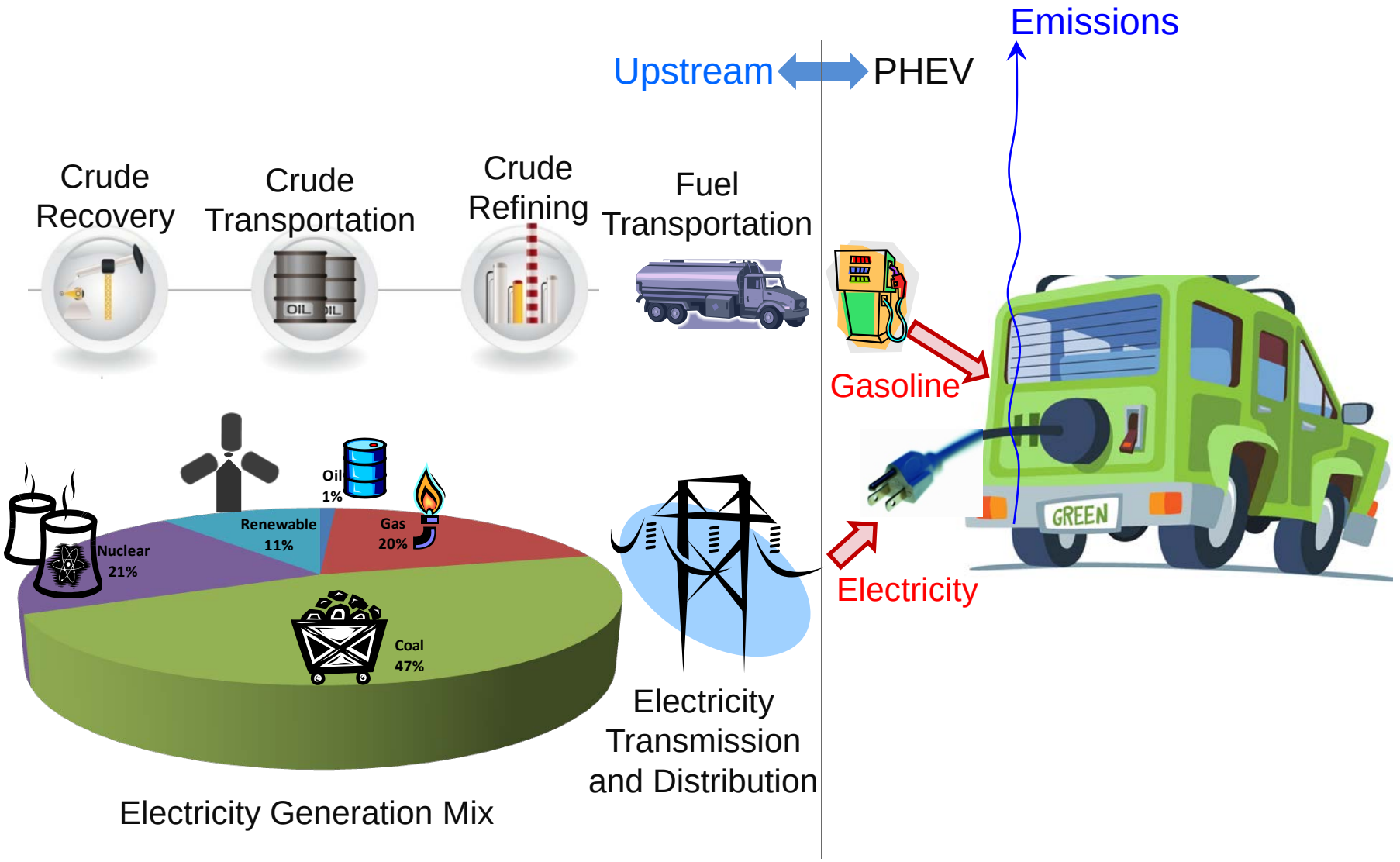
	1.0%	22.9%	46.4%	20.3%	0.2%	9.2%
5-year period	**Residual Oil**	**Natural Gas**	**Coal**	**Nuclear**	**Biomass**	**Others**
1990	4.2%	12.3%	52.5%	19.0%	1.1%	10.9%
1995	2.2%	14.8%	51.0%	20.1%	1.2%	10.7%
2000	2.9%	15.8%	51.7%	19.8%	1.1%	8.7%
2005	2.9%	15.7%	51.7%	20.3%	1.2%	8.2%
2010	**1.0%**	**22.9%**	**46.4%**	**20.3%**	**0.2%**	**9.2%**
2015	0.9%	21.5%	44.2%	21.0%	0.5%	11.8%
2020	0.9%	20.2%	45.1%	21.1%	0.9%	11.7%

CA Mix: Stationary Use

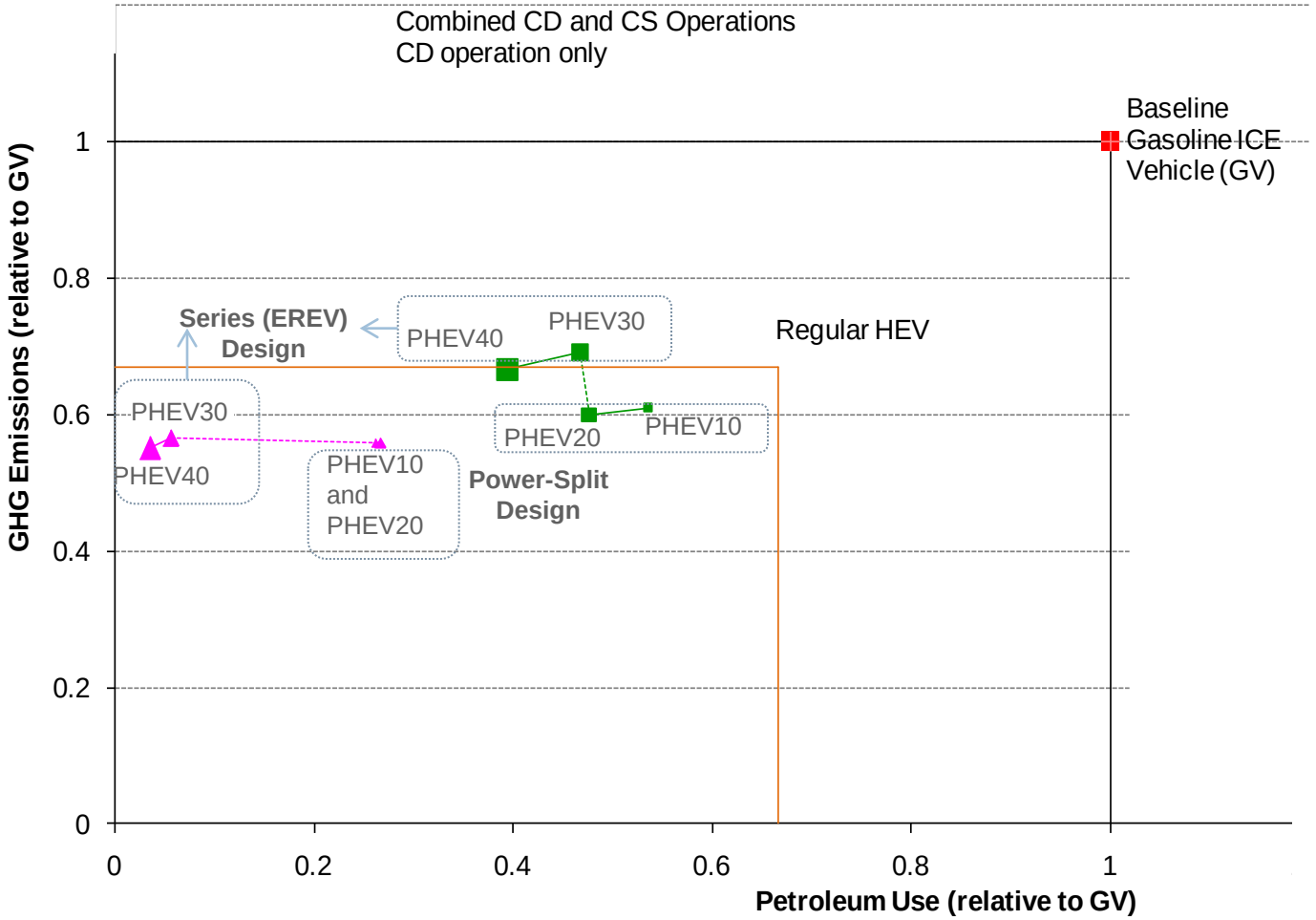
	0.0%	41.0%	8.1%	23.1%	0.9%	26.8%
5-year period	**Residual Oil**	**Natural Gas**	**Coal**	**Nuclear**	**Biomass**	**Others**
1990	2.3%	40.0%	11.2%	19.2%	1.6%	25.7%
1995	0.2%	37.5%	8.6%	17.3%	1.6%	34.8%
2000	0.2%	42.1%	14.5%	17.1%	1.6%	24.5%
2005	0.8%	35.2%	15.9%	21.5%	1.6%	25.0%
2010	**0.0%**	**41.0%**	**8.1%**	**23.1%**	**0.9%**	**26.8%**
2015	0.0%	37.4%	7.5%	22.5%	0.5%	32.2%
2020	0.0%	36.2%	7.6%	21.4%	1.4%	33.3%

WTW Analysis of PHEVs

PHEVs WTW Pathway



GREET Estimates WTW Petroleum Savings and GHG Emissions for PHEVs Relative to ICEV and HEVs
(Figure Shown for Charging in WECC)



LCA of Power Plants Construction

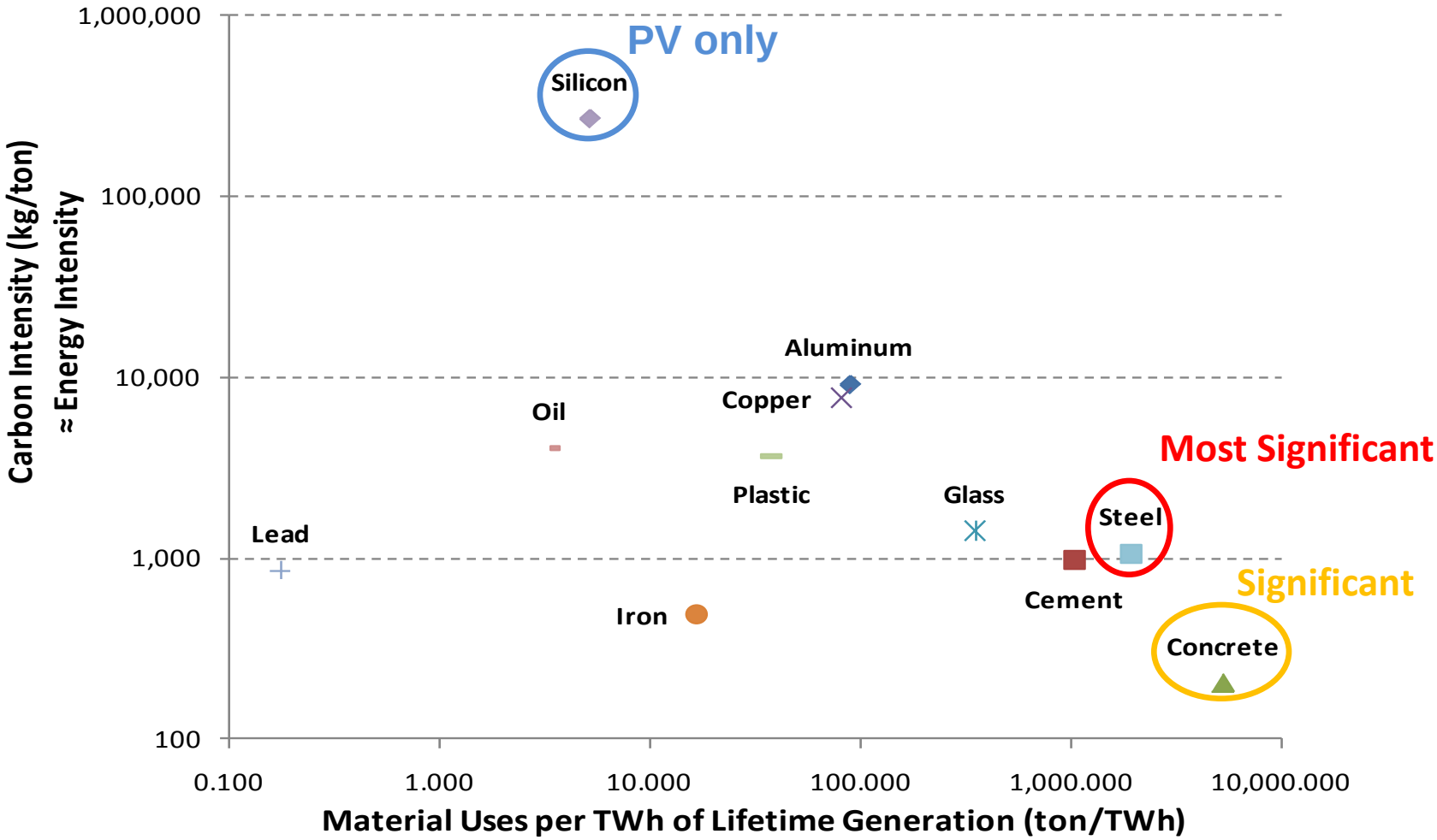
John Sullivan
ANL

Three Steps

Gather power plant infrastructure data for each power plant type (geothermal, coal, solar, etc.)

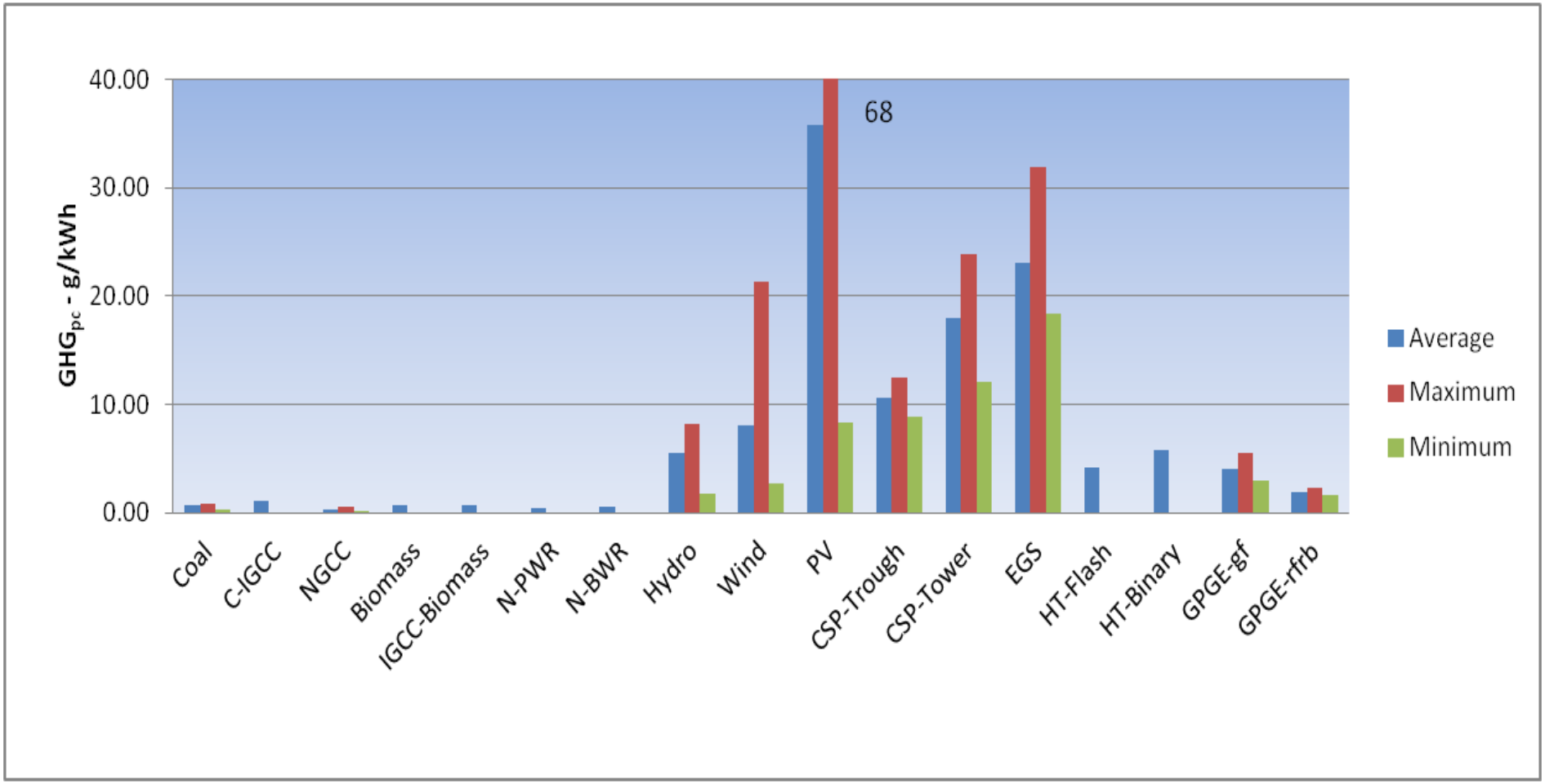
1) Plant and equipment material composition
   - For geothermal power, this includes the well
2) Develop material to power ratios (MPRs)
3) Construction energy (diesel for excavators, cranes) added where data available

Impact of Materials on Life Cycle Analysis Results

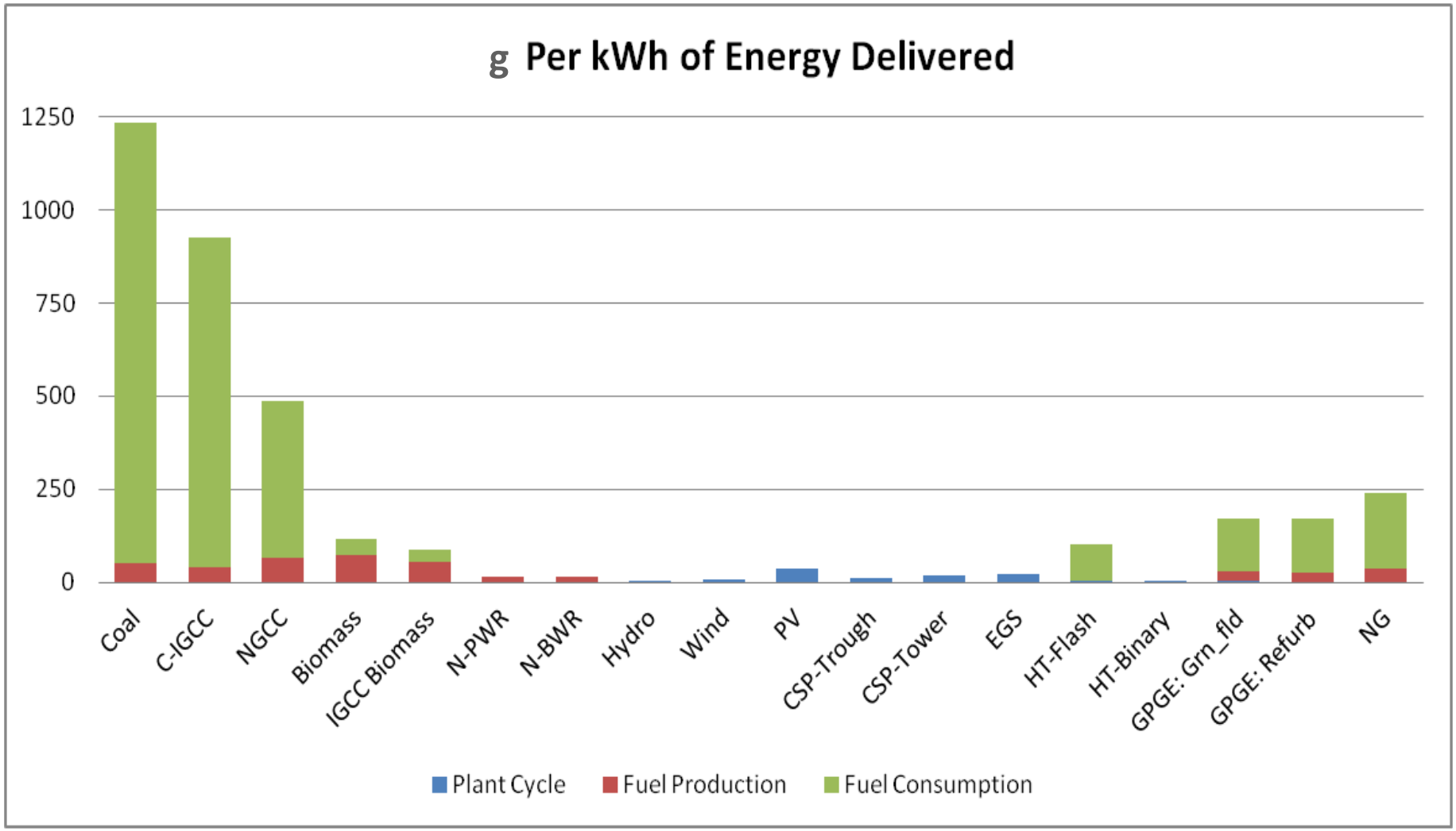


- PV requires significantly larger amount of energy/carbon intense materials (Si, Al, and glass) than other power plants
- Steel and concrete are widely used for various power plants
- 30 years lifetime

CO2 Emissions Attendant the Construction and Production of Constituent Materials for a Power Plant



GHGs for Various Power Plant Technologies



Demonstration of Case Simulations

	Vehicle Technologies	Electricity Mix	Include Infrastructure
Case 1	PHEV 40, BEV	U.S. Mix	No
Case 2	BEV	CA Mix	No
Case 3	BEV	Coal	No
Case 4	BEV	Wind	No
Case 5	BEV	Wind	Yes