UNIVERSITY OF CALGARY

CANADIAN ENERGY SYSTEMS ANALYSIS RESEARCH

Anthropogenic Energy and Carbon Flows in Canada:

Rethinking Climate Change Solutions

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Canada's GHG Emissions (722 $MtCO_2e$/yr in 2015)

Biology:

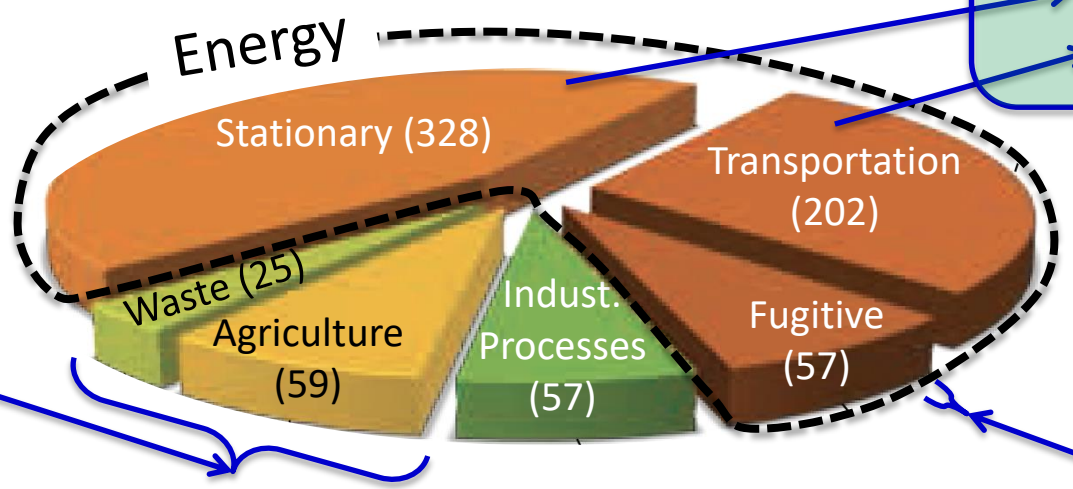
Part of the Problem & *Part of the Solution*

Bioenergy & Biofuels

Reduce fossil fuel demand:
- ✓ Wood to heat & power
- ✓ Ethanol & biodiesel

Waste & Agriculture

Microbial production of methane (CH_4) & nitrous oxide (N_2O):
- ❑ 84 Mt CO_2e/yr



Energy - Fugitive

Microbial production of CH_4 from tailings ponds:
- ❑ ?? Mt CO_2e/yr

Biological Carbon Management

C stock changes in agriculture & managed forests (reported, but not counted)

Quantifying GHG Emissions & Removals

Sectors	Flows to Atmosphere			Carbon Stock Changes
	CO_2	CH_4	N_2O	
Energy production & use	✓	✓	✓	✗
Non-energy use (exc. Agri. and For.)	✓	✓	✓	✗
Agriculture	✗	✓	✓	✓ (Soil)
Forestry	✗	-	-	✓ (Plant & soil)

Quantified, but not counted in national totals

The C stock changes may hide much large flows of CO_2 to & from the atmosphere.

Perhaps by understanding all anthropogenic energy & C flows, we may be able to identify new solutions for climate change mitigation.

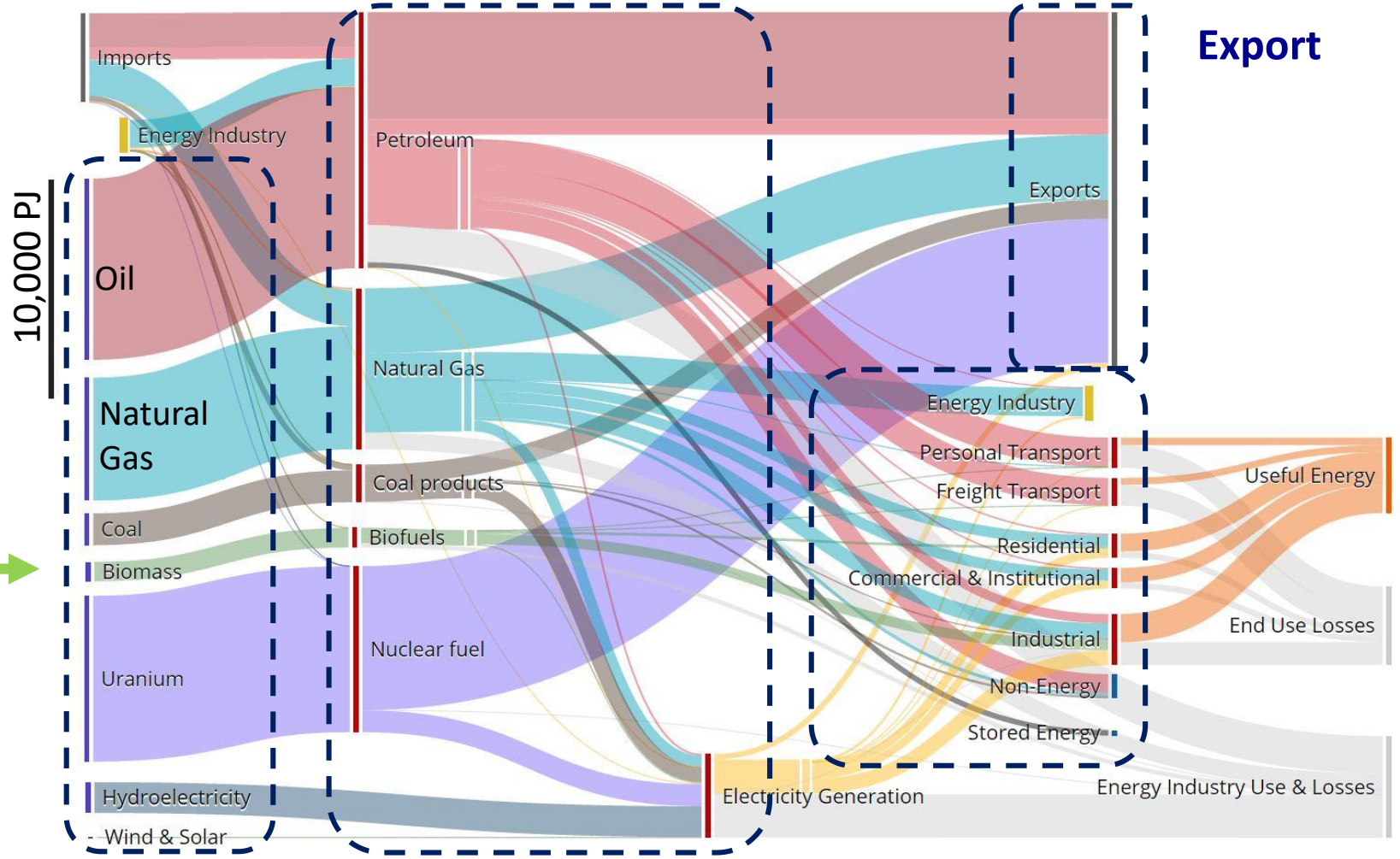
PhD Research Objective

To quantify and integrate **all** anthropogenic energy and carbon flows to inform policy and investment decisions on greenhouse gas management in Canada.

Specific Objectives:

- **Compare** energy and carbon flows associated with the production and use of fuels, electricity, food, and fibre;
- **Build** technology and behaviour-rich pathways contributing to bio-based climate change solutions to 2060; and
- **Identify** the most promising pathways to inform policy and investment decisions.

Canada's Fuel & Electricity Systems (2013)

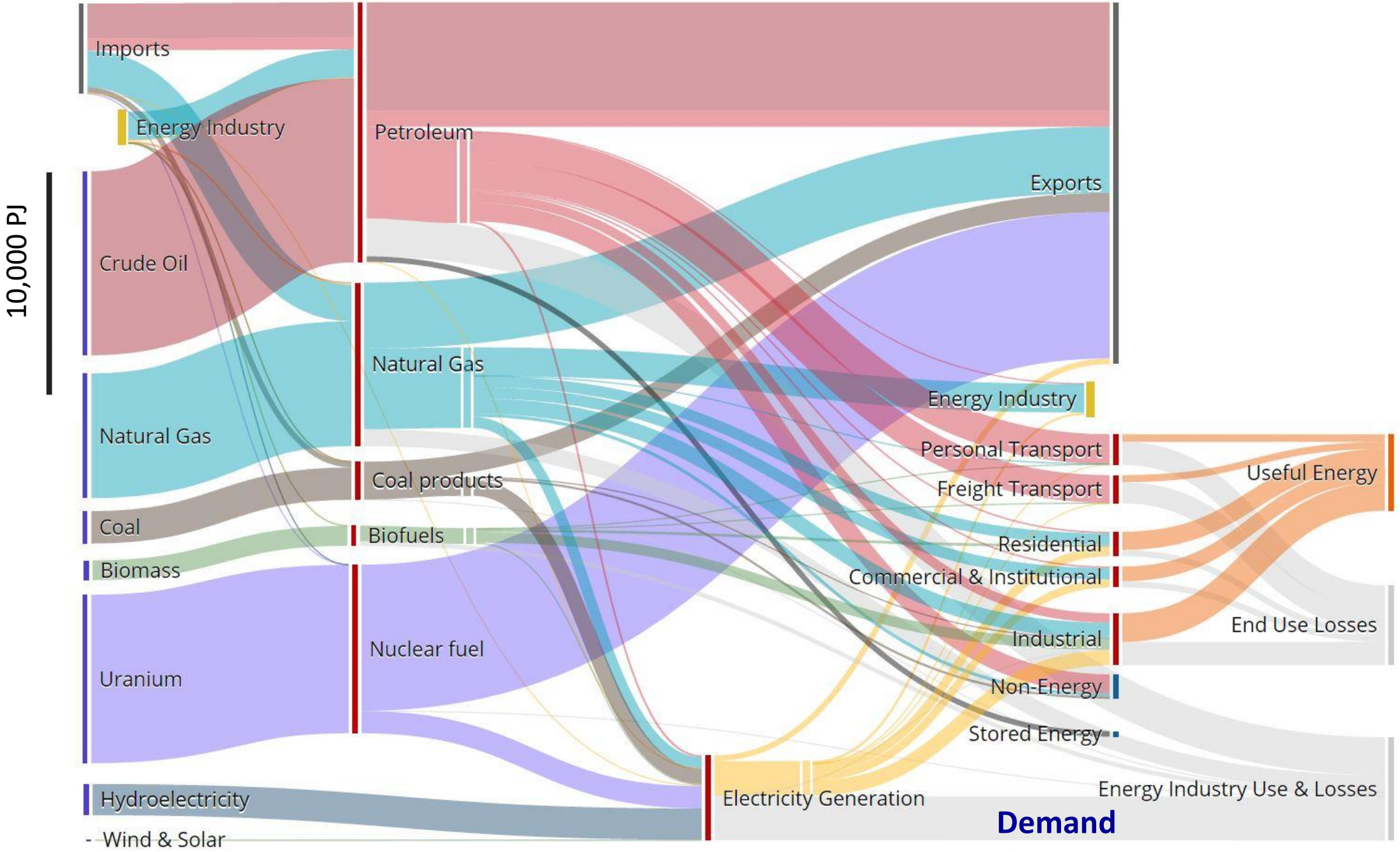


Biomass →

Primary Energy

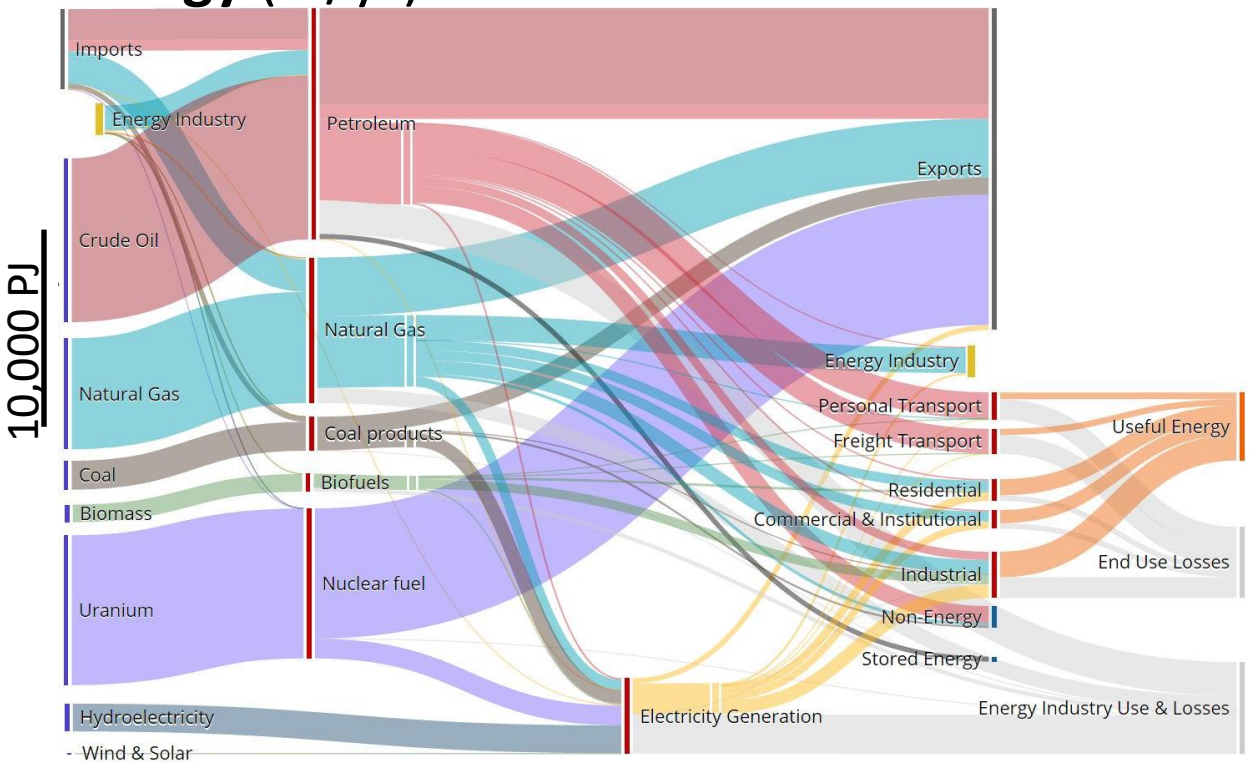
Energy Sectors *(Fuel & electricity only)*

Demand Sectors


10,000 PJ
Imports
Energy Industry
Crude Oil
Natural Gas
Coal
Biomass
Uranium
Hydroelectricity
- Wind & Solar
Petroleum
Natural Gas
Coal products
Biofuels
Nuclear fuel
Electricity Generation
Exports
Energy Industry
Personal Transport
Freight Transport
Residential
Commercial & Institutional
Industrial
Non-Energy
Stored Energy
Useful Energy
End Use Losses
Energy Industry Use & Losses
Demand Sectors

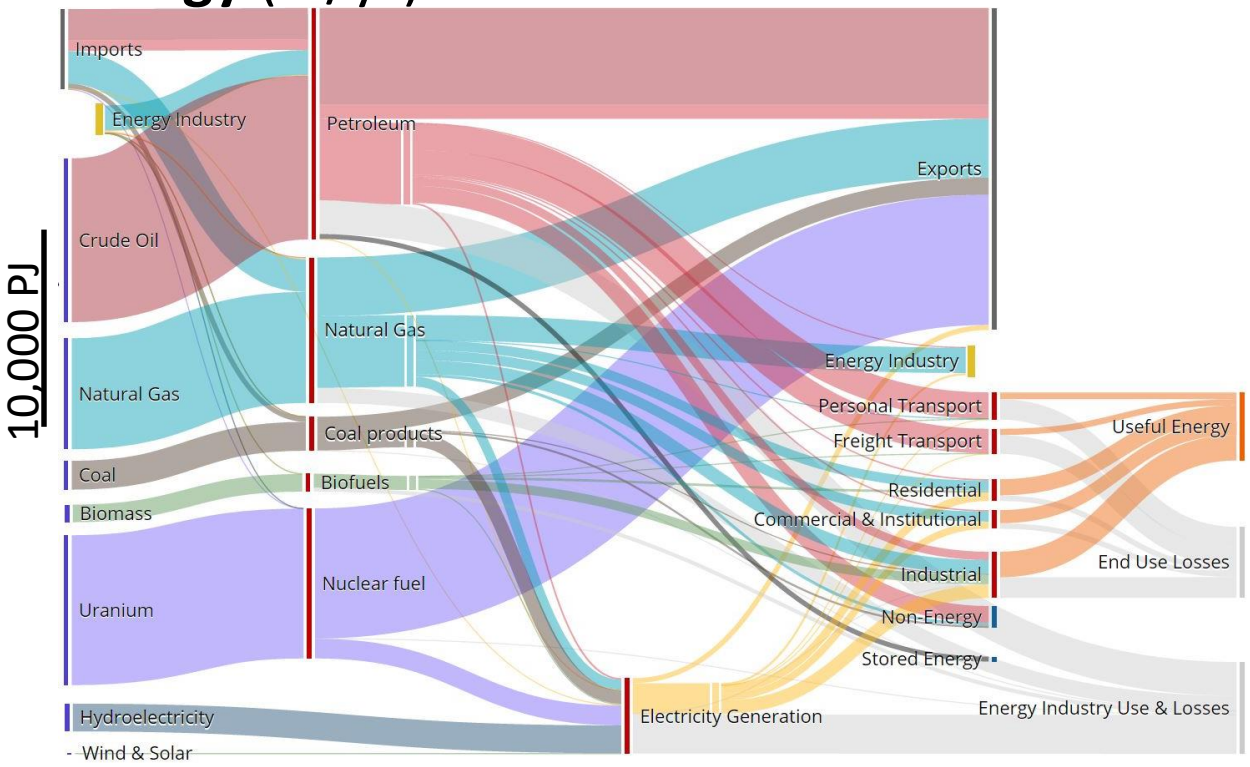
Canada's Fuel & Electricity Systems (2013)

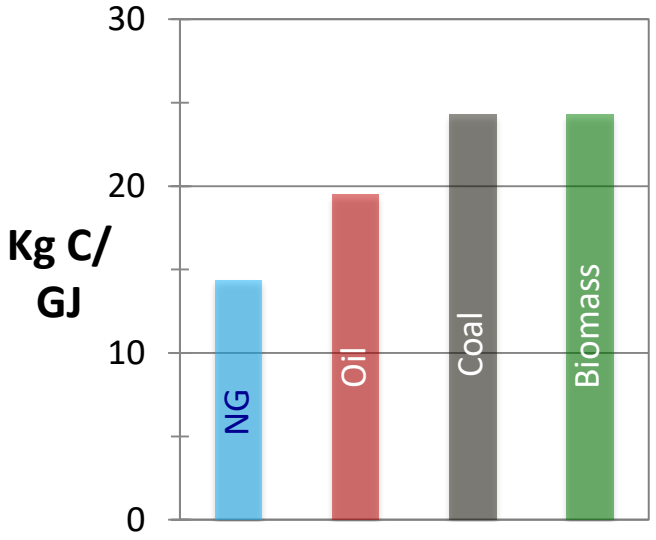
Energy (PJ/yr)



Canada's Fuel & Electricity Systems (2013)

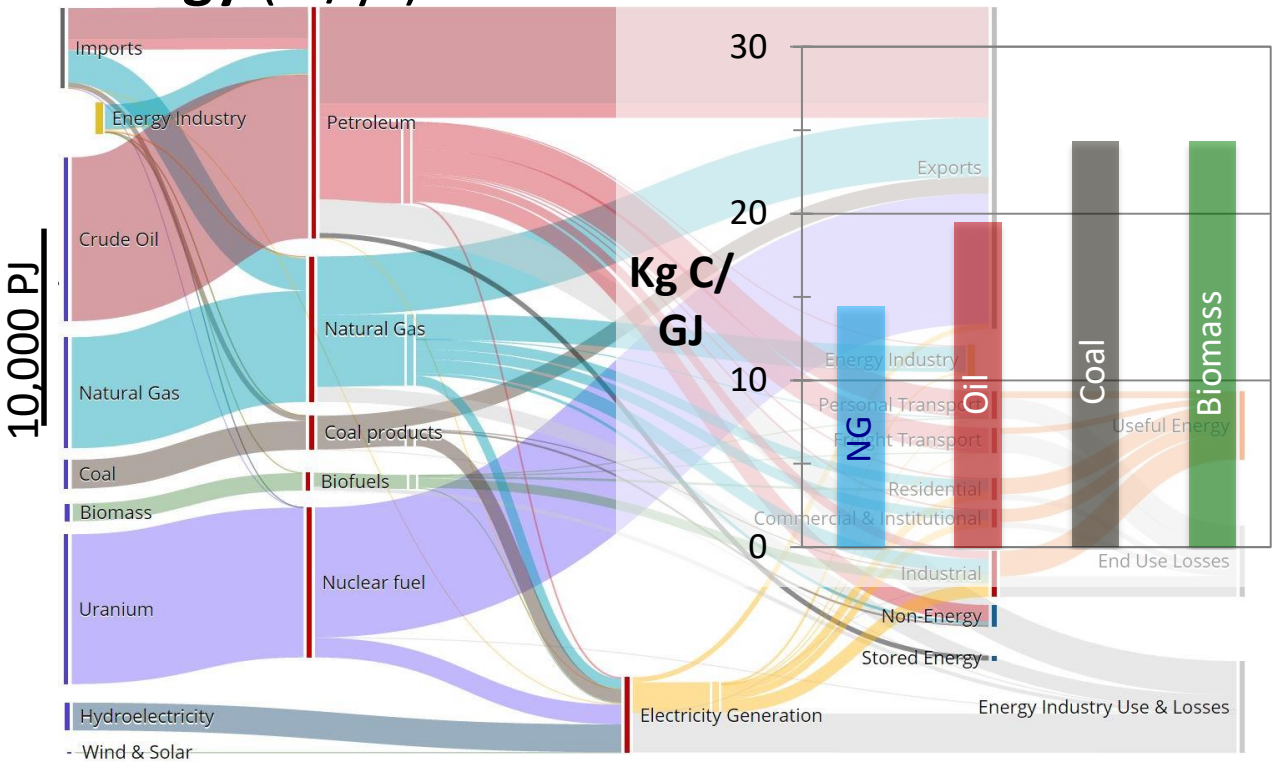
Energy (PJ/yr)



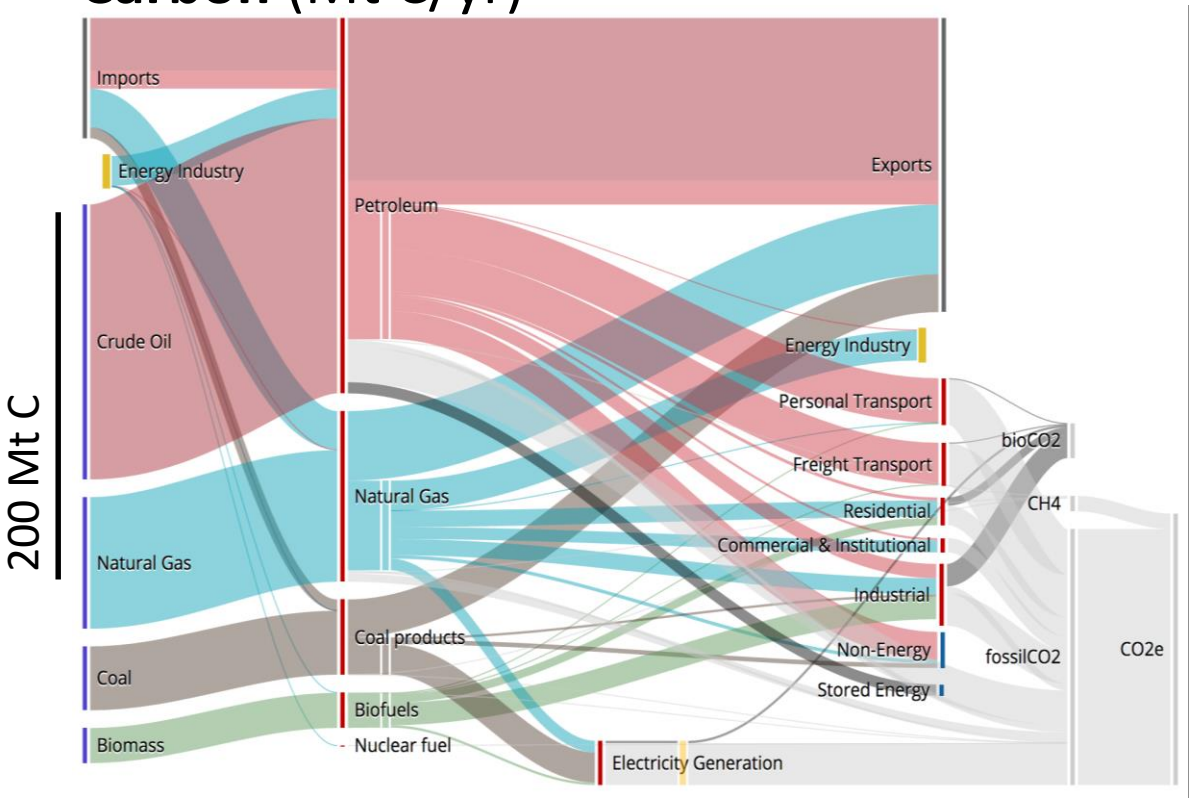


Canada's Fuel & Electricity Systems (2013)

Energy (PJ/yr)



Carbon (Mt C/yr)



The biomass flows are only for fuel and electricity.
What are the carbon flows like for all of Forestry and Agriculture?

Methods

Gov't & Industry Data

- StatsCan
- NRCan
- AgCan
- NFDB
- Prov. data

Scientific Literature

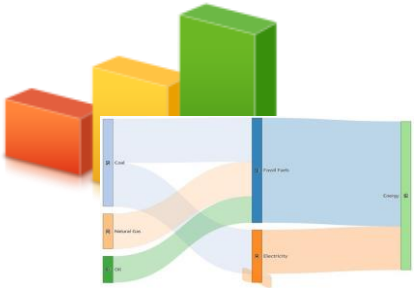
- Energy & C contents
- Fuel & electricity in / out
- Fugitive emissions

Computer Model(s)

Flows of energy & C associated with:

- Fuel & electricity production & use
- Annual harvest of forestry & agriculture

Results & Interpretation



Technology & policy options

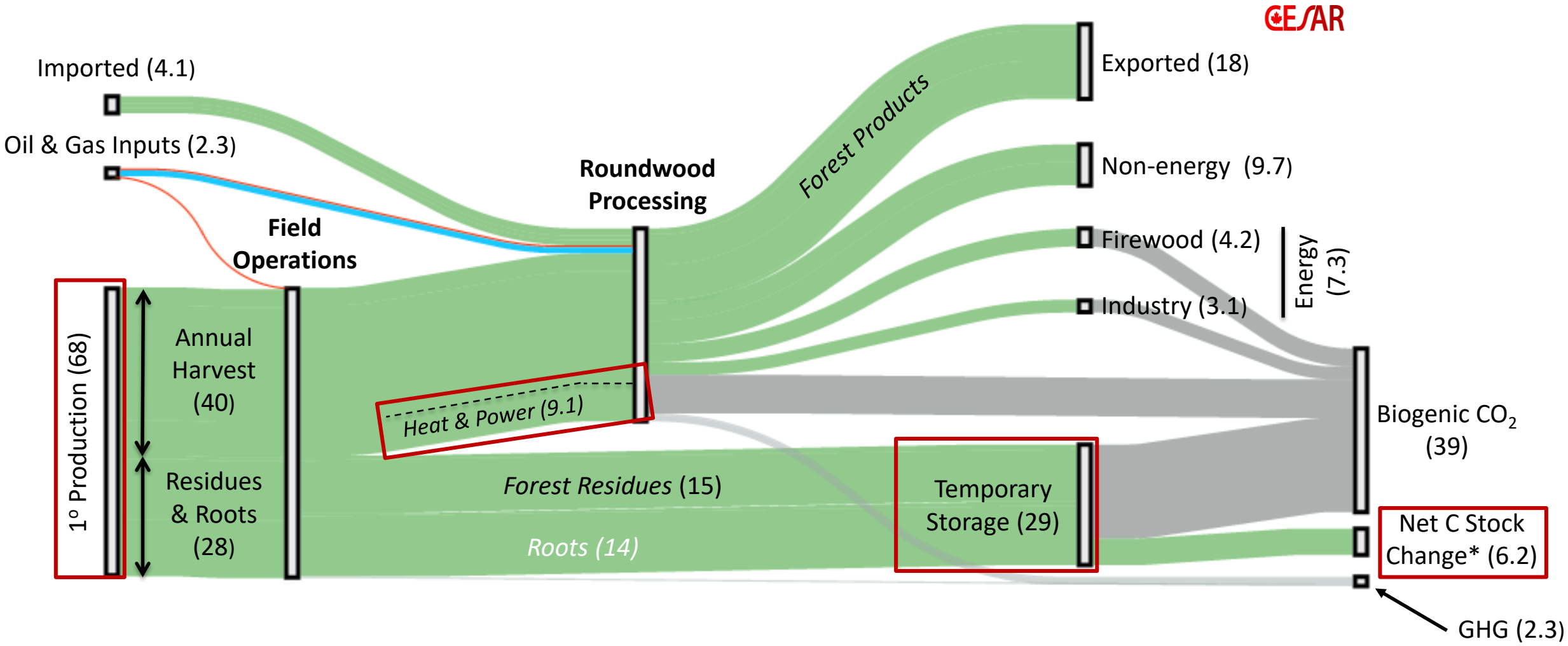
Simulate Future Energy & C Flows

Calculate and assess the costs, benefits, & trade-offs

Inform decision makers

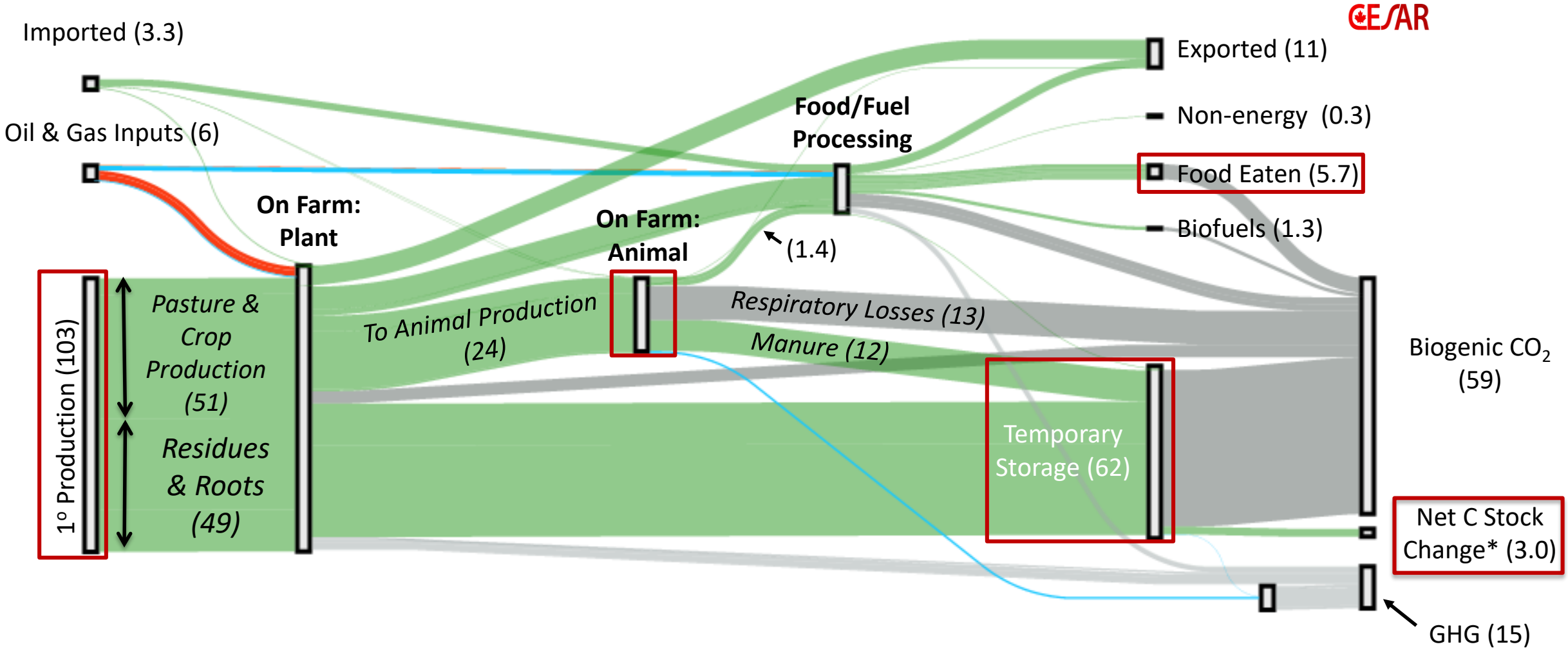
Forestry C Flows (Mt C/yr)

[For ~0.7 Mha harvested out of the 232 Mha managed forest]



* From Canada's Land Use, Land-Use Change and Forestry Calculations. National Inventory Report (2017)

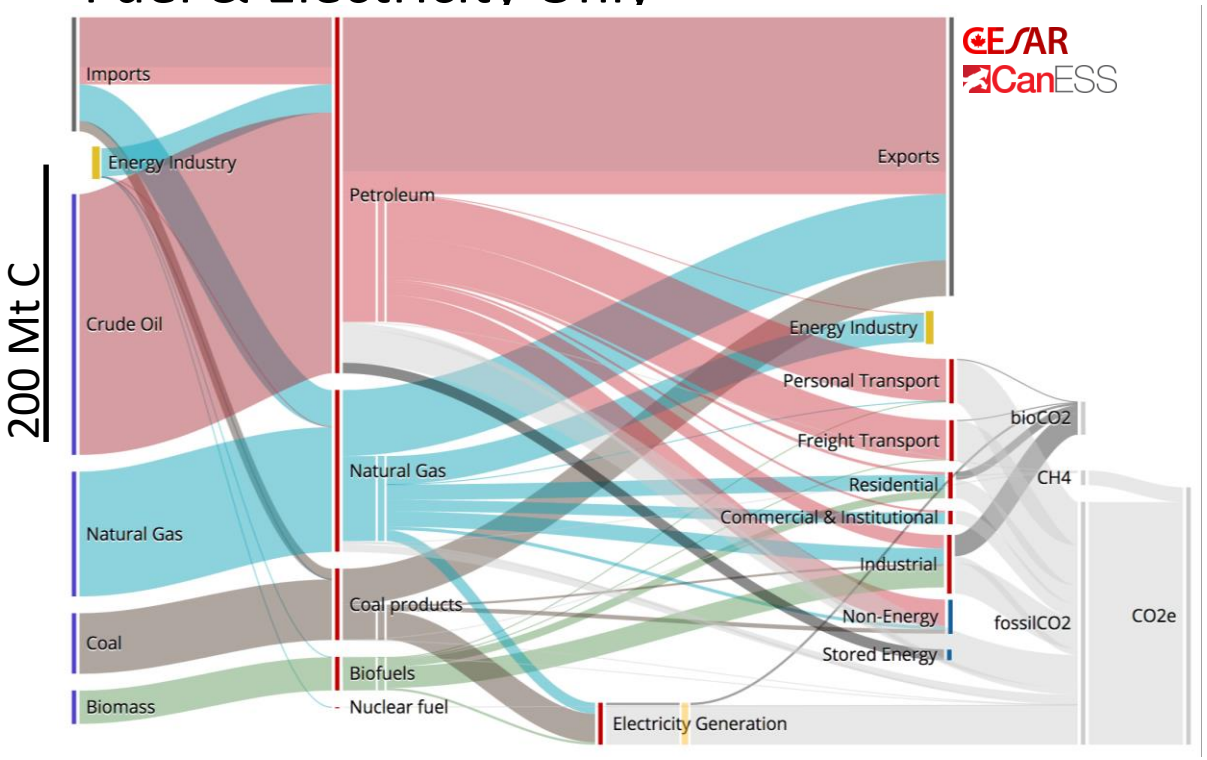
Agricultural C Flows (Mt C/yr)



* From Canada's Land Use, Land-Use Change and Forestry Calculations. National Inventory Report (2017)

All Anthropogenic C Flows in Canada (2013)

Fuel & Electricity Only



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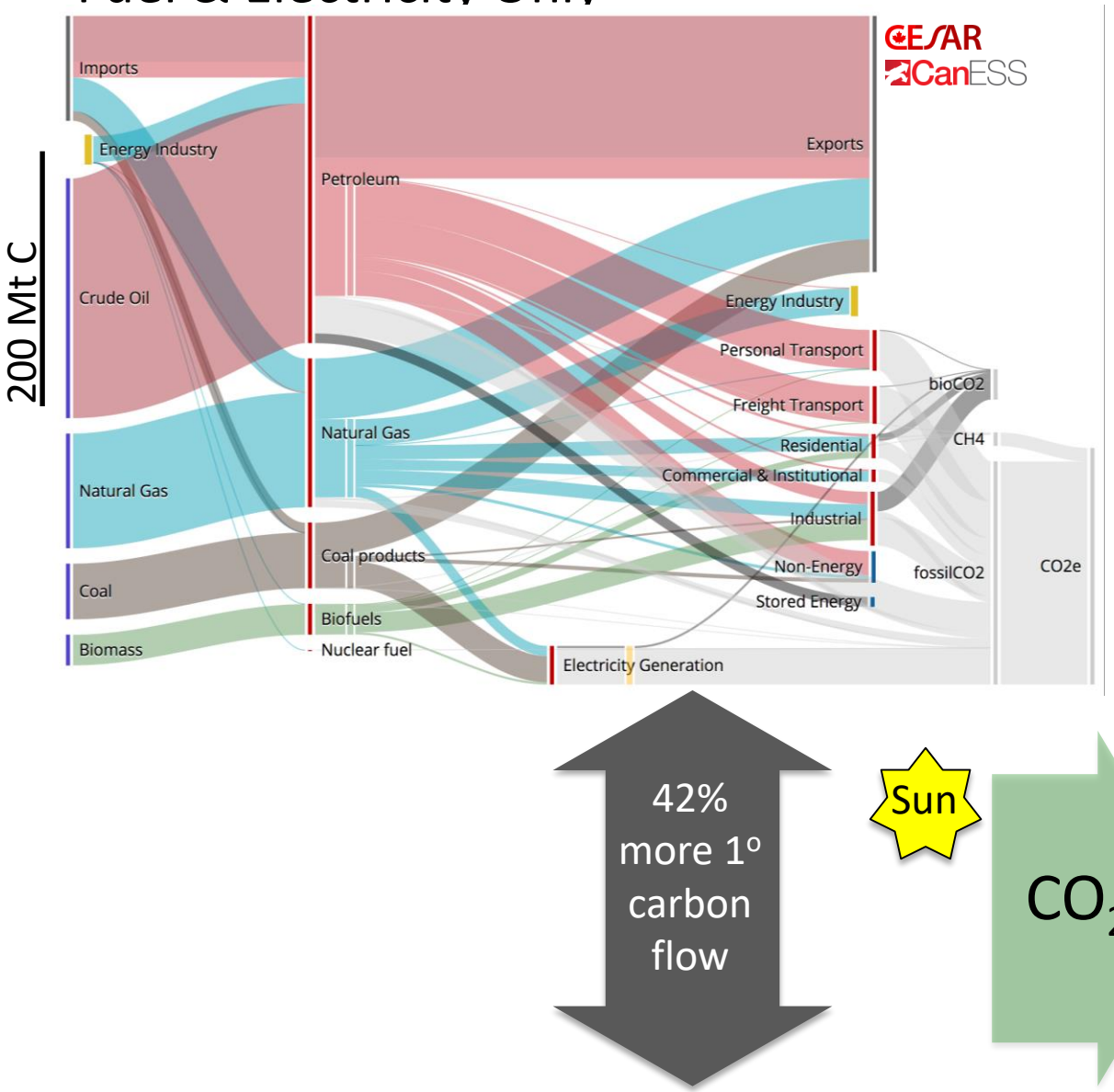
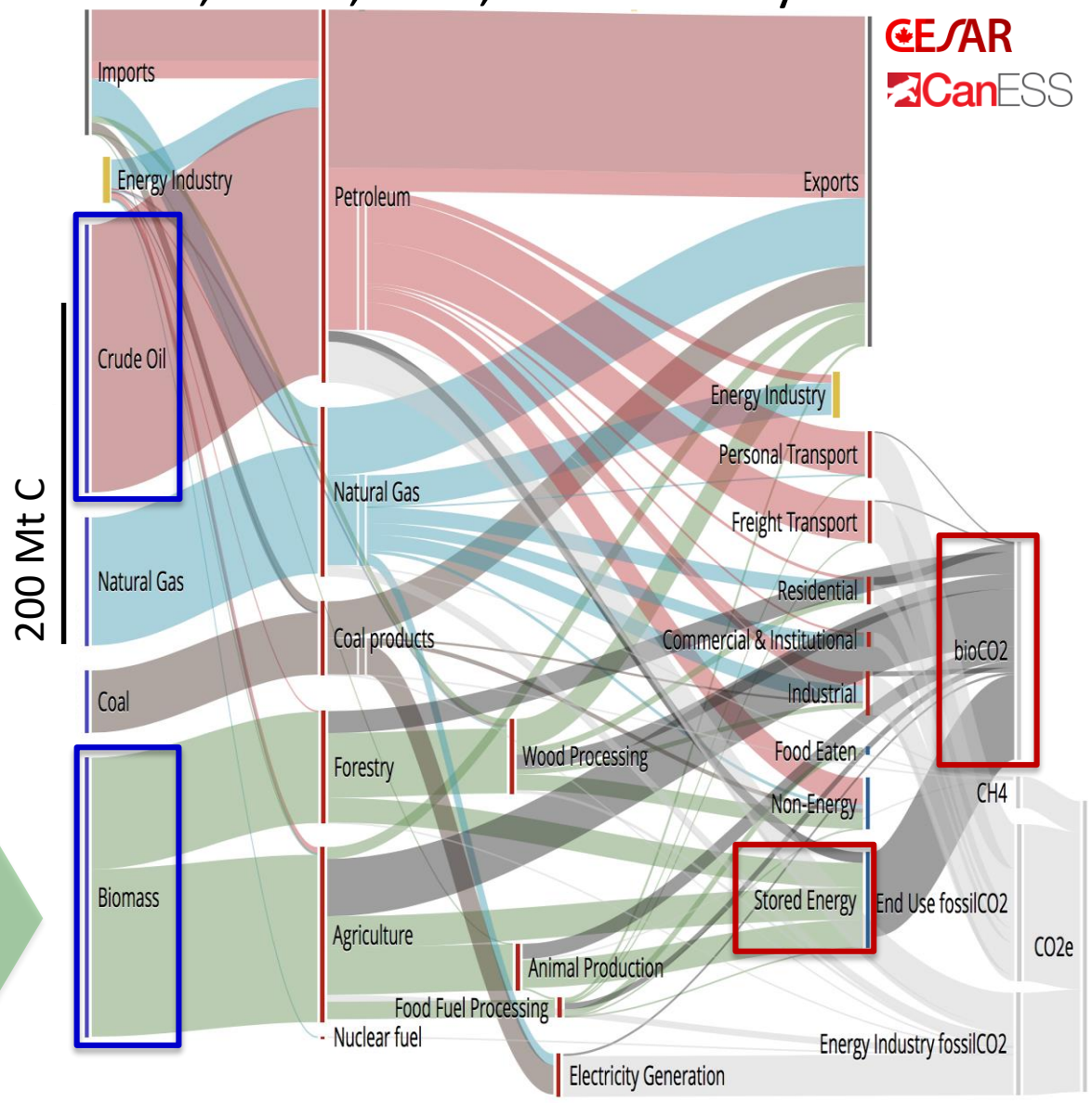


42% more 1° carbon flow

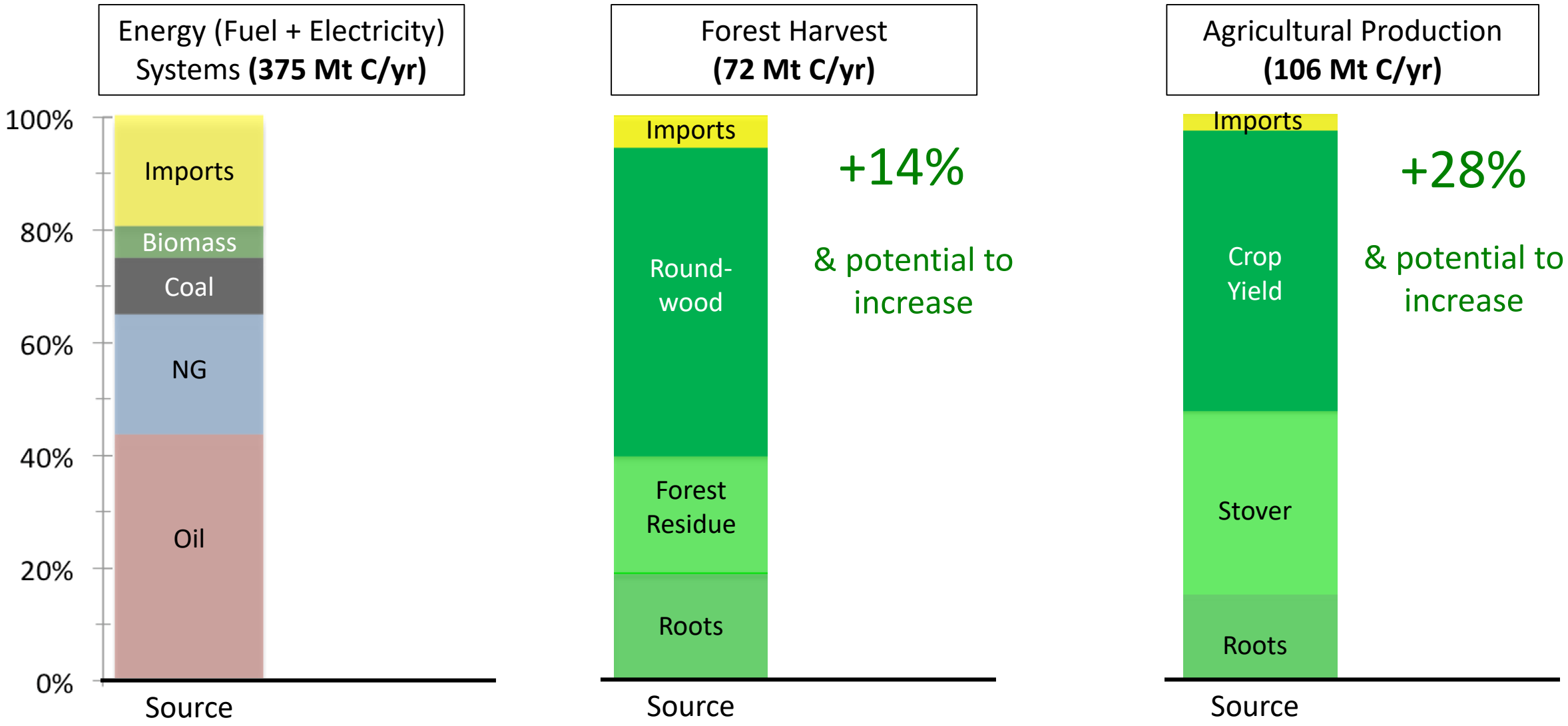
Sun

CO_2

Food, Fibre, Fuel, & Electricity



Primary Anthropogenic Carbon Flows in Canada (2013)



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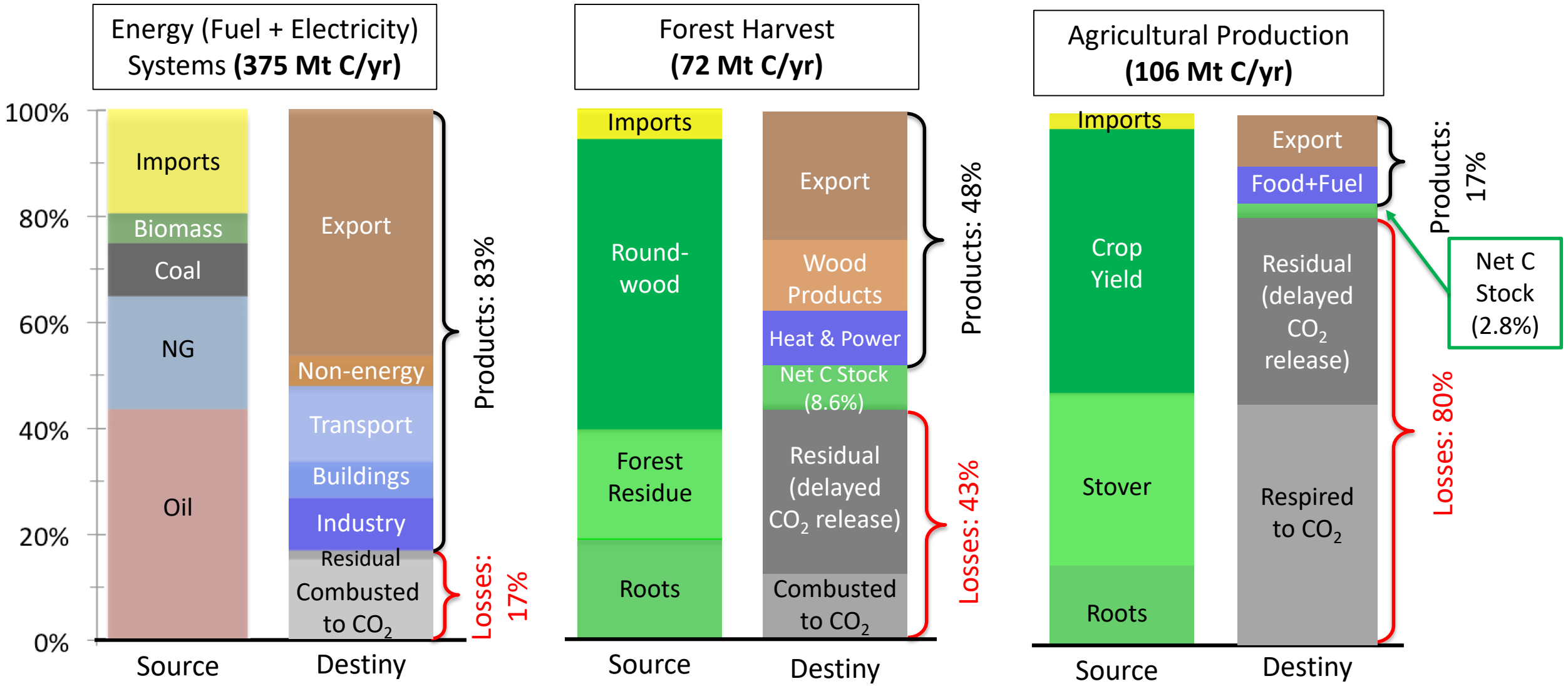

Biological Solutions

https://shivkumardas.wordpress.com/agri-tech/combine-harvester/, http://www.stockphotos.ro/aforestation.html, http://images.media-allrecipes.com/userphotos/560x315/389250.jpg, https://extension.ucsd.edu/courses-and-programs/biofuels-processes, http://gormanfarm.org/product/biochar/, http://www.ediweekly.com/cement-industry-opposes-wood-construction-taller-buildings/ , http://www.thegoodshoppingguide.com/wp-content/uploads/2013/03/vegetarian1.jpg

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Thank You

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