



Canada's Energy Systems: Integrating Food and Fibre



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INTRODUCTION

Studies of energy systems typically consider only the flows of energy and carbon associated with **fuels & electricity** (Figure 1), ignoring those associated with **food & fibre**.

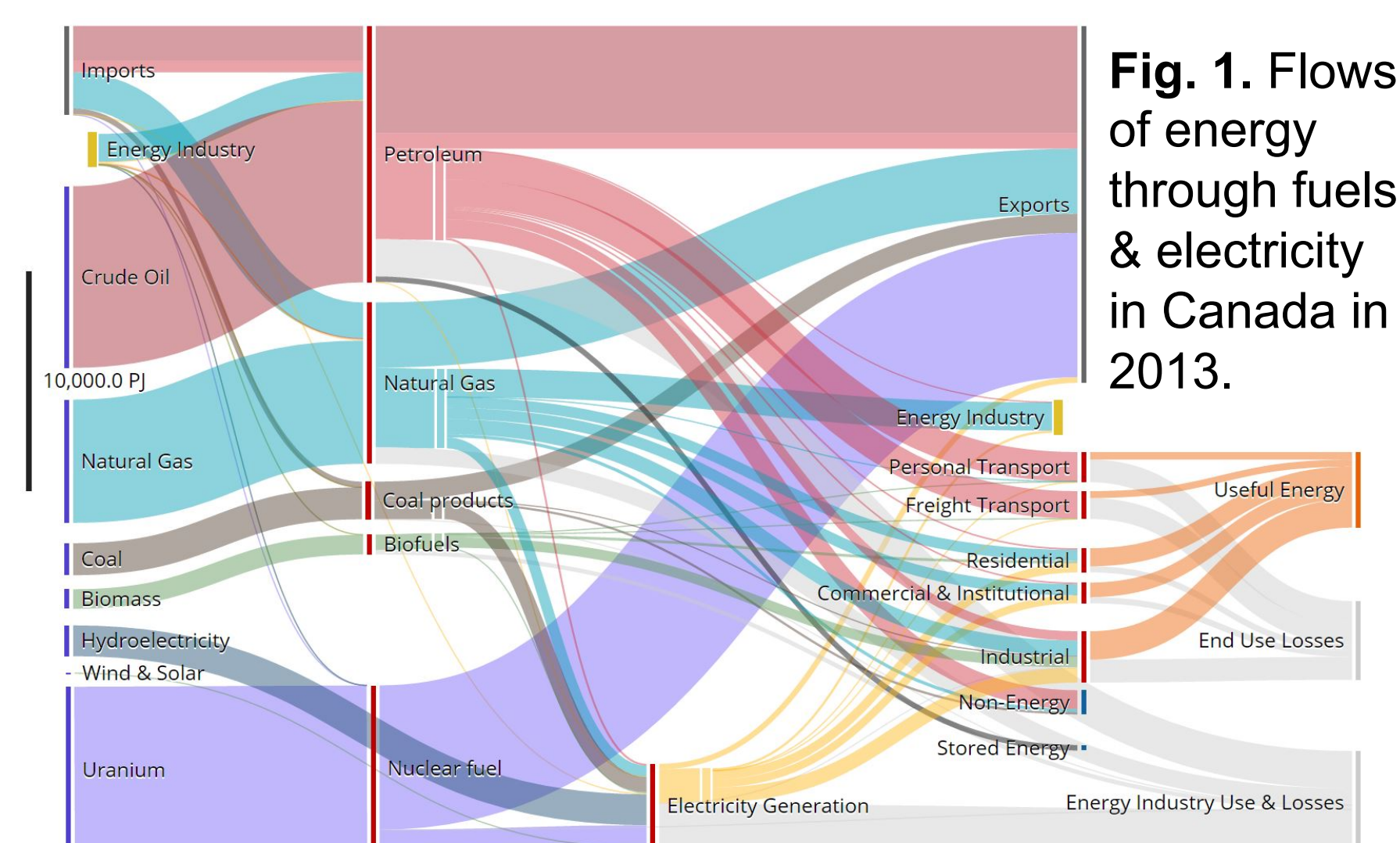


Fig. 1. Flows of energy through fuels & electricity in Canada in 2013.

To provide a better perspective for identifying climate change solutions, this study integrates food and fibre production / use into the energy systems of Canada.

METHODS

Government data sources [1, 2] were used to obtain information on the production & use of agricultural and forestry products, and converted to petajoules (PJ) using conversion factors from the literature [e.g., 3, 4].

Forest primary production was only that associated with the ~0.7 Mha/y of annually harvested land.

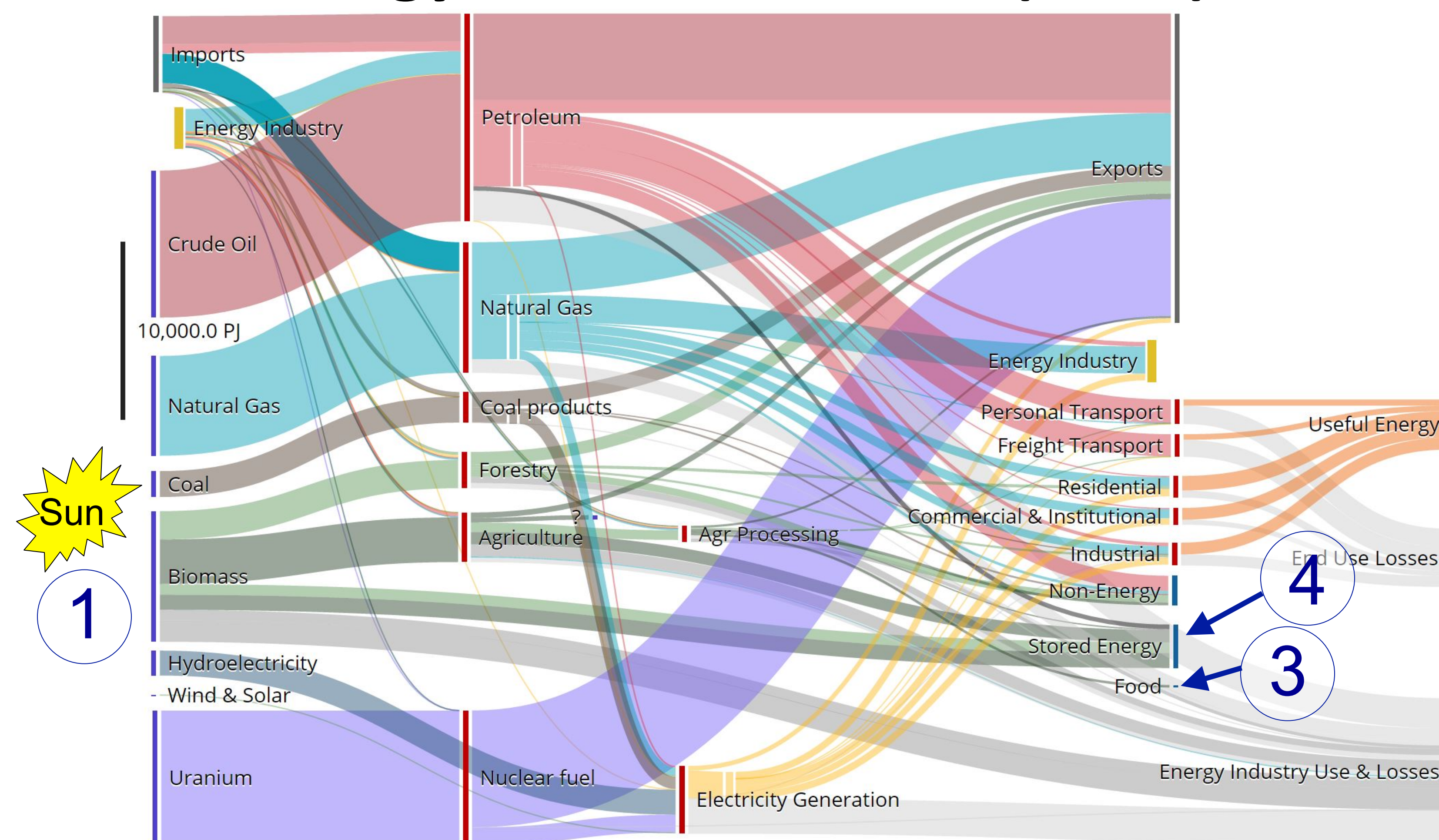
The energy flows for fuels and electricity were obtained from the CanESS [5] model, and the results were used to generate Sankey diagrams using software developed for the www.cesarnet.ca website.

REFERENCES

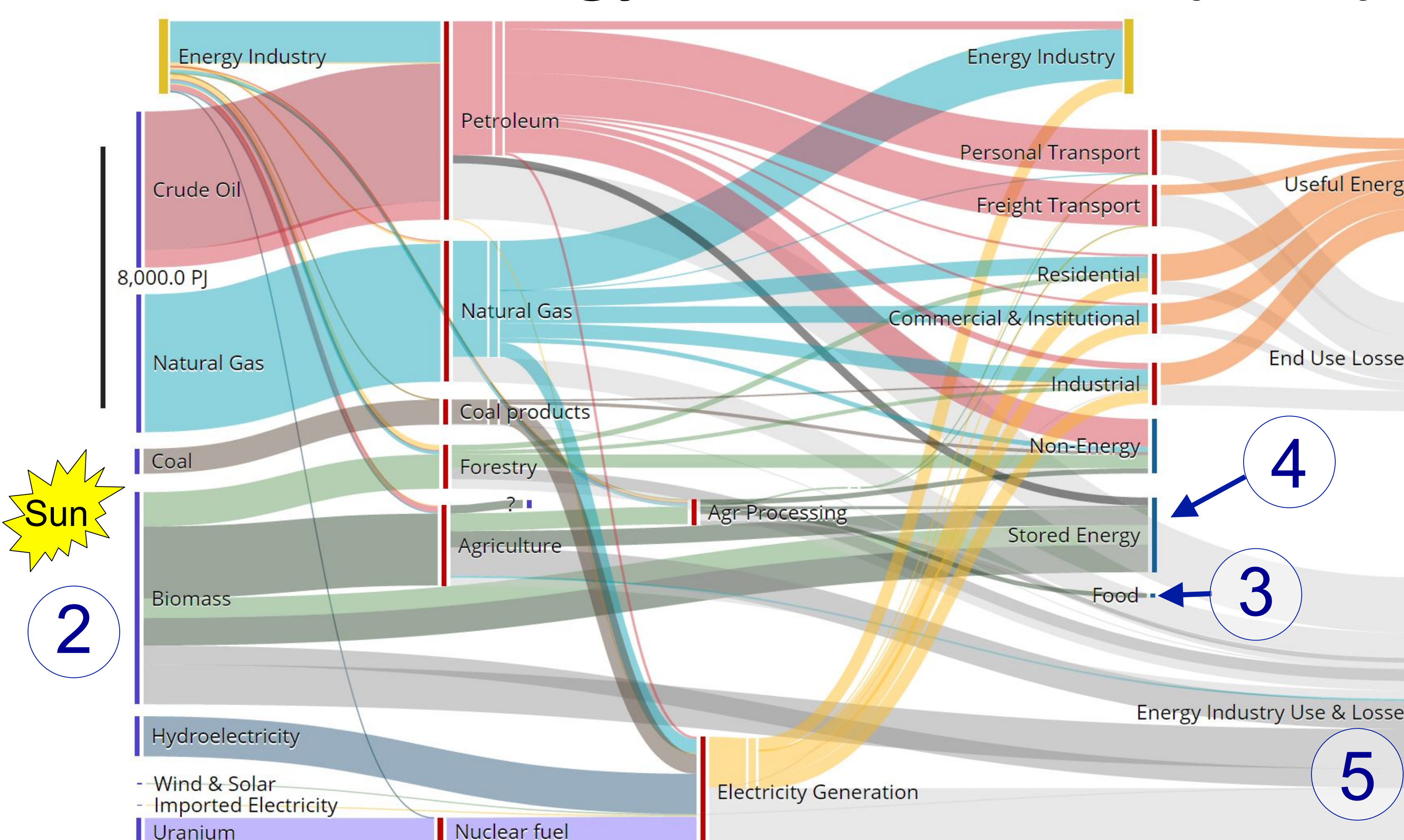
- [1] Statistics Canada, Canadian Socio-Economic Information Management System (CANSIM) Tables. [Online]. Available at: <http://www5.statcan.gc.ca/cansim/home-accueil?lang=eng>. Accessed: Oct. 2015 – Dec. 2016. Verified: Dec. 10, 2016.
- [2] National Forestry Databases. [Online]. Available at: http://nfdp.cfm.org/silviculture/national_e.php. Accessed: Oct. 2016. Verified: Dec. 10, 2016.
- [3] Li X, et al. 2012. A review of agricultural crop residue supply in Canada for cellulosic ethanol production. *Renew. Sustainable Energy Rev.* 16:2954–2965.
- [4] Food and Agriculture Organization (FAO) of the United Nations. 1997. The future of renewable biological energy systems. <http://www.fao.org/docrep/w7241e/w7241e0i.htm>. Accessed: June 2016. Verified: Dec. 10, 2016.
- [5] whatIf? Technologies Inc., 2016. Canadian Energy Systems Simulator (CanESS) - Version 7, Reference Scenario. [Online]. Available at: www.caness.ca.

RESULTS AND DISCUSSION

All Energy Flows in Canada (2013)



Domestic Energy Flows in Canada (2013)



NOTE:

Energy flows through food and fibre are large:

- 1 Agriculture and Forestry contribute 23% of the primary energy production in Canada (=32 EJ/yr), more than natural gas.
- 2 As a proportion of domestic primary energy flow, biomass energy is 1.4 -1.5X larger than either oil or nat'l gas.

Compared to other human energy demands, food is small.

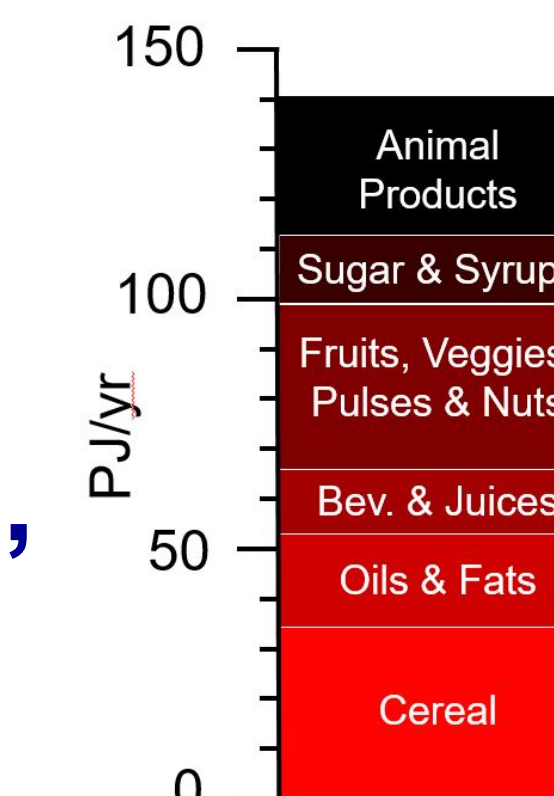
- 3 Food consumption (140 PJ/yr, see insert) is only 11% or 10% of the energy demand for residential or personal transport sectors, respectively.

Forestry and agriculture contribute large amounts to stored (unused) energy.

- 4 Examples include municipal solid waste, forest & agricultural residues. These decompose over time.

Conversion losses from agriculture and forestry are large compared with other energy industries.

- 5 Up stream 'energy industry' conversion losses from agriculture and forestry are large (61%) compared to fossil fuels (25%).



CONCLUSIONS

Three findings from this work highlight the potential of agriculture and forestry to address the challenges of climate change:

- Their large annual flows of energy;
- The proportion of that energy which is unused (stored energy); and
- The high conversion losses compared to fossil fuels.

While conversion of biomass to fuels and electricity tends to be more challenging than for fossil fuels, the relatively high carbon content of biomass, and the fact that it was recently extracted from the atmosphere, suggests that biological systems could play a much greater role in managing the anthropogenic carbon cycle.

Future Directions

Across the provinces of Canada, there is great diversity in the flows of energy and carbon associated with the production of **food, fibre, fuels & electricity**.

We are currently exploring interprovincial differences in energy flows, and extending these studies to an analysis of carbon flows in order to evaluate technological / behavioural changes in the management of our biological resources.

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