A Appendix: Detailed tables

This appendix contains some more detailed tables which underlie the plots shown in the main paper.

Province or Territory	Population (2010, thousands)	Adjusted final demand (TWh/yr)	Per capita demand (kWh/day)	Fraction of Canada's Energy Demand
Canada	**34005**	**2429**	**196**	**100.0%**
British Columbia	4466	239	147	9.8%
Alberta	3733	700	514	28.8%
Saskatchewan	1051	125	326	5.2%
Manitoba	1221	70	158	2.9%
Ontario	13135	699	146	28.8%
Quebec	7929	448	155	18.4%
New Brunswick	753	51	186	2.1%
Nova Scotia	942	49	144	2.0%
Prince Edward Island	142	7	141	0.3%
Newfoundland and Labrador	522	33	172	1.3%
Yukon	35	3	226	0.1%
Northwest Territories and Nunavut	78	5	172	0.2%

Table A.1: Energy demand by province. Population data are from Statistics Canada (2012). Original figures for Adjusted Final Demand are from Statistics Canada (2011b) but are adjusted to add energy from residential wood (provincial numbers are adjusted proportionally according to population), subtract energy used for pipelines, and adjust industry energy consumption according to Natural Resources Canada (2011, p. 46).

Province	Adjusted final demand (TWh/yr)	Onshore wind potential (TWh/yr)	Per capita demand	Onshore wind power (kWh/day/capita)	Fraction of demand available
Canada	2428	1382	195	111	56%
British Columbia	238	26	146	16	10%
Alberta	699	169	513	124	24%
Saskatchewan	125	274	326	715	219%
Manitoba	70	79	157	177	112%
Ontario	698	30	145	6	4%
Quebec	447	190	154	65	42%
New Brunswick	51	10	186	38	20%
Nova Scotia	49	30	143	89	62%
Prince Edward Island	7	7	140	138	98%
Newfoundland and Labrador	32	530	171	2783	1622%

Table A.2: Onshore wind power potential assuming 25% utilization of high potential areas.

Province	Adjusted final demand (TWh/yr)	Offshore wind potential (TWh/yr)	Per capita demand	Offshore wind power (kWh/day/capita)	Fraction of demand available
Canada	2428	521	195	42	21%
British Columbia	238	196	146	120	82%
Ontario	698	182	145	38	26%
Quebec	447	13	154	4	2%
New Brunswick	51	74	186	272	146%
Nova Scotia	49	21	143	62	43%
Prince Edward Island	7	18	140	365	258%
Newfoundland and Labrador	32	13	171	72	42%

Table A.3: Offshore wind power potential assuming 50% utilization of high potential areas.

Province	Adjusted final demand (TWh/yr)	Hydro potential (TWh/yr)	Per capita demand	Hydro power (kWh/day/capita)	Fraction of demand available
Canada	2428	1015	195	81	41%
British Columbia	238	159	146	97	66%
Alberta	699	101	513	74	14%
Saskatchewan	125	24	326	63	19%
Manitoba	70	56	157	126	80%
Ontario	698	65	145	13	9%
Quebec	447	308	154	106	69%
New Brunswick	51	5	186	19	10%
Nova Scotia	49	27	143	79	55%
Prince Edward Island	7		140		
Newfoundland and Labrador	32	61	171	321	187%

Table A.4: Hydroelectricity potential assuming that 60% of technically feasible sites are eventually developed and a standard 60% capacity factor.

Province	Adjusted final demand (TWh/yr)	Solar PV (Rural) potential (TWh/yr)	Per capita demand	Solar PV (Rural) power (kWh/day/capita)	Fraction of demand available
Canada	2428	20.7	195	1.7	0.9%
British Columbia	238	1.7	146	1.0	0.7%
Alberta	699	2.2	513	1.6	0.3%
Saskatchewan	125	1.3	326	3.3	1.0%
Manitoba	70	1.2	157	2.7	1.7%
Ontario	698	6.2	145	1.3	0.9%
Quebec	447	4.8	154	1.7	1.1%
New Brunswick	51	1.1	186	4.0	2.2%
Nova Scotia	49	1.2	143	3.5	2.4%
Prince Edward Island	7	0.2	140	4.3	3.0%
Newfoundland and Labrador	32	0.6	171	2.9	1.7%

Table A.5: Solar PV potential assuming 10 m^2 of PV panels per person in rural Canada.

Province	Adjusted final demand (TWh/yr)	Solar Thermal (Rural) potential (TWh/yr)	Per capita demand	Solar Thermal (Rural) power (kWh/day/capita)	Fraction of demand available
Canada	2428	51.8	195	4.2	2.1%
British Columbia	238	4.3	146	2.6	1.8%
Alberta	699	5.5	513	4.1	0.8%
Saskatchewan	125	3.2	326	8.2	2.5%
Manitoba	70	3.0	157	6.7	4.2%
Ontario	698	15.4	145	3.2	2.2%
Quebec	447	12.0	154	4.1	2.7%
New Brunswick	51	2.8	186	10.1	5.4%
Nova Scotia	49	3.0	143	8.6	6.0%
Prince Edward Island	7	0.6	140	10.7	7.6%
Newfoundland and Labrador	32	1.4	171	7.4	4.3%

Table A.6: Solar Thermal potential assuming 10 m^2 of solar thermal collectors per person in rural Canada.

Province	Adjusted final demand (TWh/yr)	Solar farming potential (TWh/yr)	Per capita demand	Solar farming power (kWh/day/capita)	Fraction of demand available
Canada	2428	307	195	24	12%
Alberta	699	63	513	46	9%
Saskatchewan	125	56	326	146	44%
Manitoba	70	56	157	126	80%
Ontario	698	132	145	27	18%

Table A.7: Solar Farm potential assuming 15% solar-to-electrical efficiency, 2000 km^2 of development in Manitoba, Saskatchewan, and Alberta and 5000 km^2 of development in Ontario.

Province	Adjusted final demand (TWh/yr)	Tidal potential (TWh/yr)	Per capita demand	Tidal power (kWh/day/capita)	Fraction of demand available
Canada	2428	15.97	195	1.29	0.66%
British Columbia	238	3.10	146	1.90	1.30%
Quebec	447	3.94	154	1.36	0.88%
New Brunswick	51	0.49	186	1.79	0.96%
Nova Scotia	49	1.64	143	4.77	3.32%
Prince Edward Island	7	0.03	140	0.48	0.34%
Newfoundland and Labrador	32	0.56	171	2.94	1.71%

Table A.8: Tidal potential assuming 15% of tidal power potential can be safely extracted and all of the sites identified in the CHC report are developed.

Province	Adjusted final demand (TWh/yr)	Wave potential (TWh/yr)	Per capita demand	Wave power (kWh/day/capita)	Fraction of demand available
Canada	2429	72.6	196	5.9	3.0%
British Columbia	239	16.7	147	10.2	7.0%
New Brunswick	51.2	5.7	186	20.6	11.1%
Nova Scotia	49.4	5.7	144	16.5	11.5%
Prince Edward Island	7.3	5.7	141	110	77.7%
Newfoundland and Labrador	32.7	5.7	172	29.7	17.3%

Table A.9: Wave potential assuming 500 km of development on the Atlantic and Pacific Coasts and 10% wave-to-electrical conversion efficiency.

Province	Adjusted final demand (TWh/yr)	Biomass potential (TWh/yr)	Per capita demand	Biomass power (kWh/day/capita)	Fraction of demand available
Canada	2428	261.5	195	21.1	10.8%
British Columbia (P)	238	19.8	146	12.2	8.3%
Alberta (P)	699	90.4	513	66.3	12.9%
Ontario (P)	698	86.5	145	18.1	12.4%
Quebec (E)	447	20.8	154	7.2	4.6%
New Brunswick (E)	51	4.0	186	14.6	7.9%
Nova Scotia (E)	49	0.9	143	2.7	1.9%
Newfoundland and Labrador (E)	32	0.9	171	4.9	2.9%

Table A.10: Existing and potential bioenergy exploitation. Values for existing **(E)** bioenergy generation for Newfoundland and Labrador and Nova Scotia are from Statistics Canada (2011b, p. 112). Potential **(P)** bioenergy values are from Layzell, Stephen, and Wood (2006) for Ontario, from James (2009) for Alberta, from Industrial Forestry Service Ltd. (2010) for wood in B.C., and from Ralevic and Layzell (2006) for other resources in B.C.

Province	Adjusted final demand (TWh/yr)	Total renewable potential (TWh/yr)	Per capita demand	Total renewable power (kWh/day/capita)	Fraction of demand available
Canada	2428	3668	195	295	151%
British Columbia	238	428	146	262	179%
Alberta	699	432	513	317	61%
Saskatchewan	125	359	326	937	287%
Manitoba	70	195	157	439	278%
Ontario	698	519	145	108	74%
Quebec	447	554	154	191	123%
New Brunswick	51	104	186	381	205%
Nova Scotia	49	92	143	267	186%
Prince Edward Island	7	32	140	628	446%
Newfoundland and Labrador	32	614	171	3225	1879%

Table A.11: Summary of renewable energy resources, by province.

B Appendix: Provincial summaries

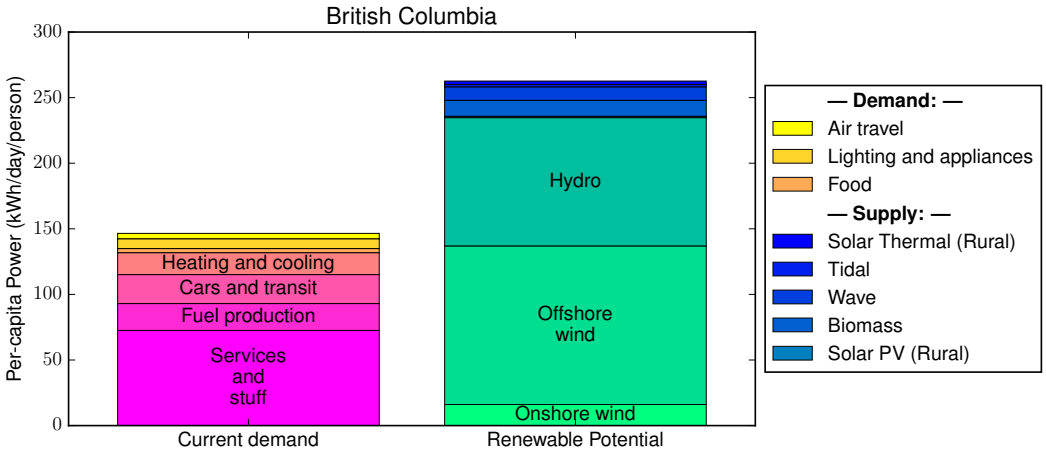
This appendix contains one-page summaries of findings for each province.

Individual pages for each province are also available separately (http://wellbeing.ihsp.mcgill.ca/publications):
BC; AB; SK; MB; ON; QC; NB; NS; PE; NF

Renewable energy scenario for B.C.

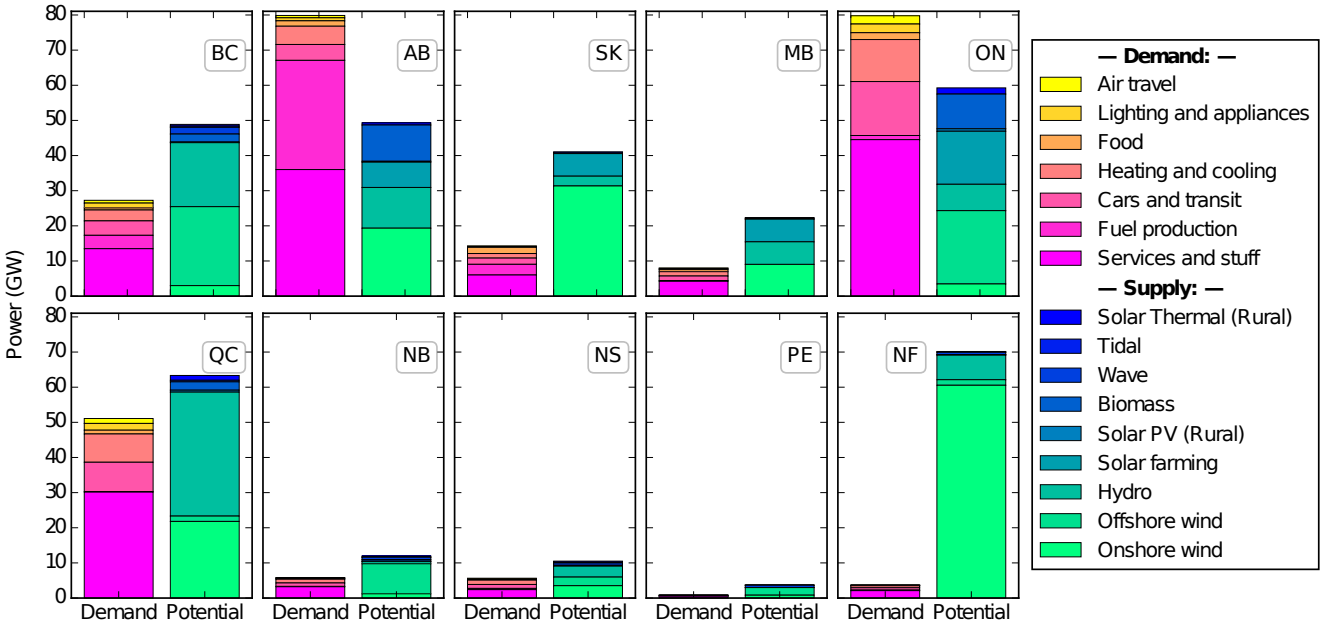
This snapshot is based on "The renewable energy landscape in Canada: a spatial analysis," *Renewable & Sustainable Energy Reviews* (2016), doi:10.1016/j.rser.2016.11.061. Our project assembles all sources of energy use into familiar household categories, and it identifies feasible sites for renewable energy generation across Canada. CONTACT: C. BARRINGTON-LEIGH, MCGILL UNIVERSITY

British Columbia's large existing wealth of hydroelectric power is complemented in our scenario with huge offshore — and some onshore — wind resources, as shown in below. All wind and solar and other intermittent renewable power developed in B.C. will benefit from their complementarity with hydroelectric dams, which can be controlled to flow when other resources aren't. We also count biomass and wave power as significant resources in B.C.'s future renewable portfolio.



The stack on the left shows the sum of all energy currently consumed, as both electricity and combustion, in B.C.. On the right is a breakdown of available renewable energy resources.

For maps, methods, sources, and more detailed discussion, see our full paper. We do not carry out an economic analysis, but our criteria for generation siting relate also to economic feasibility. Overall, our analysis shows that all but two provinces in Canada have sufficient renewable energy potential to meet the entire current energy demand.



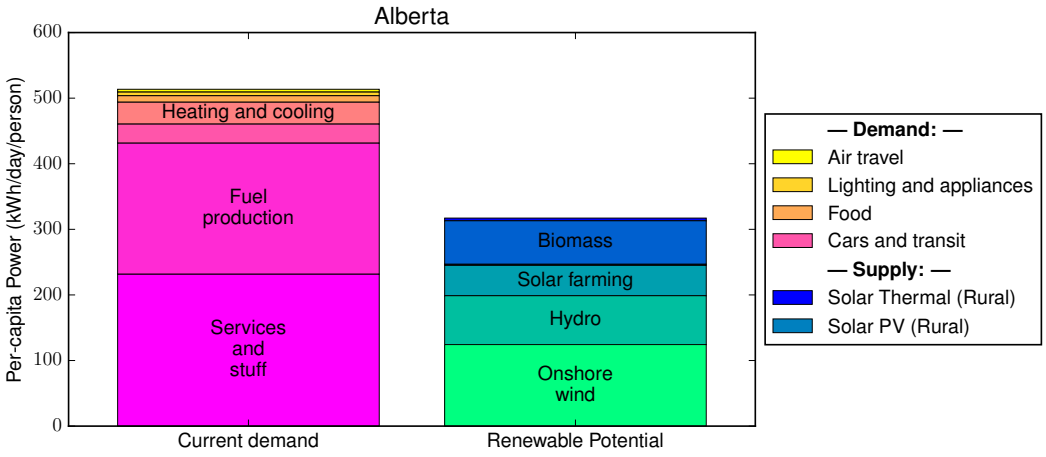
Renewable energy scenario for Alberta

This snapshot is based on "The renewable energy landscape in Canada: a spatial analysis," *Renewable & Sustainable Energy Reviews* (2016), doi:10.1016/j.rser.2016.11.061. Our project assembles all sources of energy use into familiar household categories, and it identifies feasible sites for renewable energy generation across Canada. CONTACT: C. BARRINGTON-LEIGH, MCGILL UNIVERSITY

Alberta stands out from other provinces in its current per capita energy requirements, which amount to over 500 kWh/day per person; see below. Unsurprisingly, a large component of this is due to the production of fuel, and a significant proportion of what we list as "Services and stuff" for Alberta is likely also related to the oil industry.

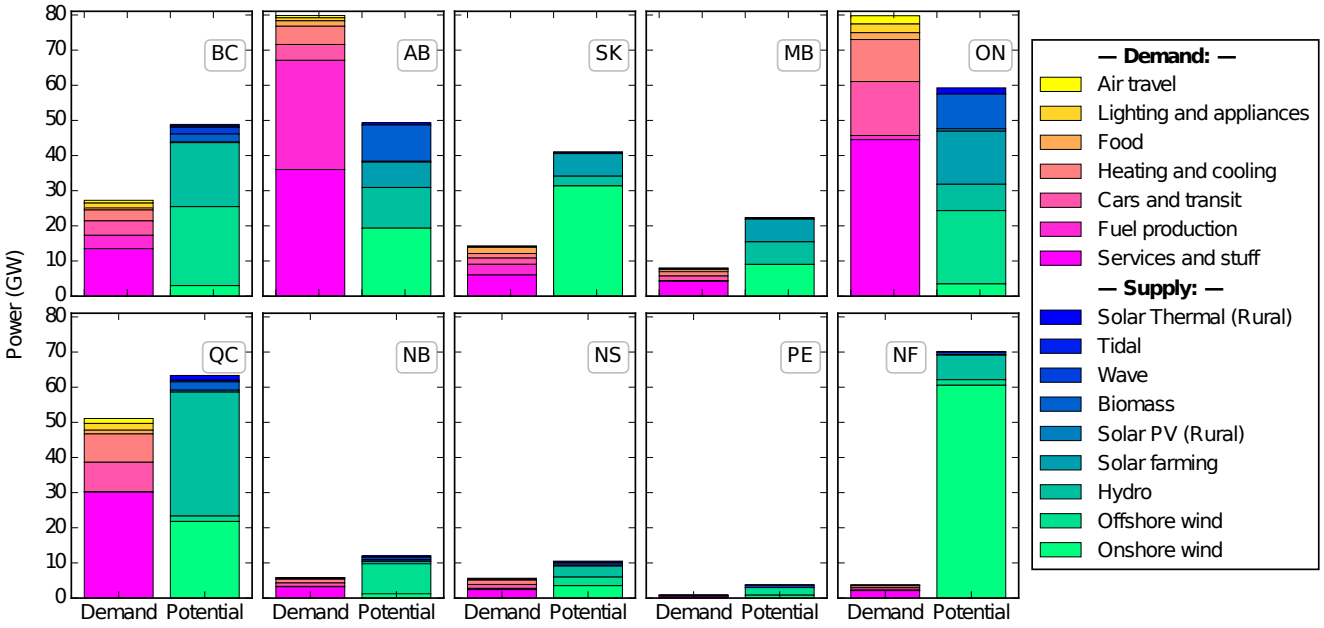
Unlike the other large provinces, Alberta has no offshore wind potential. Its potential renewable resources include wind, hydro, biomass, and solar farming. As has been mentioned, with appropriate distribution systems and a more aggressive embrace of solar, Alberta could exploit considerably more than we have included in the present assessment.

It is worth noting that on a per capita basis, Alberta has more than twice as much renewable power potential as does Ontario, the other province without sufficient renewable resources to cover its demand.



The stack on the left shows the sum of all energy currently consumed, as both electricity and combustion, in Alberta. On the right is a breakdown of available renewable energy resources.

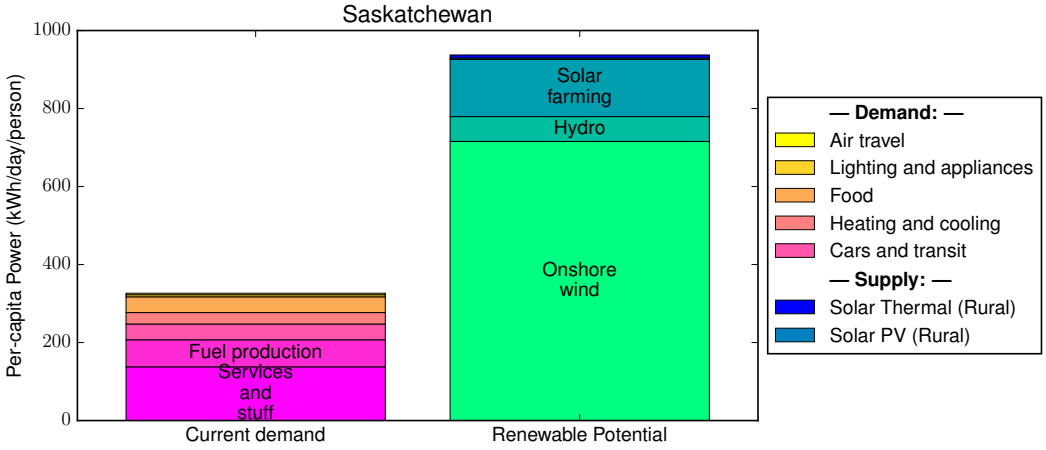
For maps, methods, sources, and more detailed discussion, see our full paper. We do not carry out an economic analysis, but our criteria for generation siting relate also to economic feasibility. Overall, our analysis shows that all but two provinces in Canada have sufficient renewable energy potential to meet the entire current energy demand.



Renewable energy scenario for Saskatchewan

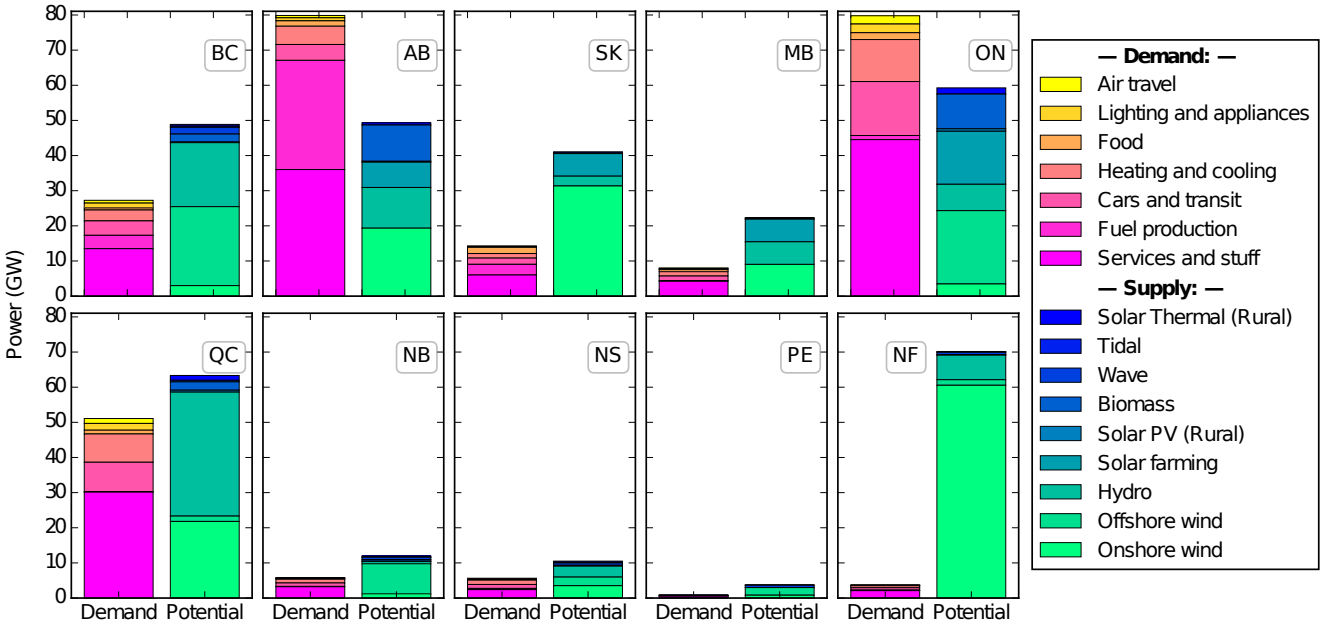
This snapshot is based on "The renewable energy landscape in Canada: a spatial analysis," *Renewable & Sustainable Energy Reviews* (2016), doi:10.1016/j.rser.2016.11.061. Our project assembles all sources of energy use into familiar household categories, and it identifies feasible sites for renewable energy generation across Canada. CONTACT: C. BARRINGTON-LEIGH, MCGILL UNIVERSITY

As shown in below, Saskatchewan also has a high per-capita energy use, currently, but with strong wind resources and the possibility of extensive solar farming, its potential renewable portfolio greatly exceeds the demand. This may represent a significant opportunity to export energy to its relatively needy neighbour, Alberta. Once again, it is important to note that, if such export demand exists, there may be even more feasible solar farming than we have allocated.



The stack on the left shows the sum of all energy currently consumed, as both electricity and combustion, in Saskatchewan. On the right is a breakdown of available renewable energy resources.

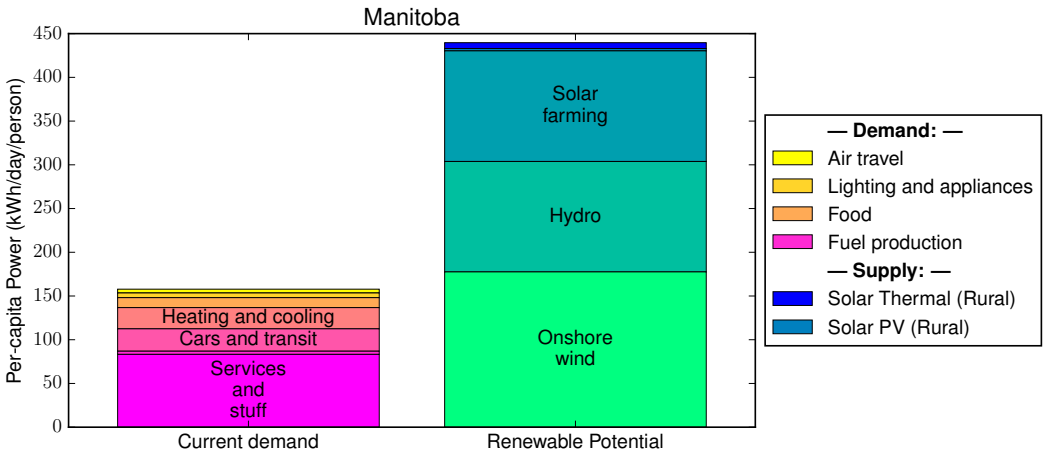
For maps, methods, sources, and more detailed discussion, see our full paper. We do not carry out an economic analysis, but our criteria for generation siting relate also to economic feasibility. Overall, our analysis shows that all but two provinces in Canada have sufficient renewable energy potential to meet the entire current energy demand.



Renewable energy scenario for Manitoba

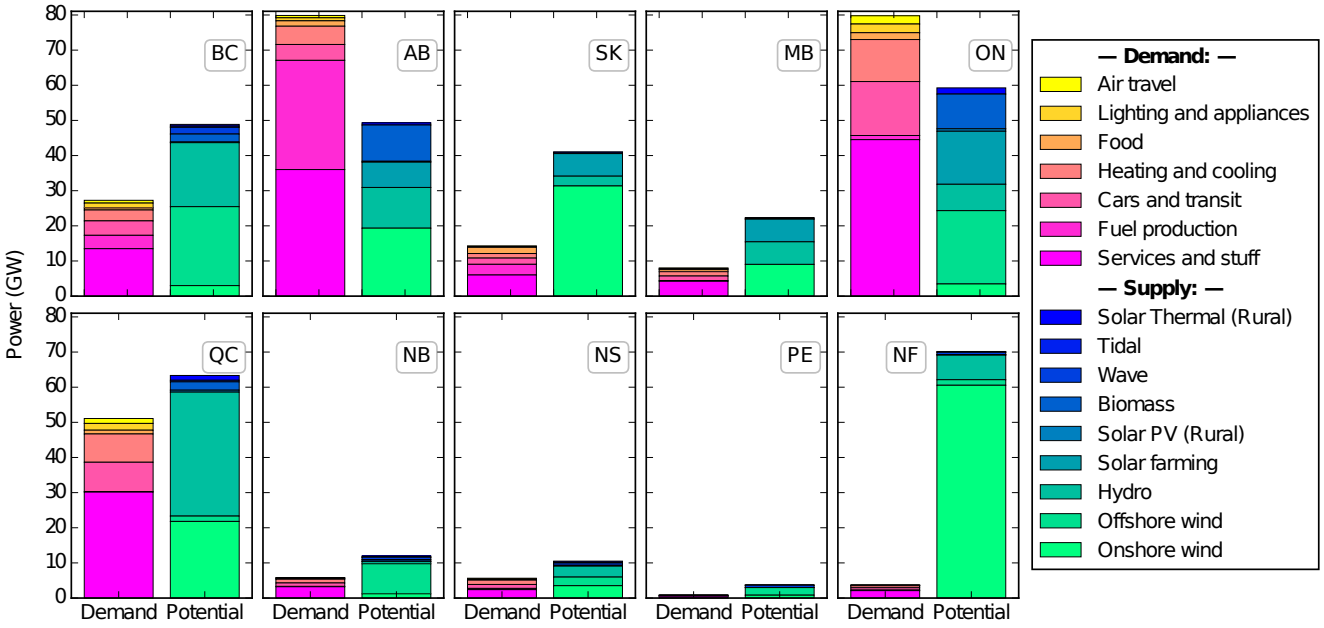
This snapshot is based on "The renewable energy landscape in Canada: a spatial analysis," *Renewable & Sustainable Energy Reviews* (2016), doi:10.1016/j.rser.2016.11.061. Our project assembles all sources of energy use into familiar household categories, and it identifies feasible sites for renewable energy generation across Canada. CONTACT: C. BARRINGTON-LEIGH, MCGILL UNIVERSITY

In comparison with Saskatchewan, Manitoba, portrayed in below, has less easily accessible wind power but more hydroelectric potential. Plenty of each of these, along with a deployment of solar farming as in Saskatchewan, would leave Manitoba with a 200% excess of renewable energy over its own (current) needs. In fact, this surplus would be sufficient, through exports, to close the gap between Ontario's demand and potential supply. Moreover, the complementarity of solar and wind power, which tend to peak at different times, and the further complementarity of these intermittent power sources with the throttlable resource of hydroelectricity, give Manitoba a particularly enviable endowment of renewables.



The stack on the left shows the sum of all energy currently consumed, as both electricity and combustion, in Manitoba. On the right is a breakdown of available renewable energy resources.

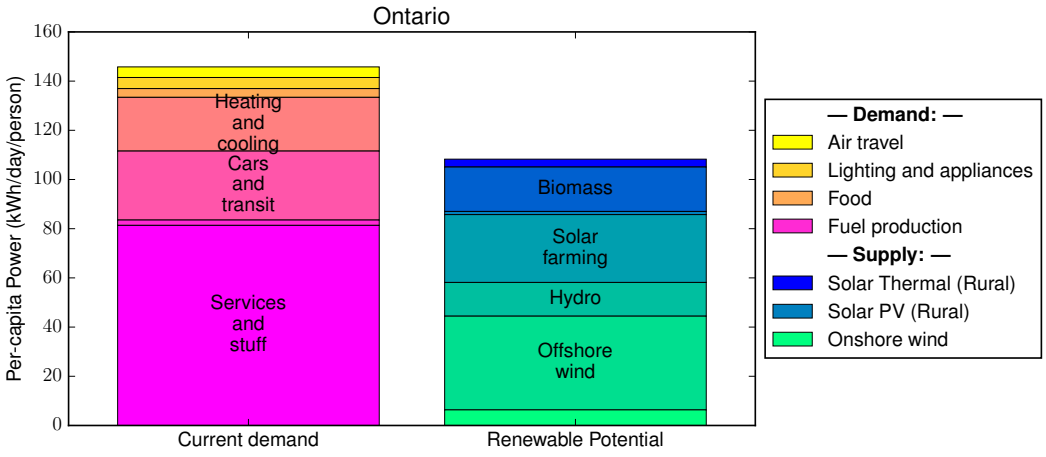
For maps, methods, sources, and more detailed discussion, see our full paper. We do not carry out an economic analysis, but our criteria for generation siting relate also to economic feasibility. Overall, our analysis shows that all but two provinces in Canada have sufficient renewable energy potential to meet the entire current energy demand.



Renewable energy scenario for Ontario

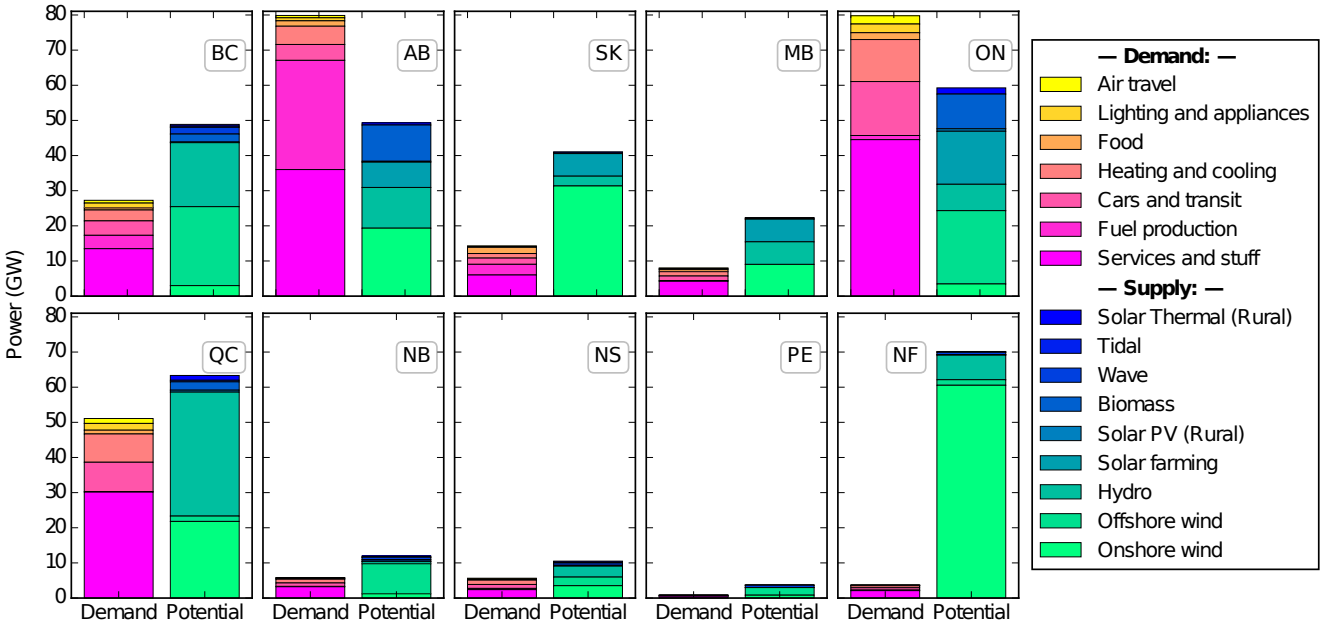
This snapshot is based on "The renewable energy landscape in Canada: a spatial analysis," *Renewable & Sustainable Energy Reviews* (2016), doi:10.1016/j.rser.2016.11.061. Our project assembles all sources of energy use into familiar household categories, and it identifies feasible sites for renewable energy generation across Canada. CONTACT: C. Barrington-Leigh, McGill University

Ontario's dense population and lower fraction of primary extraction industries gives it a relatively low per capita energy usage at present (see below). Nevertheless, in absolute terms it is the second largest consumer of power in Canada, after Alberta. We find a diversified portfolio of available renewable energy for Ontario which amounts to the third largest among the provinces, but it is insufficient to meet Ontario's demand. The largest component of renewable energy potential in our assessment comes from offshore wind, largely on Lake Erie and Georgian Bay, but the portfolio includes also significant bioenergy, solar farming, hydroelectricity, and some onshore wind.



The stack on the left shows the sum of all energy currently consumed, as both electricity and combustion, in Ontario. On the right is a breakdown of available renewable energy resources.

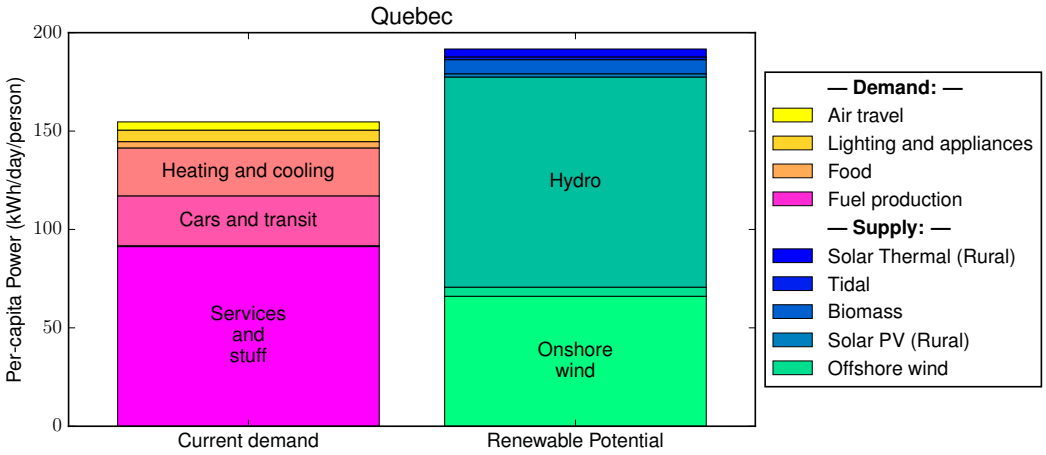
For maps, methods, sources, and more detailed discussion, see our full paper. We do not carry out an economic analysis, but our criteria for generation siting relate also to economic feasibility. Overall, our analysis shows that all but two provinces in Canada have sufficient renewable energy potential to meet the entire current energy demand.



Renewable energy scenario for Quebec

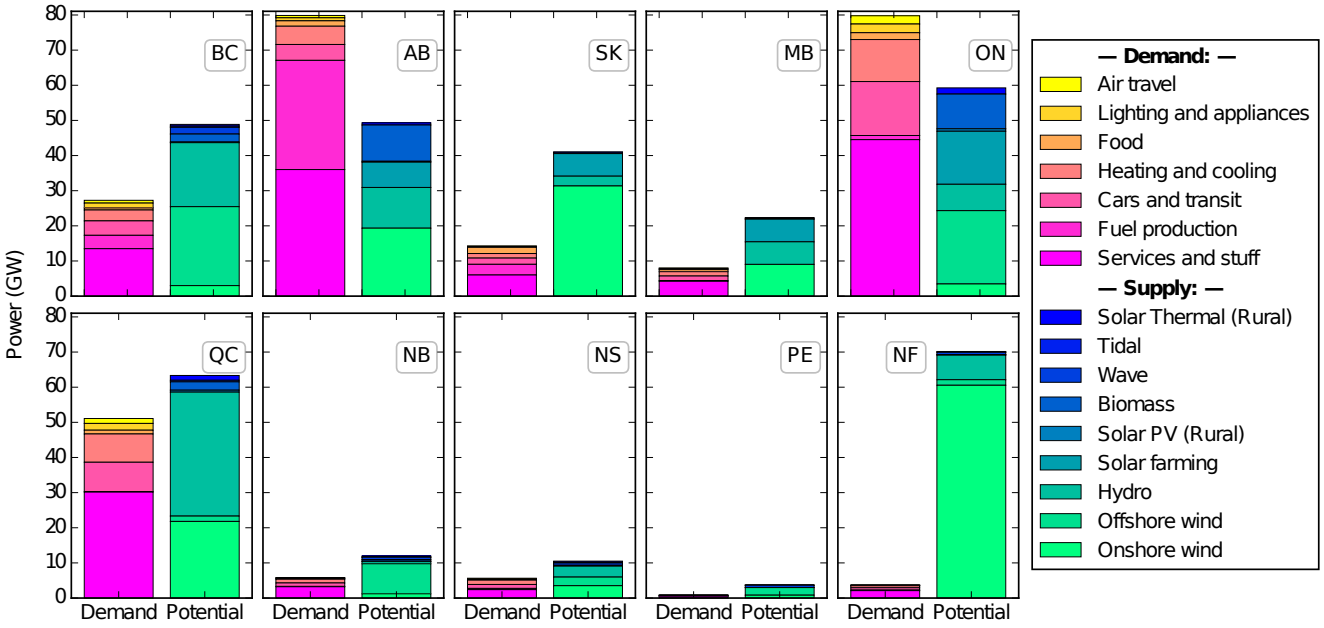
This snapshot is based on "The renewable energy landscape in Canada: a spatial analysis," *Renewable & Sustainable Energy Reviews* (2016), doi:10.1016/j.rser.2016.11.061. Our project assembles all sources of energy use into familiar household categories, and it identifies feasible sites for renewable energy generation across Canada. CONTACT: C. BARRINGTON-LEIGH, MCGILL UNIVERSITY

Per capita energy demand in Quebec is typical of other provinces, at around 150 kWh per person, per day. Quebec is already exploiting an enormous hydroelectricity resource but, as shown in below, it has further capacity and in addition a large potential for wind power. Together, these would be more than sufficient to cover all of the existing energy demand of Canada's second largest province. As a reminder, the "Current demand" includes not only existing electricity use, but also all fossil fuel consumption for transportation, heating and cooking, and industry. Moreover, as in British Columbia, Quebec's huge load-stabilizing hydroelectricity capacity gives it a major advantage for developing intermittent renewables such as its onshore wind resources. In addition to these two primary energy sources, Quebec has the potential to generate power from biomass, tides, and offshore wind.



The stack on the left shows the sum of all energy currently consumed, as both electricity and combustion, in Quebec. On the right is a breakdown of available renewable energy resources.

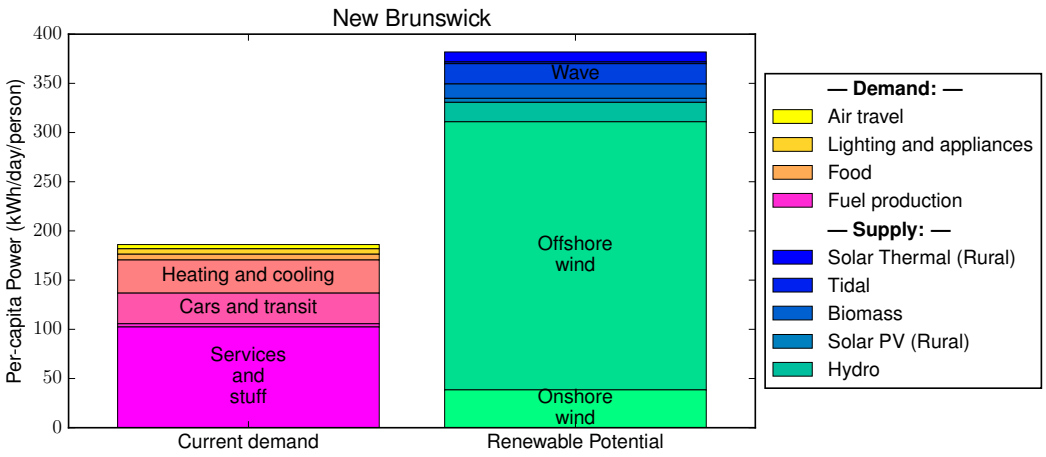
For maps, methods, sources, and more detailed discussion, see our full paper. We do not carry out an economic analysis, but our criteria for generation siting relate also to economic feasibility. Overall, our analysis shows that all but two provinces in Canada have sufficient renewable energy potential to meet the entire current energy demand.



Renewable energy scenario for New Brunswick

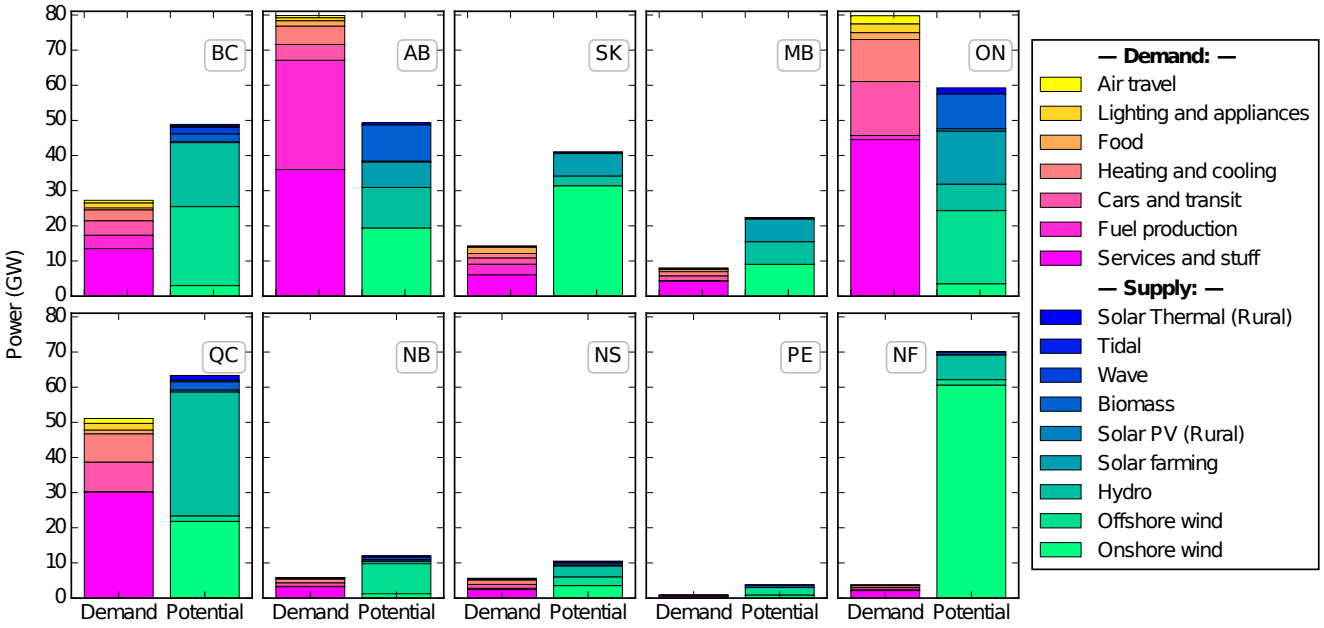
This snapshot is based on "The renewable energy landscape in Canada: a spatial analysis," *Renewable & Sustainable Energy Reviews* (2016), doi:10.1016/j.rser.2016.11.061. Our project assembles all sources of energy use into familiar household categories, and it identifies feasible sites for renewable energy generation across Canada. CONTACT: C. BARRINGTON-LEIGH, MCGILL UNIVERSITY

New Brunswick has an average level of current energy consumption for its population but, on a per capita basis, is extremely wealthy in renewable energy potential. As shown in below, the province could supply more than its entire current energy needs with offshore wind power alone, but in addition has biomass, tidal, onshore wind, and hydroelectric resources.



The stack on the left shows the sum of all energy currently consumed, as both electricity and combustion, in New Brunswick. On the right is a breakdown of available renewable energy resources.

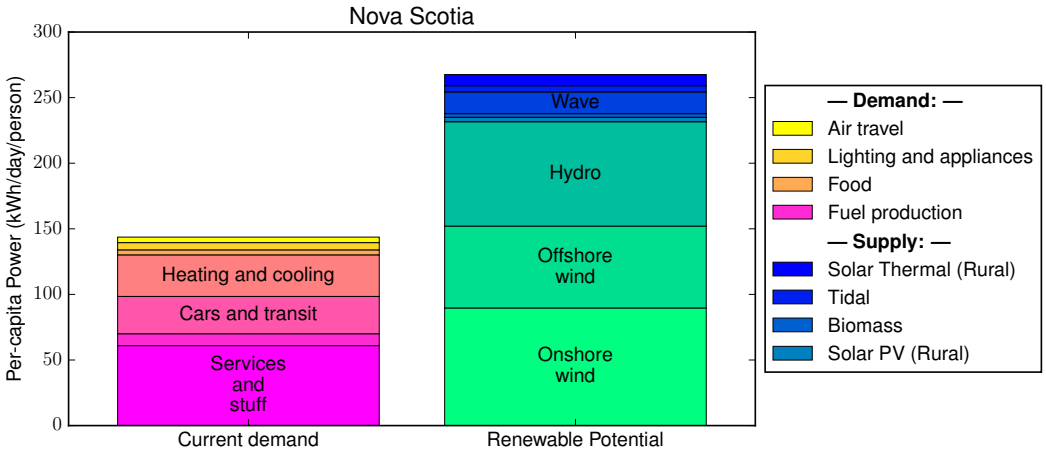
For maps, methods, sources, and more detailed discussion, see our full paper. We do not carry out an economic analysis, but our criteria for generation siting relate also to economic feasibility. Overall, our analysis shows that all but two provinces in Canada have sufficient renewable energy potential to meet the entire current energy demand.



Renewable energy scenario for Nova Scotia

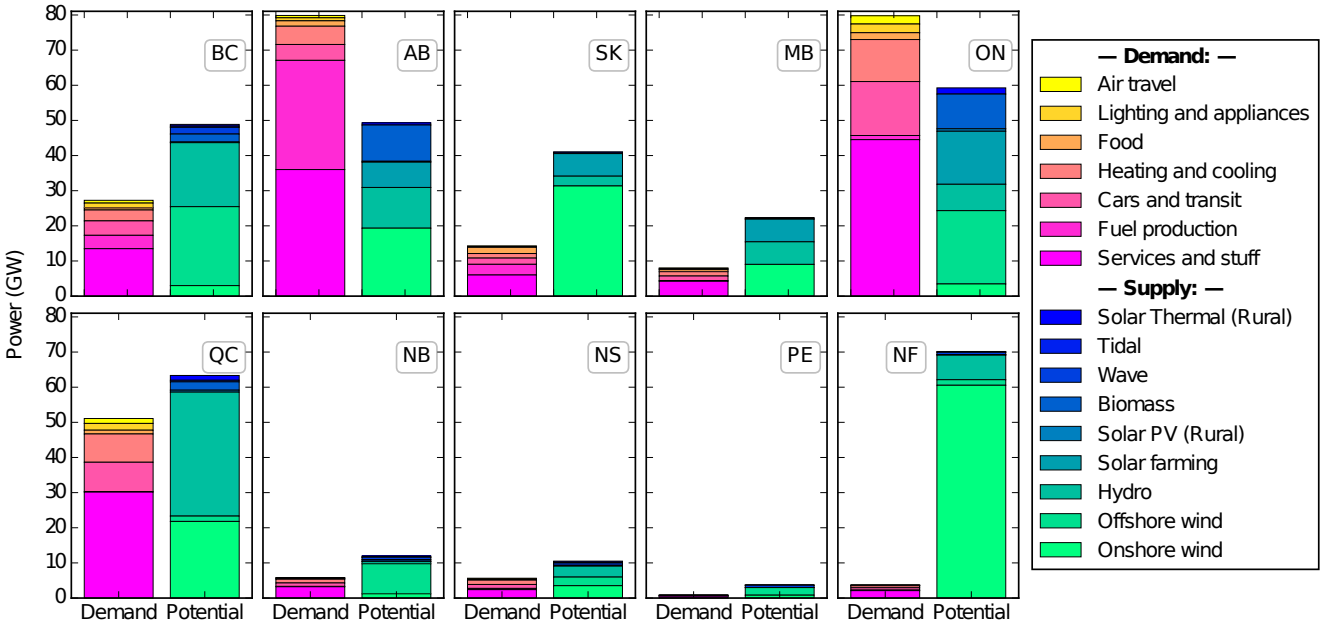
This snapshot is based on "The renewable energy landscape in Canada: a spatial analysis," *Renewable & Sustainable Energy Reviews* (2016), doi:10.1016/j.rser.2016.11.061. Our project assembles all sources of energy use into familiar household categories, and it identifies feasible sites for renewable energy generation across Canada. CONTACT: C. BARRINGTON-LEIGH, MCGILL UNIVERSITY

Nova Scotia has a diverse potential portfolio of renewable energy sources, among which hydroelectricity, offshore wind, and onshore wind each could produce enough power to cover a large fraction of the province's current energy demand (below). In addition, wave power figures significantly in Nova Scotia's potential resources. Nova Scotia also stands to benefit from the combination of its intermittent wind power and its complementarity hydroelectric capacity.



The stack on the left shows the sum of all energy currently consumed, as both electricity and combustion, in Nova Scotia. On the right is a breakdown of available renewable energy resources.

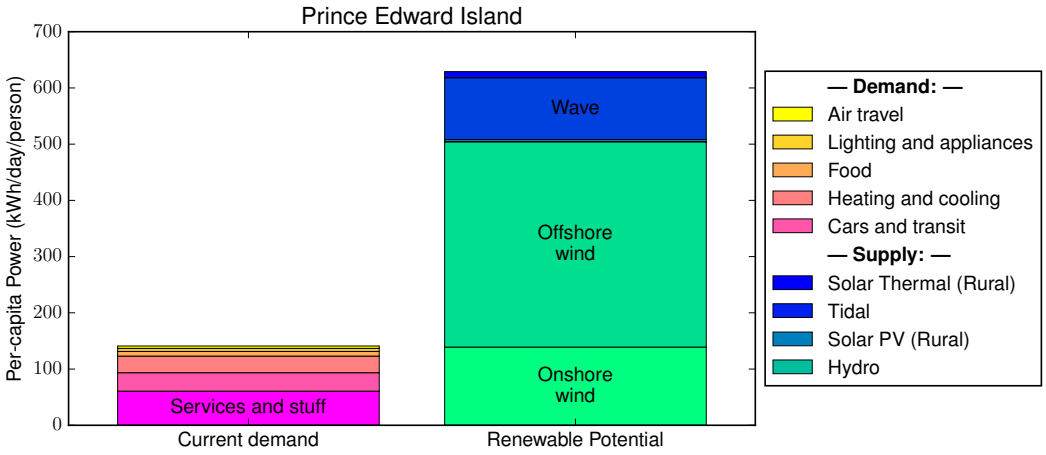
For maps, methods, sources, and more detailed discussion, see our full paper. We do not carry out an economic analysis, but our criteria for generation siting relate also to economic feasibility. Overall, our analysis shows that all but two provinces in Canada have sufficient renewable energy potential to meet the entire current energy demand.



Renewable energy scenario for Prince Edward Island

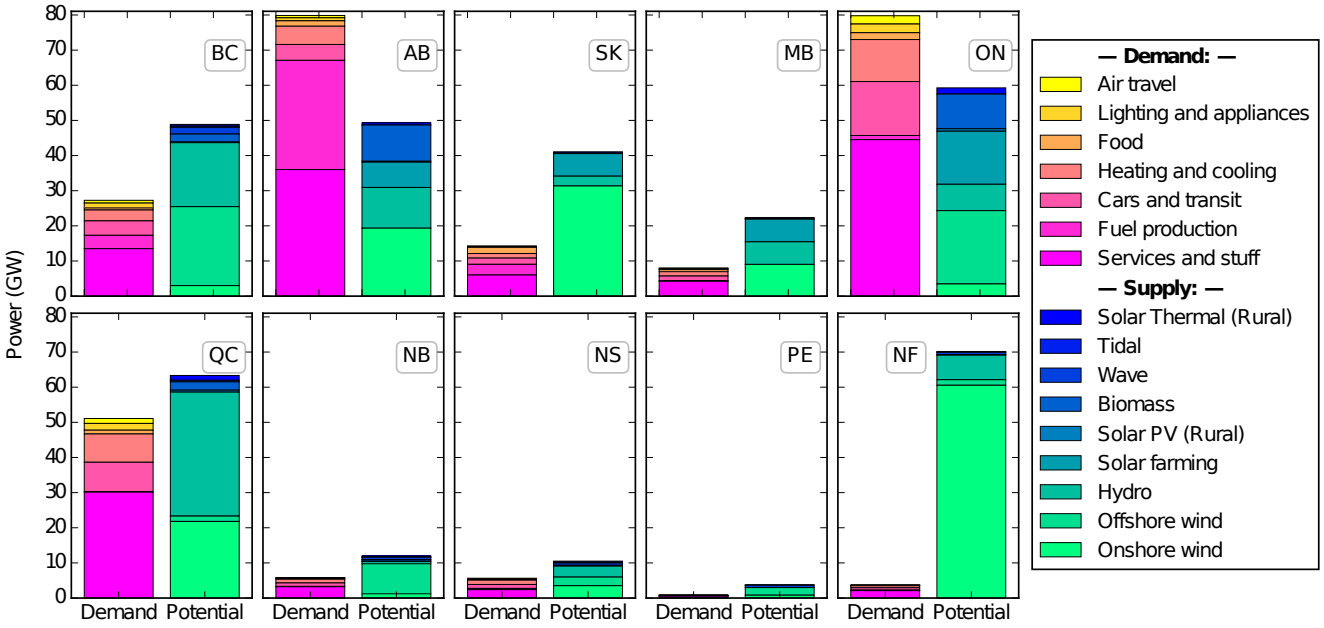
This snapshot is based on "The renewable energy landscape in Canada: a spatial analysis," *Renewable & Sustainable Energy Reviews* (2016), doi:10.1016/j.rser.2016.11.061. Our project assembles all sources of energy use into familiar household categories, and it identifies feasible sites for renewable energy generation across Canada. CONTACT: C. BARRINGTON-LEIGH, MCGILL UNIVERSITY

The small population of P.E.I. has a typical per capita energy consumption for Canada; see below. Yet its maritime borders offer it a large surplus of renewable power from offshore wind farms and wave power. In addition, even its onshore wind resources could be sufficient by themselves to supply all current demand for energy, as long as it could be traded with neighbours to cover periods with low local wind velocity.



The stack on the left shows the sum of all energy currently consumed, as both electricity and combustion, in Prince Edward Island. On the right is a breakdown of available renewable energy resources.

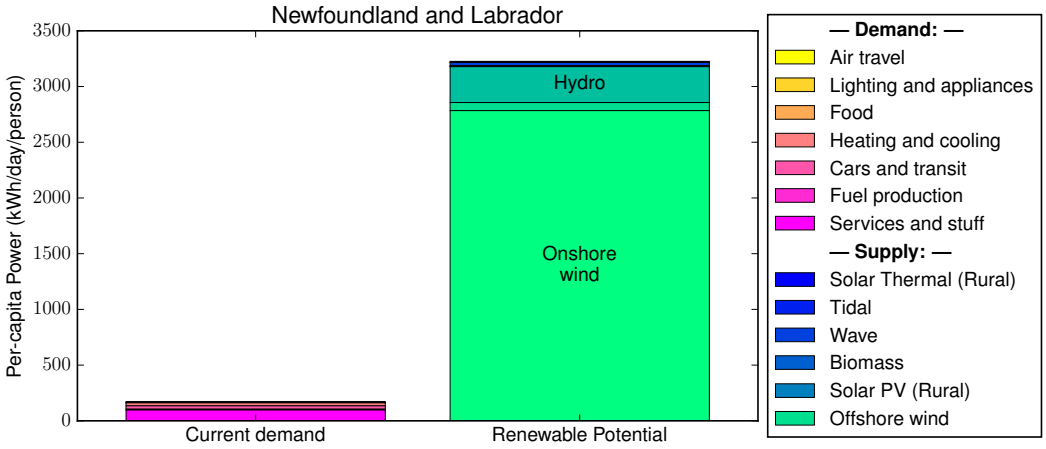
For maps, methods, sources, and more detailed discussion, see our full paper. We do not carry out an economic analysis, but our criteria for generation siting relate also to economic feasibility. Overall, our analysis shows that all but two provinces in Canada have sufficient renewable energy potential to meet the entire current energy demand.



Renewable energy scenario for Newfoundland & Labrador

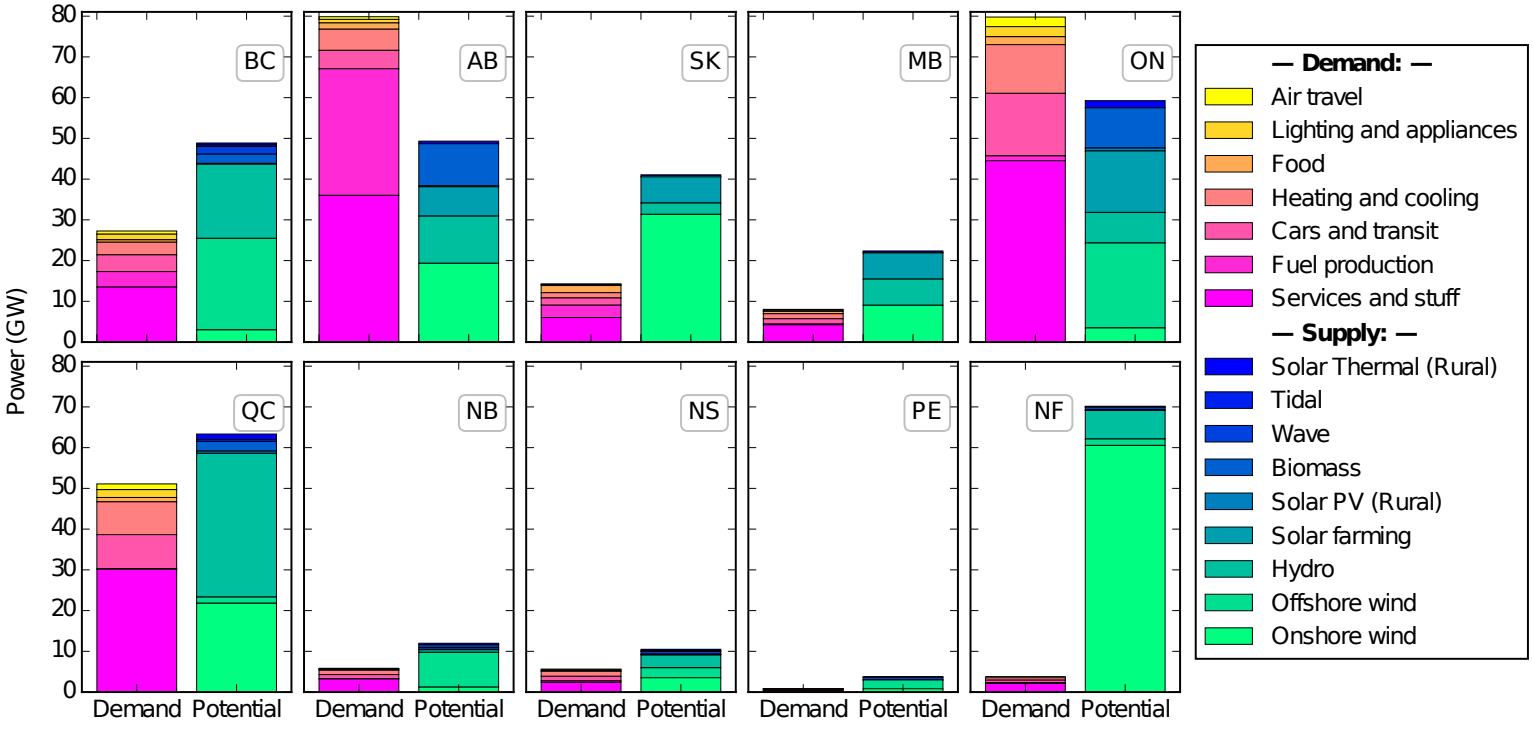
This snapshot is based on "The renewable energy landscape in Canada: a spatial analysis," *Renewable & Sustainable Energy Reviews* (2016), doi:10.1016/j.rser.2016.11.061. Our project assembles all sources of energy use into familiar household categories, and it identifies feasible sites for renewable energy generation across Canada. CONTACT: C. Barrington-Leigh, McGill University

The onshore wind potential for Newfoundland and Labrador, shown in below, is remarkable by any measure. In per capita terms, it dwarfs the province's own needs and at current energy prices could generate $200,000 per household of annual revenue if a market existed for it.[8] In absolute terms, our estimate of Newfoundland and Labrador's renewable energy potential is the largest in the country. Although it includes some hydroelectricity and a dispersed wind catchment area, both of which would help with reliability of power, the resource would clearly be developed only if it was exportable. This might involve new transmission systems such as a direct-current link connecting to Quebec and U.S.A markets. In addition, while we have sited high-potential wind areas only near existing roads and transmission lines, clearly the nature of the transmission infrastructure to these locations would need to change drastically for the exploitation of new energy resources on the scale of those envisioned here for Newfoundland and Labrador, as well as for other provinces. For very large developments, new roads and population centres may be developed to suit the location of the wind, rather than vice versa, in which case the geography of our analysis may be taken as only representative.



The stack on the left shows the sum of all energy currently consumed, as both electricity and combustion, in Newfoundland & Labrador. On the right is a breakdown of available renewable energy resources.

For maps, methods, sources, and more detailed discussion, see our full paper. We do not carry out an economic analysis, but our criteria for generation siting relate also to economic feasibility. Overall, our analysis shows that all but two provinces in Canada have sufficient renewable energy potential to meet the entire current energy demand.



[8] The average household size in Newfoundland and Labrador is 2.4. At a domestic energy price of $0.10/kWh, the value of 3000 kWh/day would be, annually, ∼ $110k per *individual*.