Energy 2020

"*Energy 2020 is an integrated, multi-region, multi-sector North American model that simulates the supply, price and demand for all fuels. The model can determine energy output and prices for each sector, both in regulated and unregulated markets. It simulates how such factors as energy prices and government measures affect the choices that consumers and businesses make when they buy and use energy. The model's outputs include changes in energy use, energy prices, greenhouse gas emissions, investment costs and possible cost savings from measures, which are used to identify the direct effects stemming from greenhouse gas reduction measures*" (Environment Canada 2013).

Energy 2020 is based on a representation of all existing power plants in Canada and the US. It models Ontario, Québec and Alberta as well as their interconnections with US states and other Canadian provinces and territories. Its energy demand structure makes it possible to model data centers power demand independently of the rest of the energy demand. It models the future evolution of the Canadian energy sector based on economic assumptions and optimization rules. It has been used by many governmental agencies in the US and Canada (including the US EPA and Environment Canada) to analyze various energy and GHG emissions policies (Amlin 2015). There are several versions of the model with varying levels of regional detail. In this study, the version is regionally aggregated for the US and provincially disaggregated for Canada. This version is used by Environment Canada in its Energy, Emissions and Economy Model for Canada (E3MC).

Table S1: Business as usual scenario assumptions (adapted from Environment Canada, Canada's Emissions Trends. 2013. p. 1-80)

Parameter	Value
Annual Growth (2011-2020):	
Gross domestic product	2.1%
Price index (inflation)	1.8%
Population	1.1%
Household formation	1.3%
Labor force	0.8%
Labor productivity	1.2%
Price (2020):	
World crude oil price	102 (US)$/barrel
Henry Hub natural gas price	5.30 (CAN)$/GJ
Crude oil and natural gas production (2020):	
Crude and condensates	$1{,}441\times10^3$ barrels/day
Oil sands	$3{,}315\times10^3$ barrels/day
Natural gas (shale gas included)	$4{,}861\times10^9$ cubic feet
Electricity generation (2020):	
Coal and Petroleum Coke	58 TWh
Refined Petroleum Products	3 TWh
Natural Gas	40 TWh
Hydro	397 TWh
Nuclear	84 TWh
Other Renewables	28 TWh
Total generation	609 TWh

Table S2: Electric demand of extra data centres per year and scenario

Electricity (TWh)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Sc1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Sc2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Sc3	0.2	0.2	0.2	0.2	0.4	0.4	0.4	0.4	0.6	0.6	0.6	0.6	0.8	0.8	0.9	0.9
Sc4	0.2	0.2	0.4	0.4	0.6	0.6	0.8	0.8	1.0	1.0	1.3	1.3	1.5	1.5	1.7	1.7
Sc5	0.4	0.7	1.0	1.2	1.5	1.8	2.0	2.3	2.6	2.9	3.1	3.4	3.7	3.9	4.2	4.5

Note: while table S2 and totals in table S4 should be the same, some differences can be seen. These differences are due to the imperfect convergence of the solutions computed by Energy2020.

Table S3: Electricity generated in US and Canada by source, by year and by scenario

Electricity (GWh)		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biomass	BAU	4710	4804	5192	5354	5399	5128	5329	5407	5784	8602	9220	9798	9835	9934	10675	11072
	Sc1	4710	4804	5229	5393	5401	5128	5329	5407	5784	8602	9220	9798	9835	9934	10676	11072
	Sc2	4710	4804	5229	5390	5401	5128	5329	5407	5784	8603	9220	9798	9835	9934	10676	11073
	Sc3	4710	4804	5223	5384	5405	5128	5329	5407	5784	8603	9221	9798	9836	9935	10677	11074
	Sc4	4710	4804	5250	5412	5429	5128	5329	5407	5784	8604	9222	9799	9837	9937	10679	11074
	Sc5	4710	4804	5322	5518	5545	5129	5329	5445	5784	8607	9224	9800	9838	10244	10685	11080
Coal	BAU	1679294	1660258	1662659	1667756	1679885	1691570	1695203	1707310	1708937	1712049	1720484	1725842	1731380	1736559	1736553	1728192
	Sc1	1679332	1660349	1662695	1667808	1679963	1691659	1695300	1707406	1709036	1712148	1720569	1725924	1731462	1736639	1736641	1728278
	Sc2	1679331	1660349	1662695	1667814	1679965	1691664	1695295	1707408	1709098	1712208	1720620	1725973	1731511	1736687	1736688	1728322
	Sc3	1679329	1660337	1662689	1667808	1680017	1691734	1695367	1707482	1709184	1712300	1720688	1726043	1731652	1736827	1736822	1728458
	Sc4	1679330	1660340	1662716	1667854	1680053	1691802	1695516	1707631	1709339	1712451	1720883	1726232	1731842	1737021	1737086	1728639
	Sc5	1679360	1660500	1662790	1668072	1680233	1692263	1696001	1708201	1709778	1713192	1721401	1726836	1732469	1737432	1737883	1729341
Heavy Fuel Oil	BAU	427	626	222	153	155	154	155	153	151	147	150	189	189	187	186	156
	Sc1	429	633	225	153	155	154	155	153	151	147	150	189	189	187	186	156
	Sc2	429	633	225	153	155	154	155	153	151	147	150	189	189	187	186	156
	Sc3	429	632	225	153	155	154	155	153	151	147	150	189	189	187	186	156
	Sc4	429	633	228	153	155	154	155	153	151	147	150	189	189	187	186	156
	Sc5	431	645	239	153	155	154	155	155	151	147	150	189	189	187	186	156
Diesel-Gazoline	BAU	359	359	359	359	359	359	359	359	359	359	359	358	357	357	354	330
	Sc1	359	359	359	359	359	359	359	359	359	359	359	358	357	357	354	330
	Sc2	359	359	359	359	359	359	359	359	359	359	359	358	357	357	354	330
	Sc3	359	359	359	359	359	359	359	359	359	359	359	358	357	357	354	330
	Sc4	359	359	359	359	359	359	359	359	359	359	359	358	357	357	354	330
	Sc5	359	359	359	359	359	359	359	359	359	359	359	358	357	357	355	330
Hydro	BAU	751830	756178	781651	788557	793002	795622	796995	801696	817145	830003	838052	840444	841150	848072	854313	859175
	Sc1	751830	756178	781663	788557	793001	795622	796995	801696	817145	830003	838052	840444	841150	848084	854326	859188
	Sc2	751830	756178	781663	788557	793001	795622	796995	801696	817145	830002	838052	840445	841150	848097	854338	859203
	Sc3	751830	756178	781666	788557	793002	795622	796995	801696	817145	830003	838052	840445	841150	848129	854370	859235
	Sc4	751830	756178	781678	788557	793002	795622	796995	801696	817145	830003	838052	840445	841150	848176	854438	859499
	Sc5	751829	756178	781718	788557	793002	795622	796996	801697	817427	830003	838333	840726	841431	848556	854617	859699
Natural Gas	BAU	786408	853323	878532	918744	946074	966106	994120	1020838	1041483	1056195	1079781	1106573	1128162	1144695	1161039	1181434
	Sc1	786607	853373	878588	918794	946141	966166	994186	1020912	1041557	1056275	1079864	1106663	1128255	1144789	1161137	1181532
	Sc2	786613	853382	878602	918805	946152	966176	994196	1020918	1041665	1056379	1079969	1106765	1128356	1144891	1161238	1181635
	Sc3	786598	853375	878592	918795	946268	966277	994298	1021023	1041780	1056497	1080086	1106881	1128588	1145122	1161465	1181866
	Sc4	786607	853382	878709	918903	946348	966349	994482	1021205	1041971	1056686	1080395	1107188	1128903	1145438	1161898	1182187
	Sc5	786767	853647	879017	919320	946855	966948	995085	1021897	1042578	1057569	1081191	1108132	1129872	1146557	1163155	1183777
Nuclear	BAU	869150	866110	874149	866478	858123	851771	858379	858379	865825	865825	865825	865825	865825	866957	868409	868409
	Sc1	869150	866110	874149	866478	858123	851771	858379	858379	865825	865825	865825	865825	865825	866957	868409	868409
	Sc2	869150	866110	874149	866478	858123	851771	858379	858379	865825	865825	865825	865825	865825	866957	868409	868409
	Sc3	869150	866110	874149	866478	858123	851771	858379	858379	865825	865825	865825	865825	865825	866957	868409	868409
	Sc4	869150	866110	874149	866478	858123	851771	858379	858379	865825	865825	865825	865825	865825	866957	868409	868409
	Sc5	869150	866110	874149	866478	858123	851771	858379	858379	865825	865825	865825	865825	865825	866957	868409	868409
Wind	BAU	256084	259216	262406	265305	267524	269004	270796	272515	274348	276937	279184	281567	285563	288691	291586	294696
	Sc1	256084	259216	262406	265305	267524	269004	270796	272515	274348	276937	279184	281567	285563	288691	291587	294697
	Sc2	256084	259216	262407	265305	267524	269004	270796	272515	274348	276937	279184	281567	285563	288692	291587	294697
	Sc3	256084	259216	262406	265305	267524	269004	270796	272515	274348	276937	279184	281568	285563	288693	291589	294699
	Sc4	256084	259216	262407	265306	267524	269004	270796	272515	274348	276937	279184	281568	285563	288695	291591	294699
	Sc5	256083	259216	262408	265305	267528	269008	270830	272520	274352	276941	279189	281572	285568	288704	291604	294718
Total	BAU	4348261	4400874	4465170	4512706	4550521	4579714	4621336	4666657	4714033	4750117	4793056	4830597	4862462	4895452	4923116	4943464
	Sc1	4348501	4401022	4465314	4512847	4550668	4579863	4621499	4666828	4714205	4750296	4793224	4830769	4862636	4895637	4923315	4943662
	Sc2	4348505	4401030	4465328	4512860	4550681	4579878	4621504	4666837	4714375	4750461	4793381	4830920	4862787	4895802	4923477	4943824
	Sc3	4348489	4401010	4465309	4512839	4550853	4580050	4621678	4667016	4714576	4750672	4793566	4831106	4863161	4896207	4923874	4944226
	Sc4	4348498	4401021	4465496	4513021	4550993	4580190	4622011	4667346	4714923	4751012	4794072	4831603	4863666	4896768	4924641	4944993
	Sc5	4348690	4401458	4466001	4513762	4551799	4581255	4623135	4668653	4716253	4752644	4795673	4833439	4865550	4898994	4926895	4947509

Table S4: Marginal electricity generated in US and Canada by source, by year and by scenario

Electricity (GWh)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biomass																
Sc1	0	0	36	39	2	0	0	0	0	0	0	0	0	0	0	0
Sc2	0	0	36	36	2	0	0	0	0	1	1	0	0	1	1	1
Sc3	0	0	30	30	6	0	0	0	0	1	1	1	1	2	2	2
Sc4	0	0	57	57	30	0	0	0	0	2	2	2	2	3	4	2
Sc5	0	0	130	164	146	0	0	38	0	5	4	3	3	310	10	8
Coal																
Sc1	38	91	35	52	78	89	97	96	99	99	85	82	82	79	87	87
Sc2	37	91	36	58	81	94	92	99	161	159	136	130	130	128	135	130
Sc3	35	79	30	52	132	164	164	173	247	252	204	200	272	267	269	266
Sc4	36	82	56	98	169	231	313	322	402	402	399	390	462	462	532	448
Sc5	66	242	131	316	348	693	798	892	841	1143	917	993	1089	873	1330	1149
Heavy Fuel Oil																
Sc1	1	7	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Sc2	2	7	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Sc3	2	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Sc4	2	7	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Sc5	3	20	17	0	0	0	0	2	0	0	0	0	0	0	0	0
Diesel-Gazoline																
Sc1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sc2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sc3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sc4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sc5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydro																
Sc1	0	0	12	0	0	0	0	0	0	0	0	0	0	12	13	12
Sc2	0	0	12	0	0	0	0	0	0	0	0	0	0	24	25	27
Sc3	0	0	15	0	0	0	0	0	0	0	0	0	0	57	57	59
Sc4	0	0	27	0	0	0	0	0	0	0	0	0	0	104	124	324
Sc5	0	0	67	0	0	0	0	0	281	0	281	281	281	484	304	523
Natural Gas																
Sc1	199	50	56	50	67	60	67	75	74	80	83	90	93	93	98	98
Sc2	204	58	70	61	78	70	76	81	182	184	188	192	194	196	200	201
Sc3	190	51	60	51	194	171	179	186	297	302	304	308	426	426	427	432
Sc4	199	59	178	158	274	244	362	367	488	491	614	615	741	743	859	753
Sc5	359	323	485	576	781	843	966	1059	1095	1374	1410	1559	1710	1861	2116	2343
Nuclear																
Sc1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sc2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sc3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sc4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sc5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind																
Sc1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Sc2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Sc3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	2
Sc4	0	0	1	0	0	0	0	0	0	0	0	0	0	4	5	2
Sc5	0	0	2	0	4	4	34	4	4	4	4	5	5	13	18	22
Total																
Sc1	239	148	144	141	147	149	163	171	173	179	168	172	175	185	199	198
Sc2	243	156	158	154	160	164	168	179	343	344	325	323	325	350	361	360
Sc3	227	137	139	133	332	335	342	358	544	555	510	509	699	755	757	762
Sc4	236	147	326	314	472	475	676	689	890	895	1016	1006	1205	1317	1525	1529
Sc5	428	585	831	1055	1279	1540	1799	1996	2221	2528	2617	2842	3088	3542	3778	4045

Table S5: ecoinvent processes used to model Energy 2020 electricity generation technologies

Energy2020	Ecoinvent	
Technology	Fraction	Process
		US
Coal	6.30%	{WECC, US only}| electricity production, hard coal
	4.54%	{MRO, US only}| electricity production, hard coal
	0.26%	{NPCC, US only}| electricity production, hard coal
	15.42%	{RFC}| electricity production, hard coal
	13.48%	{SERC}| electricity production, hard coal
	1.81%	{SPP}| electricity production, hard coal
	4.43%	{TRE}| electricity production, hard coal
	1.40%	{FRCC}| electricity production, hard coal
	6.93%	{WECC, US only}| electricity production, lignite
	4.98%	{MRO, US only}| electricity production, lignite
	0.29%	{NPCC, US only}| electricity production, lignite
	16.95%	{RFC}| electricity production, lignite
	14.82%	{SERC}| electricity production, lignite
	1.98%	{SPP}| electricity production, lignite
	4.87%	{TRE}| electricity production, lignite
	1.54%	{FRCC}| electricity production, lignite
Hydro	0.52%	{WECC, US only}| electricity production, hydro, pumped storage
	0.82%	{NPCC, US only}| electricity production, hydro, pumped storage
	1.57%	{RFC}| electricity production, hydro, pumped storage
	3.63%	{SERC}| electricity production, hydro, pumped storage
	0.13%	{SPP}| electricity production, hydro, pumped storage
	12.98%	{WECC, US only}| electricity production, hydro, reservoir, alpine region
	0.84%	{MRO, US only}| electricity production, hydro, reservoir, alpine region
	2.15%	{NPCC, US only}| electricity production, hydro, reservoir, alpine region
	0.47%	{RFC}| electricity production, hydro, reservoir, alpine region
	1.98%	{SERC}| electricity production, hydro, reservoir, alpine region
	0.08%	{SPP}| electricity production, hydro, reservoir, non-alpine region
	0.04%	{TRE}| electricity production, hydro, reservoir, non-alpine region
	0.55%	{FRCC}| electricity production, hydro, reservoir, non-alpine region
	51.93%	{WECC, US only}| electricity production, hydro, run-of-river
	3.37%	{MRO, US only}| electricity production, hydro, run-of-river
	8.59%	{NPCC, US only}| electricity production, hydro, run-of-river
	1.89%	{RFC}| electricity production, hydro, run-of-river
	7.93%	{SERC}| electricity production, hydro, run-of-river
	0.32%	{SPP}| electricity production, hydro, run-of-river
	0.16%	{TRE}| electricity production, hydro, run-of-river
	0.04%	{FRCC}| electricity production, hydro, run-of-river
Natural Gas	6.22%	{WECC, US only}| electricity production, natural gas, combined cycle power plant
	0.06%	{MRO, US only}| electricity production, natural gas, combined cycle power plant
	3.56%	{NPCC, US only}| electricity production, natural gas, combined cycle power plant
	4.80%	{RFC}| electricity production, natural gas, combined cycle power plant
	7.85%	{SERC}| electricity production, natural gas, combined cycle power plant
	1.26%	{SPP}| electricity production, natural gas, combined cycle power plant
	5.32%	{TRE}| electricity production, natural gas, combined cycle power plant
	4.48%	{FRCC}| electricity production, natural gas, combined cycle power plant
	8.81%	{WECC, US only}| electricity production, natural gas, conventional power plant
	0.90%	{MRO, US only}| electricity production, natural gas, conventional power plant
	5.04%	{NPCC, US only}| electricity production, natural gas, conventional power plant
	6.80%	{RFC}| electricity production, natural gas, conventional power plant
	11.12%	{SERC}| electricity production, natural gas, conventional power plant
	1.78%	{SPP}| electricity production, natural gas, conventional power plant
	7.53%	{TRE}| electricity production, natural gas, conventional power plant
	6.35%	{FRCC}| electricity production, natural gas, conventional power plant
	1.23%	{WECC, US only}| heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical
	0.13%	{MRO, US only}| heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical

	0.71%	{NPCC, US only}| heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical
	0.95%	{RFC}| heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical
	1.56%	{SERC}| heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical
	0.25%	{SPP}| heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical
	1.05%	{TRE}| heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical
	0.89%	{FRCC}| heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical
	2.07%	{WECC, US only}| heat and power co-generation, natural gas, conventional power plant, 100MW electrical
	0.21%	{MRO, US only}| heat and power co-generation, natural gas, conventional power plant, 100MW electrical
	1.18%	{NPCC, US only}| heat and power co-generation, natural gas, conventional power plant, 100MW electrical
	1.60%	{RFC}| heat and power co-generation, natural gas, conventional power plant, 100MW electrical
	2.61%	{SERC}| heat and power co-generation, natural gas, conventional power plant, 100MW electrical
	0.42%	{SPP}| heat and power co-generation, natural gas, conventional power plant, 100MW electrical
	1.77%	{TRE}| heat and power co-generation, natural gas, conventional power plant, 100MW electrical
	1.49%	{FRCC}| heat and power co-generation, natural gas, conventional power plant, 100MW electrical
Nuclear	5.09%	{WECC, US only}| electricity production, nuclear, boiling water reactor
	1.91%	{MRO, US only}| electricity production, nuclear, boiling water reactor
	3.34%	{NPCC, US only}| electricity production, nuclear, boiling water reactor
	11.45%	{RFC}| electricity production, nuclear, boiling water reactor
	11.67%	{SERC}| electricity production, nuclear, boiling water reactor
	0.36%	{SPP}| electricity production, nuclear, boiling water reactor
	1.67%	{TRE}| electricity production, nuclear, boiling water reactor
	0.78%	{FRCC}| electricity production, nuclear, boiling water reactor
	2.60%	{WECC, US only}| electricity production, nuclear, pressure water reactor
	3.76%	{MRO, US only}| electricity production, nuclear, pressure water reactor
	6.55%	{NPCC, US only}| electricity production, nuclear, pressure water reactor
	22.44%	{RFC}| electricity production, nuclear, pressure water reactor
	22.86%	{SERC}| electricity production, nuclear, pressure water reactor
	0.71%	{SPP}| electricity production, nuclear, pressure water reactor
	3.28%	{TRE}| electricity production, nuclear, pressure water reactor
	1.52%	{FRCC}| electricity production, nuclear, pressure water reactor
Heavy Fuel Oil, Diesel and Gazoline	5.07%	{WECC, US only}| electricity production, oil
	1.53%	{MRO, US only}| electricity production, oil
	4.40%	{NPCC, US only}| electricity production, oil
	16.57%	{RFC}| electricity production, oil
	28.44%	{SERC}| electricity production, oil
	0.25%	{SPP}| electricity production, oil
	0.78%	{TRE}| electricity production, oil
	7.21%	{FRCC}| electricity production, oil
	2.71%	{WECC, US only}| heat and power co-generation, oil
	0.86%	{MRO, US only}| heat and power co-generation, oil
	2.45%	{NPCC, US only}| heat and power co-generation, oil
	9.25%	{RFC}| heat and power co-generation, oil
	15.87%	{SERC}| heat and power co-generation, oil
	0.14%	{SPP}| heat and power co-generation, oil
	0.44%	{TRE}| heat and power co-generation, oil
	4.03%	{FRCC}| heat and power co-generation, oil
Wind and other	1.96%	{WECC, US only}| electricity production, wind, <1MW turbine, onshore
	1.61%	{MRO, US only}| electricity production, wind, <1MW turbine, onshore
	0.21%	{NPCC, US only}| electricity production, wind, <1MW turbine, onshore
	0.83%	{RFC}| electricity production, wind, <1MW turbine, onshore
	0.06%	{SERC}| electricity production, wind, <1MW turbine, onshore
	0.66%	{SPP}| electricity production, wind, <1MW turbine, onshore
	1.59%	{TRE}| electricity production, wind, <1MW turbine, onshore
	0.20%	{WECC, US only}| electricity production, wind, >3MW turbine, onshore
	0.17%	{MRO, US only}| electricity production, wind, >3MW turbine, onshore
	0.02%	{NPCC, US only}| electricity production, wind, >3MW turbine, onshore
	0.08%	{RFC}| electricity production, wind, >3MW turbine, onshore
	0.01%	{SERC}| electricity production, wind, >3MW turbine, onshore
	0.07%	{SPP}| electricity production, wind, >3MW turbine, onshore
	0.16%	{TRE}| electricity production, wind, >3MW turbine, onshore

	23.39%	{WECC, US only}| electricity production, wind, 1-3MW turbine, onshore
	19.20%	{MRO, US only}| electricity production, wind, 1-3MW turbine, onshore
	2.51%	{NPCC, US only}| electricity production, wind, 1-3MW turbine, onshore
	9.87%	{RFC}| electricity production, wind, 1-3MW turbine, onshore
	0.76%	{SERC}| electricity production, wind, 1-3MW turbine, onshore
	7.85%	{SPP}| electricity production, wind, 1-3MW turbine, onshore
	18.95%	{TRE}| electricity production, wind, 1-3MW turbine, onshore
	9.83%	{WECC, US only}| electricity production, deep geothermal
Biomass	8.16%	{WECC, US only}| heat and power co-generation, biogas, gas engine
	5.93%	{MRO, US only}| heat and power co-generation, biogas, gas engine
	12.83%	{NPCC, US only}| heat and power co-generation, biogas, gas engine
	17.94%	{RFC}| heat and power co-generation, biogas, gas engine
	5.94%	{SERC}| heat and power co-generation, biogas, gas engine
	0.21%	{SPP}| heat and power co-generation, biogas, gas engine
	2.05%	{TRE}| heat and power co-generation, biogas, gas engine
	6.90%	{FRCC}| heat and power co-generation, biogas, gas engine
	13.02%	{WECC, US only}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014
	3.12%	{MRO, US only}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014
	11.41%	{NPCC, US only}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014
	3.56%	{RFC}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014
	7.07%	{SERC}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014
	0.46%	{TRE}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014
	1.42%	{FRCC}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014

Canada

Technology	Process
Coal	{CA-X*}| electricity production, lignite
	{CA-X}| electricity production, hard coal
Hydro	{CA-X}| electricity production, hydro, pumped storage
	{CA-X}| electricity production, hydro, reservoir, alpine region
	{CA-X}| electricity production, hydro, reservoir, non-alpine region
	{CA-X}| electricity production, hydro, run-of-river
Natural gas	{CA-X}| electricity production, natural gas, conventional power plant
	{CA-X}| heat and power co-generation, natural gas, conventional power plant, 100MW electrical
	{CA-X}| electricity production, natural gas, combined cycle power plant
Nuclear	{CA-X}| electricity production, nuclear, pressure water reactor, heavy water moderated
Heavy Fuel Oil, Diesel and Gazoline	{CA-X}| electricity production, oil
Wind	{CA-X}| electricity production, wind, <1MW turbine, onshore
	{CA-X}| electricity production, wind, 1-3MW turbine, onshore
	{CA-X}| electricity production, wind, >3MW turbine, onshore
	{CA-X}| electricity production, wind, 2.3MW turbine, precast concrete tower, onshore
Biomass	{CA-X}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014

*X refers to the abbreviation of the Canadian province in ecoinvent (e.g. QC for Quebec, ON for Ontario, etc.)

Note: since the electricity generation processes are modeled at the power plant level in ecoinvent, the electric losses and emissions occurring during the transport and distribution of electricity were added (based on regional data of ecoinvent) to each electric process so the transport and distribution is included.

Technology innovation

Finally, past tendencies observed in electricity generation were used to represent future evolution of technology efficiencies. The annual efficiencies of thermal power plants (coal, oil, natural gas and biomass) were computed on the basis of the amount of fuel burned and the electricity generated per fuel from 1996 to 2015. For that purpose, data have been collected from the US Energy Information Administration (EIA) database (US Energy Information Administration 2013b) for US thermal power plants. Then an extrapolation (linear regression) was made for 2015-2030 and the average annual change in efficiency was computed for each thermal technology. It was intended to follow the same approach for Canadian thermal power plants using data from Statistics Canada (Statistics Canada 2013). However, the too short period (nine years) covered by the Canadian database made the results quite uncertain. Therefore it was preferred to use US data to model the future efficiencies of the Canadian thermal technologies. Regarding nuclear power plants, the amounts of nuclear fuels consumed annually were not found, thus it was anticipated the future efficiency of Canadian nuclear power plants would follow the trend observed during 2003-2013 among the US nuclear power plants (US Energy Information Administration 2013a). The efficiency trend of wind power was computed with the annual electricity generation by wind farms and the installed capacity of wind power. The US EIA database (US Energy Information Administration 2013b) was used to compute the US wind farms efficiency trend but also for the Canadian one (due to the too short period covered by Statistics Canada). Then, following the same approach than for thermal technologies, the average annual change in efficiency of wind power technology was calculated for the 2015-2030 period. No efficiency trend data were found for hydropower. Therefore it was assumed this technology would not improve in the near future. Regarding this assumption, it should be noted that hydropower efficiency is already close to its theoretical limit (Liu et al. 2015) and is not expected to change significantly in the future. The annual efficiency changes of each technology are presented in table S7. Then, the substances inventory was computed based on the amount of electricity generated by each energy source, as modeled by Energy 2020 each year for each scenario. Finally, each data center deployment scenario was

compared to the BAU scenario to determine the differential energy sources used to power the additional Canadian data centers.

Table S7: Annual efficiency changes in US and Canada electricity generation anticipated for 2015-2030

Technology	**Annual efficiency changes***
Coal	-0.48 %
Oil (heavy fuel oil and diesel)	-0.02 %
Natural gas	1.15 %
Biomass	-0.67 %
Nuclear	-0.03 %
Hydro	0.00 %
Wind	0.02 %

* Negative efficiency changes are interpreted as the aging of equipment and infrastructures.