Ontario, Quebec, and the Pickering Nuclear Station

The myth and the reality

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PART 0

Introduction

ONTARIO ELECTRICITY GENERATION–RELATED GREENHOUSE GAS and air pollution emissions will increase significantly if and when the Pickering Nuclear Generating Station goes out of service beginning 2025. This is because PNGS's 2,000–3,000 megawatts of round-the-clock electrical power will be replaced with natural gas–fired power. The reason for this is straightforward: no other available generation source in Ontario is capable of 24/7 operation.

Hourly Ontario data from a representative ten-day period in early February 2021 show the CO_2 emissions we can expect when Pickering is replaced with gas. Fig. 1.1 shows greater hourly and of course greater cumulative emissions without Pickering. It is important to note that CO_2 has a residence time in the atmosphere of over 1,000 years—emissions today are literally a thousand-year legacy.

The generally "flat" output of Pickering—individual and collective unit output—versus that of extremely variable wind is shown in fig. 1.2. Pickering, and the other 12 units in Ontario's nuclear fleet, in addition to providing most of Ontario's power at any given time, have a stabilizing effect on the grid. This is extremely important.

Nonetheless, the electricity system operator must perform a complex choreography in order to manage generation (supply) so as to match Ontario's daily electricity demand fluctuations, in light of significant amounts of wildly variable wind and solar output that is inherently uncorrelated with demand. See fig. 1.3. The implication of this is that the system operator can only throttle wind down (most solar is outside the operator's direct control).

So the choreography is performed within this significant constraint. To keep the lights on, the system operator must err on the side of over-supply. This is why you see wind and solar usually exceeding Ontario demand during the daily demand peaks in fig. 1.3. With Ontario's current supply mix, the CO_2 implications are not as serious as in more fossil dependent systems—the operator has not just gas but also significant amounts of throttlable hydro to keep the grid in sync within the necessarily tight voltage and frequency parameters. But that changes when Pickering comes offline.

Claims that PNGS's output could be replaced with a combination of hydropower from Quebec and intermittent renewable sources like wind and solar lack credibility. Quebec currently possesses neither the generation nor transmission capacity to maintain a round-the-clock flow of at least 2,000 MW to Ontario, and wind/solar at current installed capacity would require at least that much firm output just for grid stability.

The most recent 12 months of hourly electricity flows between Ontario and Quebec at the largest transmission intertie show directional changes occurring almost daily in all months of the year; see figs. 2.1 to 2.12. That should put to rest any notion that

that flow could or should be changed from bi-directional to one direction only—Quebec to Ontario. Unless Pickering is replaced with another nuclear plant of equivalent capacity, the station's current output will simply be replaced with gas-fired output. This carries sobering implications for Ontario's and Canada's ability to meet Paris Climate targets.

PART 1

Representative data and what it shows us

REAL WORLD CONDITIONS ON ONTARIO'S ELECTRICITY GRID are well represented in a ten-day period in early to mid-February 2021. Current generation, demand, and CO_2 emissions tell at a glance what kind of performance we can expect from each of the major generation types, and when we can expect it. Implications for CO_2 emissions—and Ontario's ability to contribute toward meeting Canada's Paris climate commitments—are obvious. Fig. 1.1 shows that hourly CO_2 emissions would increase by at least 1,000 tons when Pickering is replaced with natural gas. Cumulative emissions over ten days would increase from 250,000 tons to nearly 500,000 tons.

Half a million tons every ten days equates to 18.2 million tons per year, over 4 times Ontario's current annual total from power generation. With a carbon tax of \$50 per ton, annual CO_2 emissions this size would cost Ontarians over \$900 million per year. That would impair OPG's ability to provide dividend revenues to Ontario, and hurt the province's fiscal health.

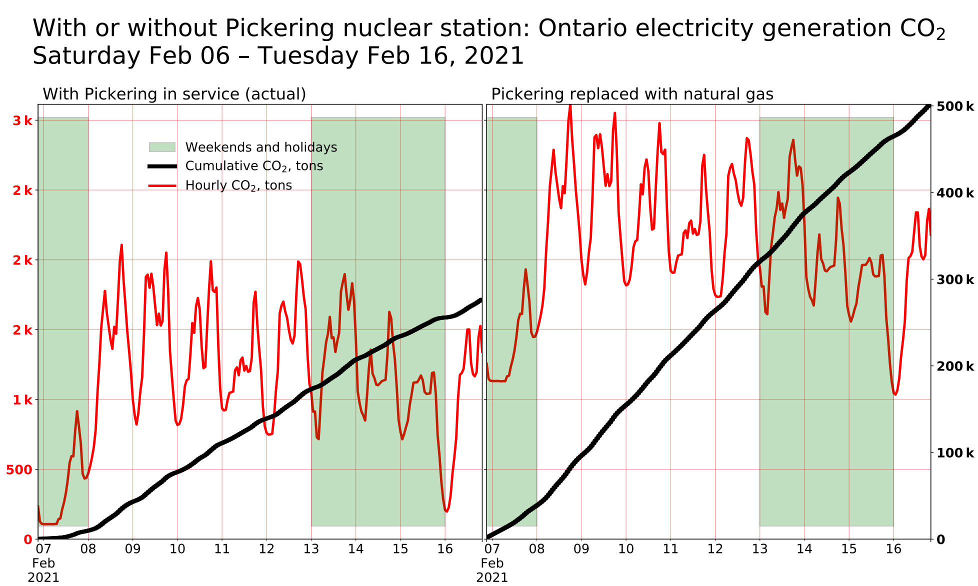

Fig. 1.1: Ontario electricity CO_2, with and without Pickering

1.1 Firm vs infirm power

THE WIND CURVE IN FIG. 1.2 SHOWS the great variability of wind and its non-correlation with demand. During the period shown, Ontario was experiencing a prolonged cold snap. Energy demand—not just electricity, but transportation and especially heating—was often more than three times electricity demand. Though wind is officially classified as a component of baseload supply, its performance especially through the very cold working week of Feb 8–13 suggests that that classification is inaccurate. In any case, Ontario should be under no illusion that it can replace Pickering's flat, stable, high output with wind.

This inherent uncertainty of supply explains the regularity or periodicity of CO_2 emissions in fig. 1.1. The system operator has control over gas-fired generation, and little control over wind.

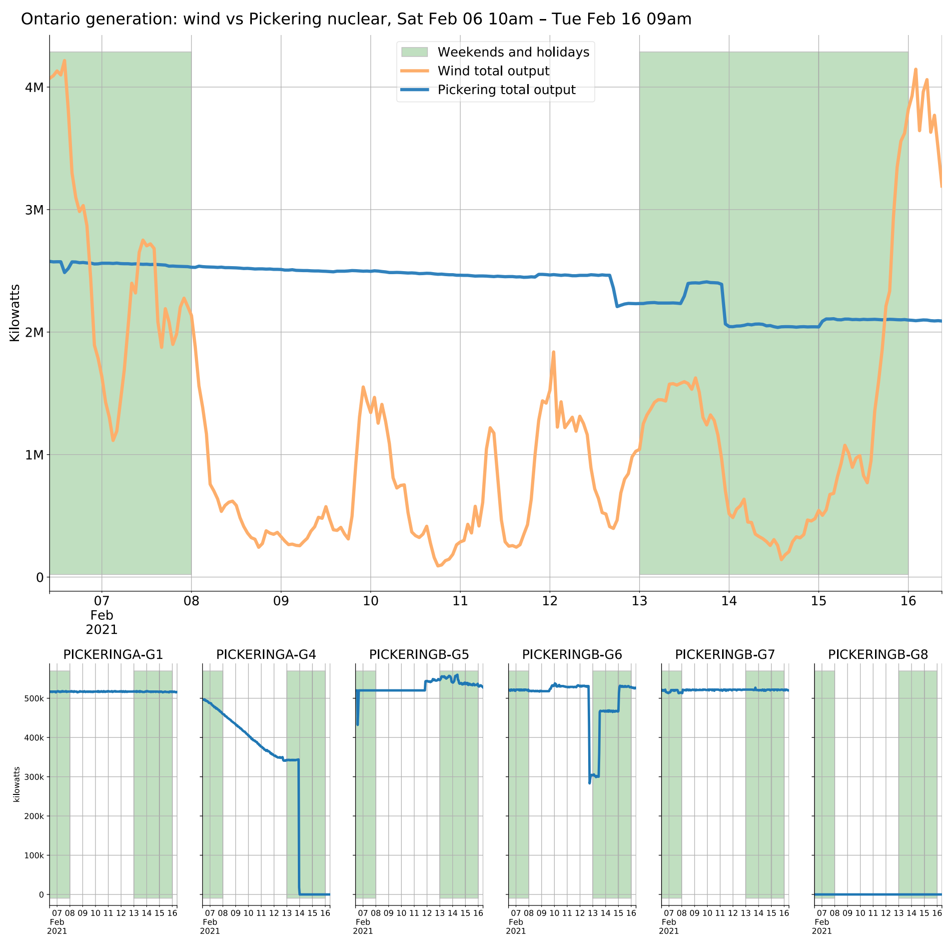

Fig. 1.2: Pickering output vs wind

1.2 Choreography and risk management

THE MAIN PLOT IN FIG. 1.3 shows where the action is as far as Ontario's electricity system operator is concerned; note the minimum value of the plot is about 9,000 megawatts, i.e. the very top of the nuclear "tranche" that represents the thickest layer of baseload supply. The scatterplots on the right are the correlations of each generation type with Ontario demand over the ten day period. The top two of those, solar and wind, show little correlation with demand. The job of ensuring supply does meet the daily demand peaks falls to the maneuverable types: Gas, peaking hydro, ramping hydro, and some portions of baseload hydro.

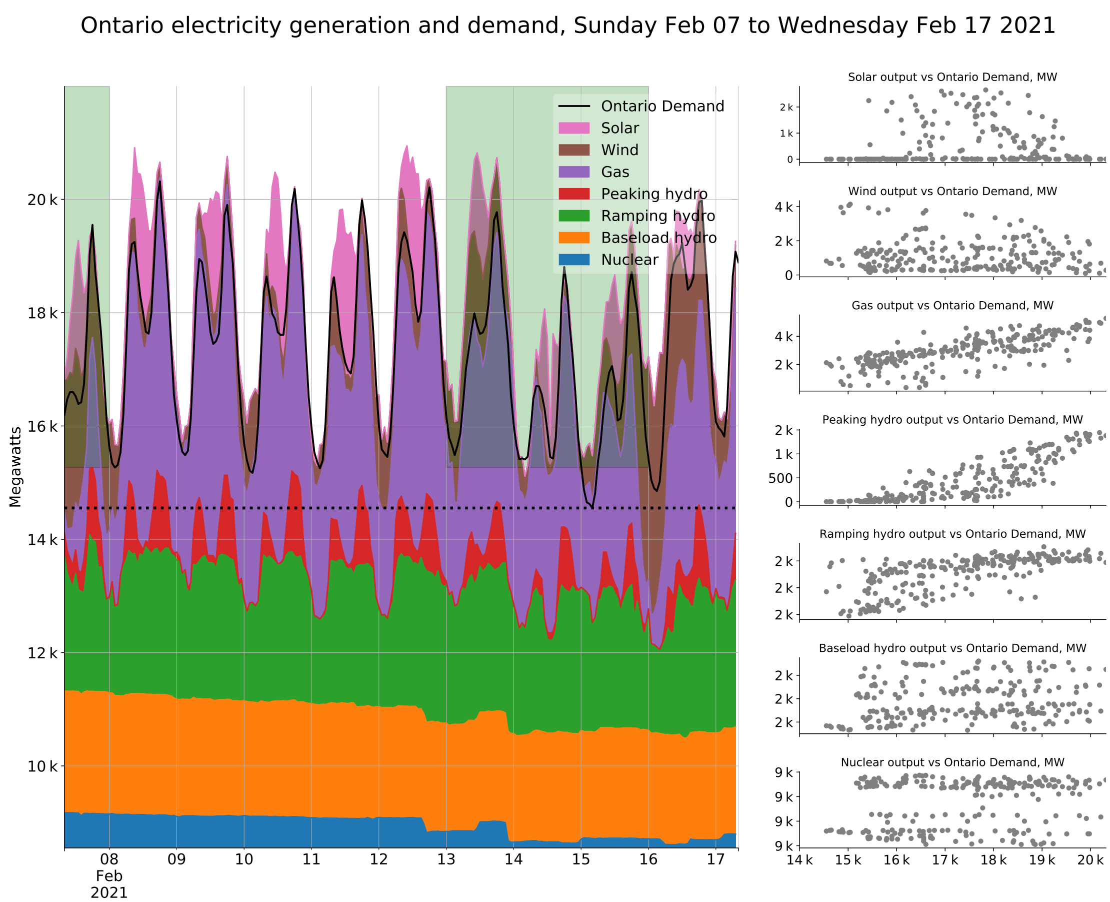

Fig. 1.3: Ontario electricity supply and demand

PART 2

Quebec and Ontario electricity trade, at one intertie

2.1 What do intertie flows tell us?

ONTARIO AND QUEBEC TRADE ELECTRICITY, often many times a day. These daily directional changes in the flow of electricity through the main Outaouais intertie near Ottawa reflect the importance of that intertie to both provinces. Regardless of the season, the flow pattern generally shows:

- Nightly exports from Ontario to Quebec, and daily imports from Quebec to Ontario.
- Daily maximum exports close to the intertie capacity of 1,250 usually occurring several times per month.

This might give the impression that Quebec balances Ontario's supply. However, that impression would be wrong. The daily directional changes at the Outaouais intertie reflect demand and supply conditions in the Ottawa area, on both sides of the provincial border. Ontario is a significant exporter to New York (maximum capacity 1,000 MW) and Michigan (also 1,000).

2.2 Outaouais intertie daily flow data, by month

2.2.1 January 2020

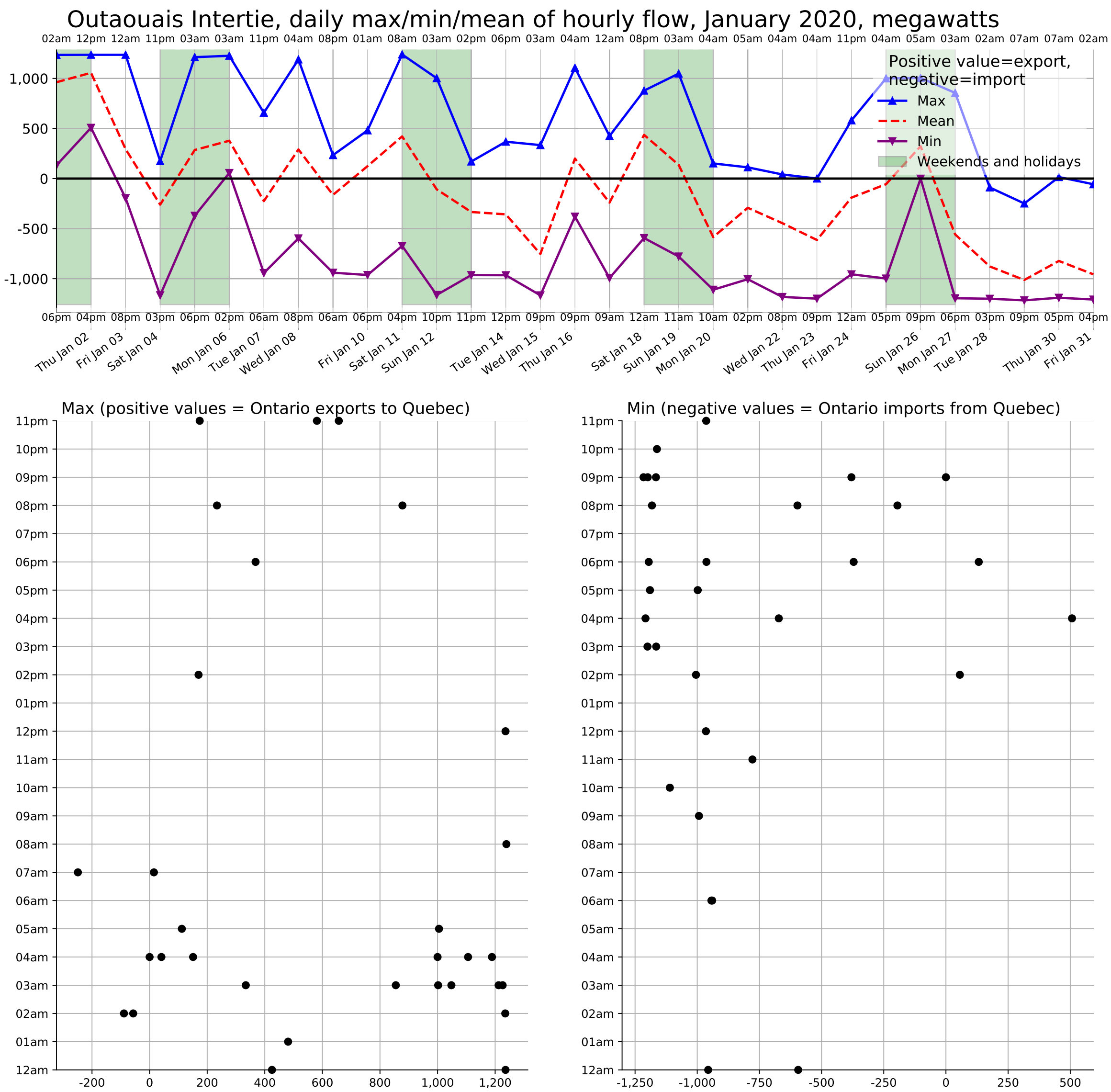

Fig. 2.1: Outaouais intertie flow, January 2020.

2.2.2 February 2020

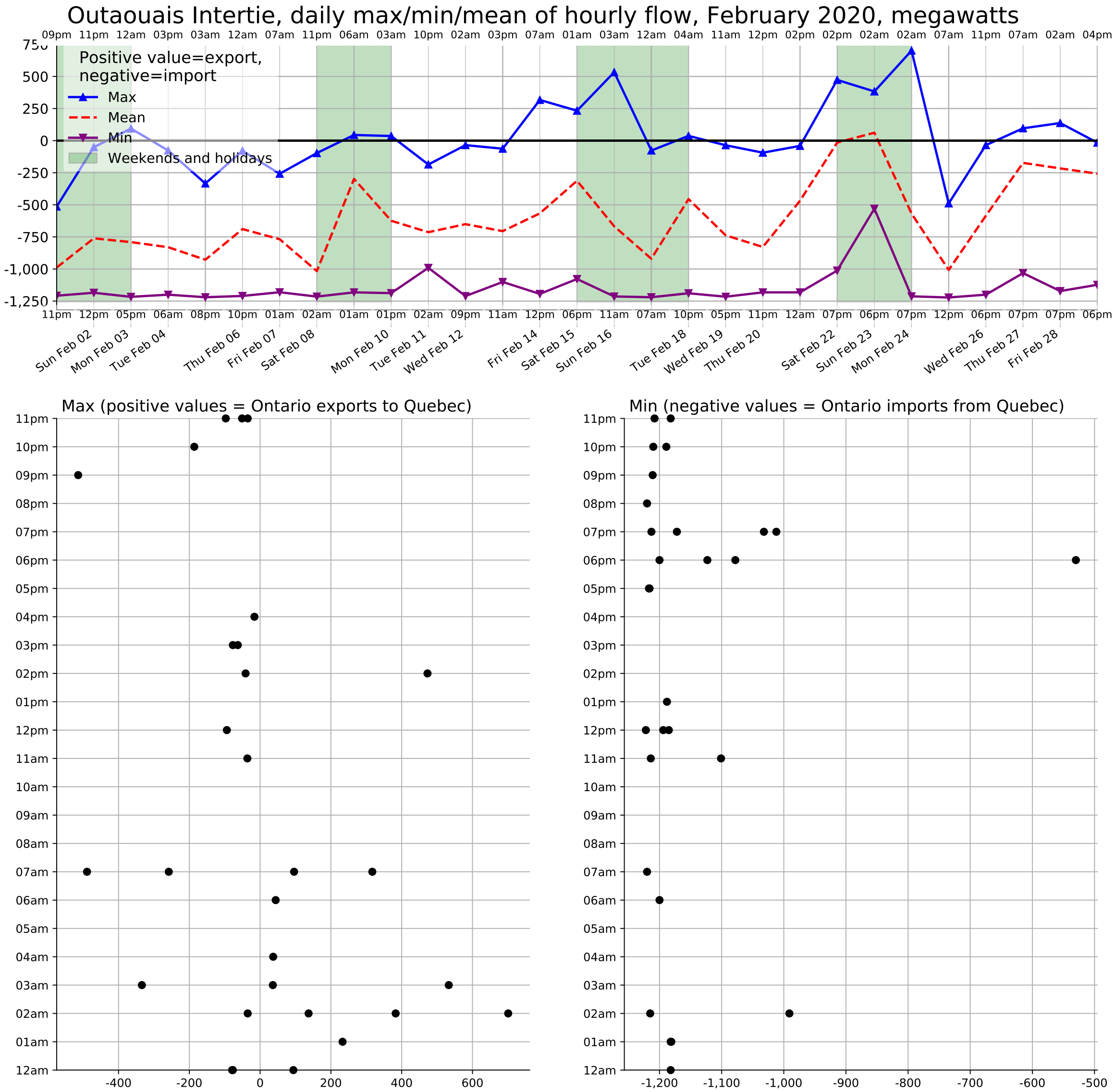

Fig. 2.2: Outaouais intertie flow, February 2020.

2.2.3 March 2020

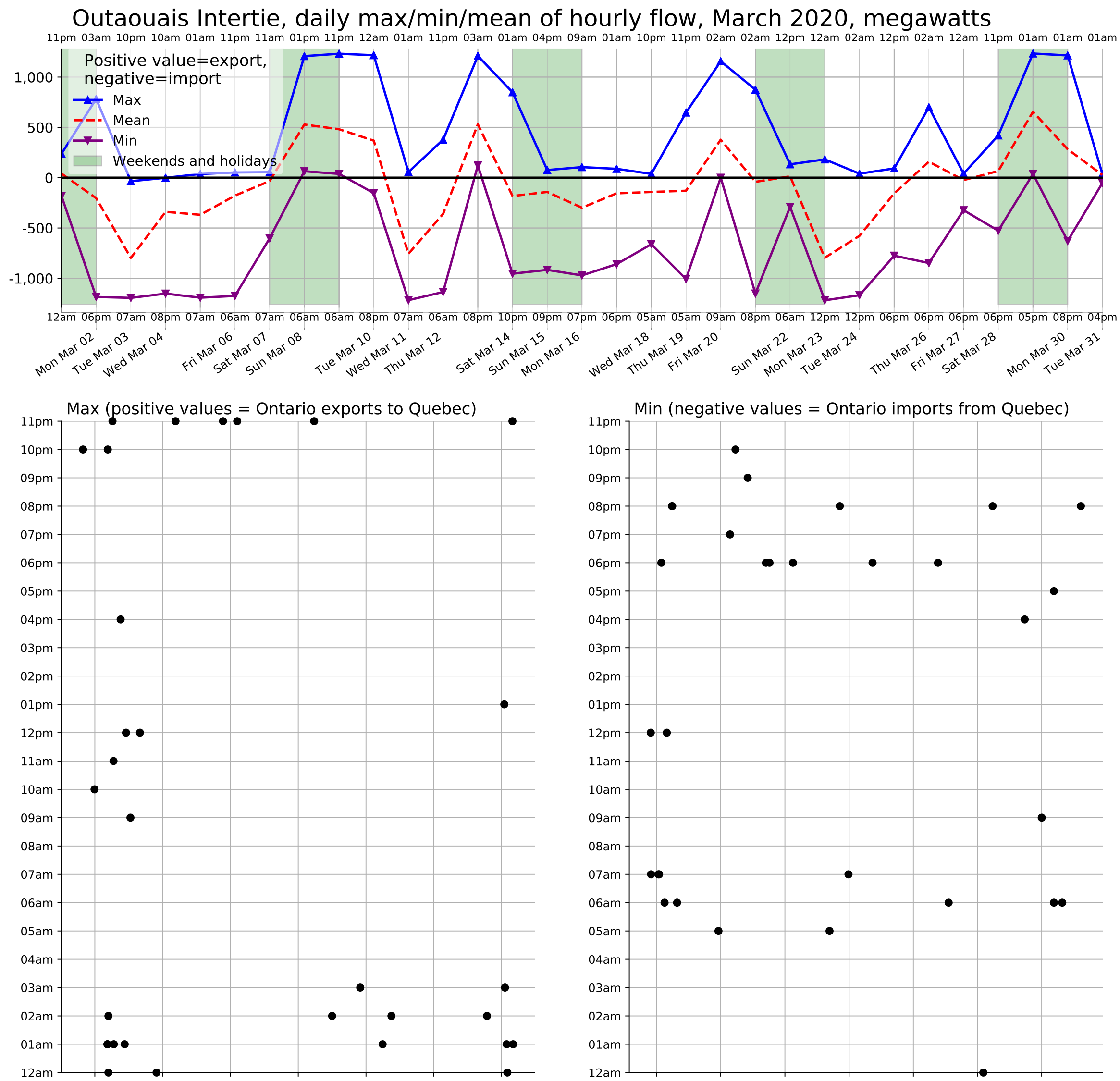

Fig. 2.3: Outaouais intertie flow, March 2020.

2.2.4 April 2020

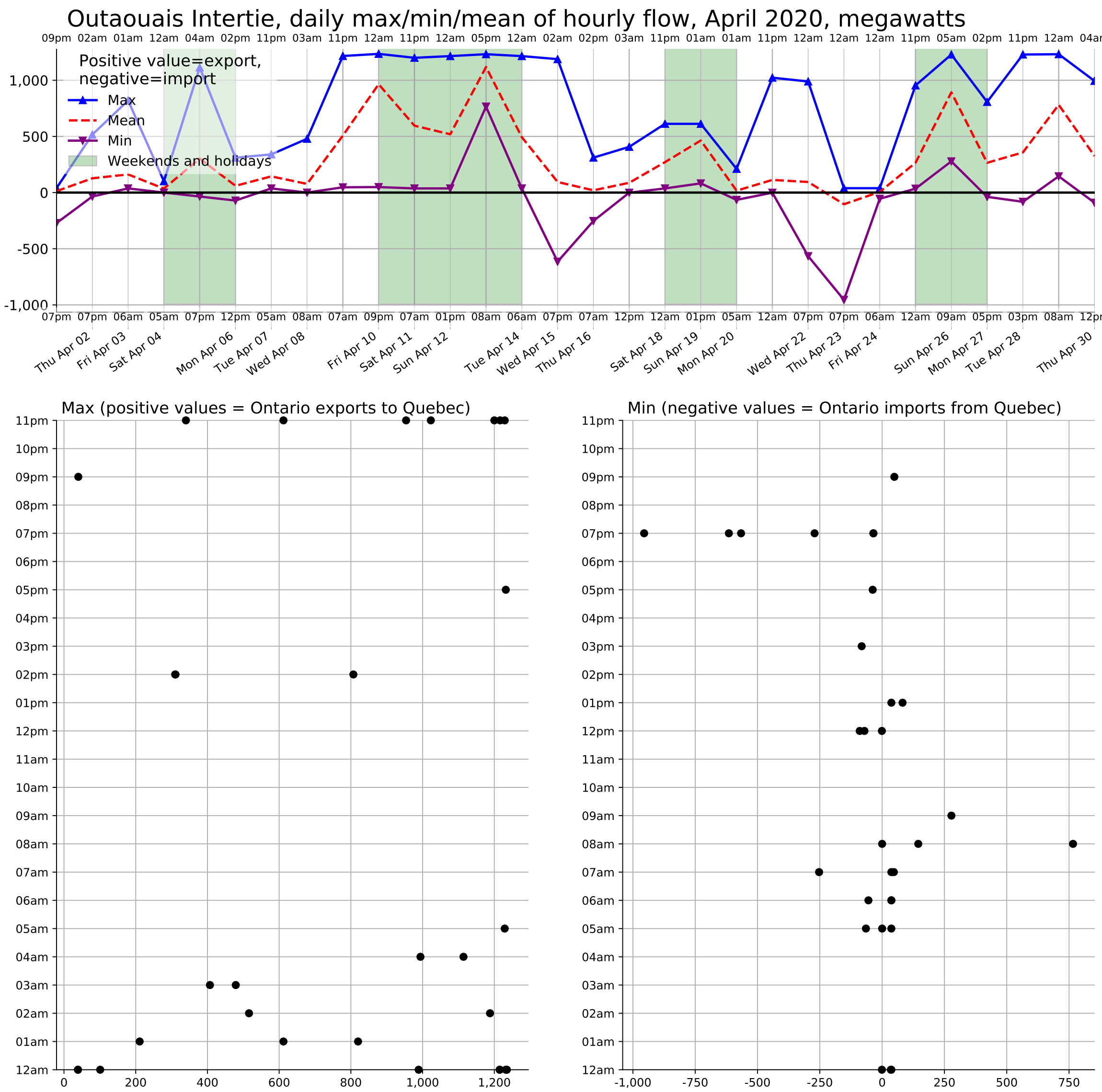

Fig. 2.4: Outaouais intertie flow, April 2020.

2.2.5 May 2020

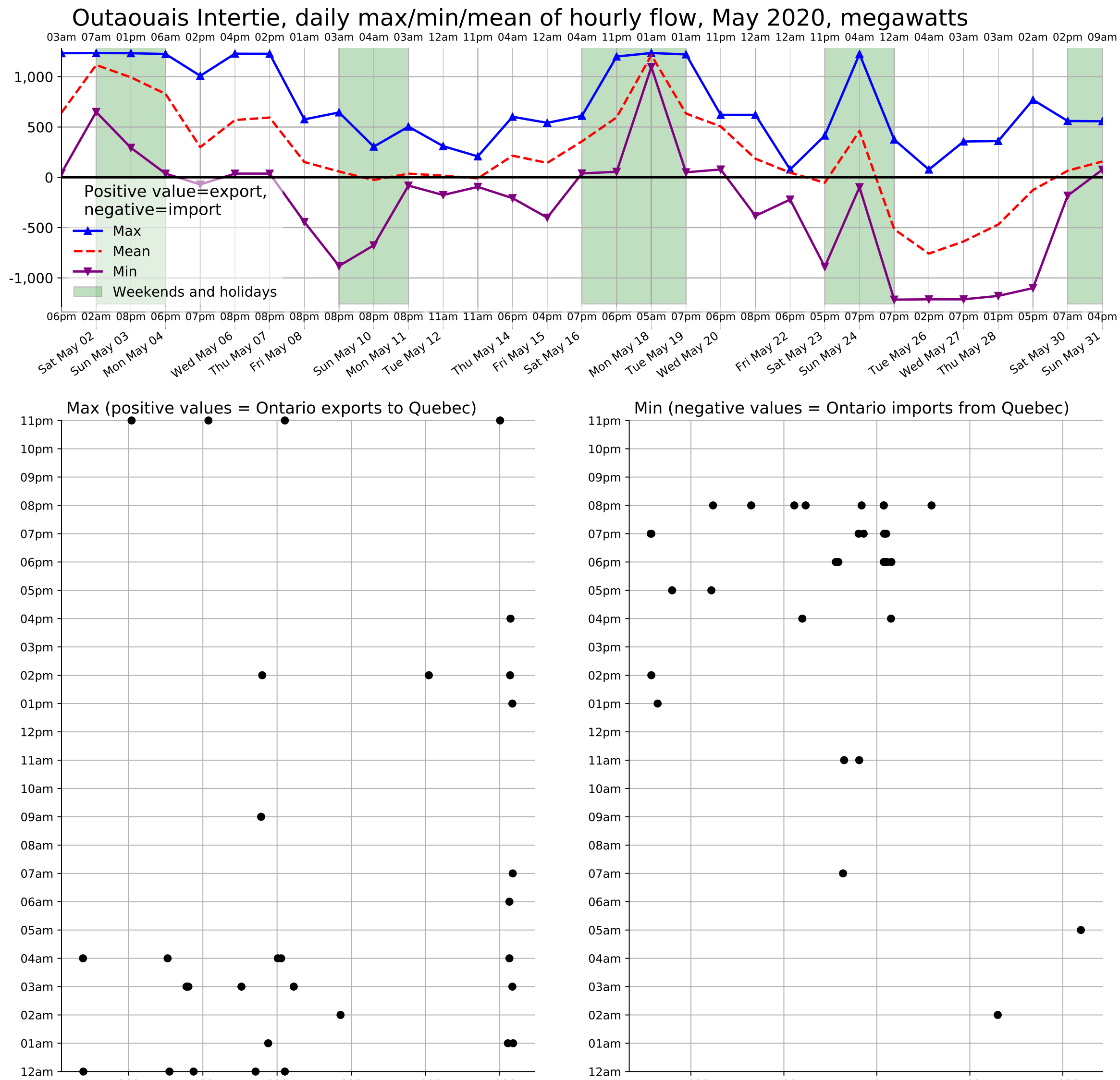

Fig. 2.5: Outaouais intertie flow, May 2020.

2.2.6 June 2020

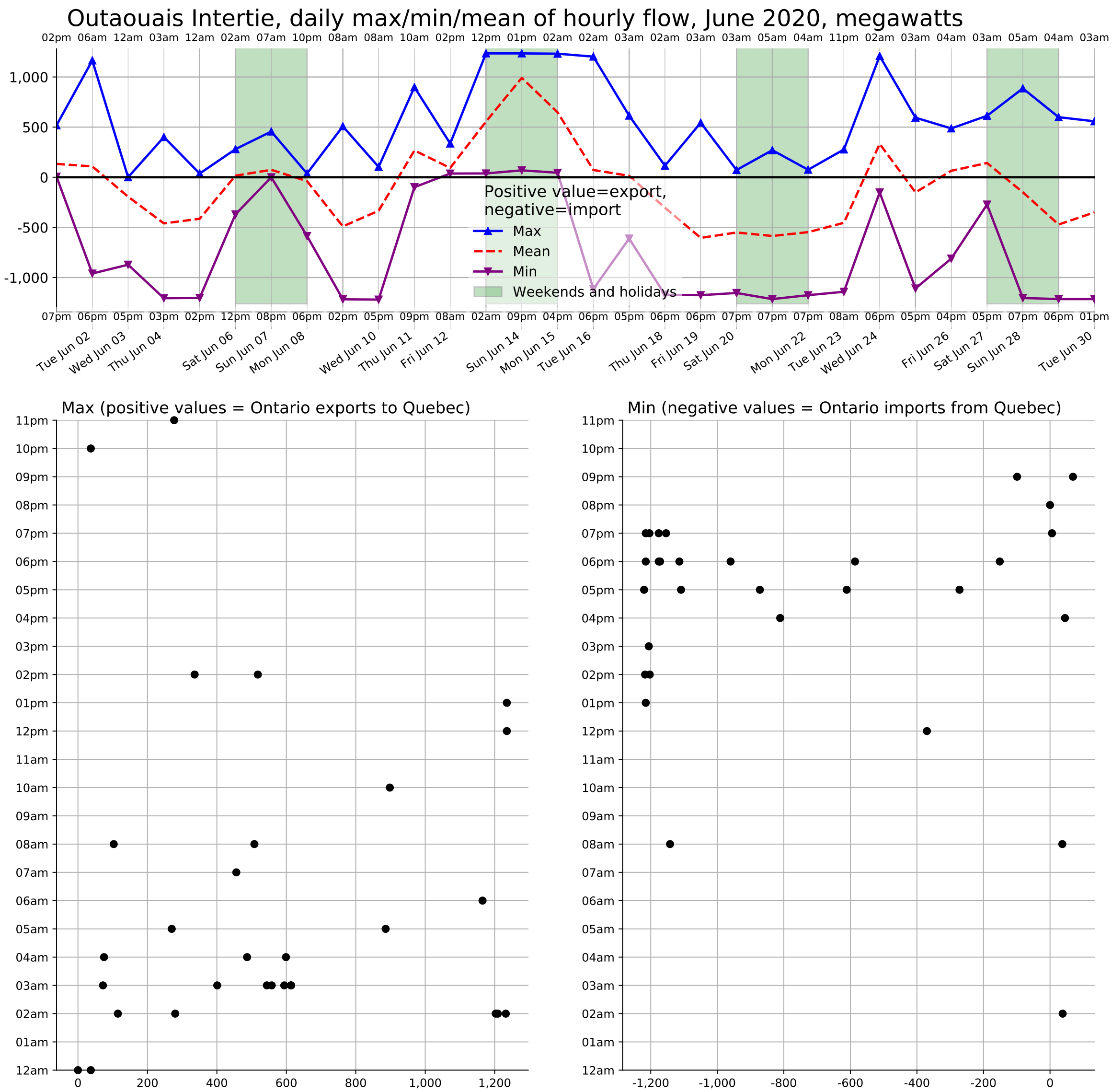

Fig. 2.6: Outaouais intertie flow, June 2020.

2.2.7 July 2020

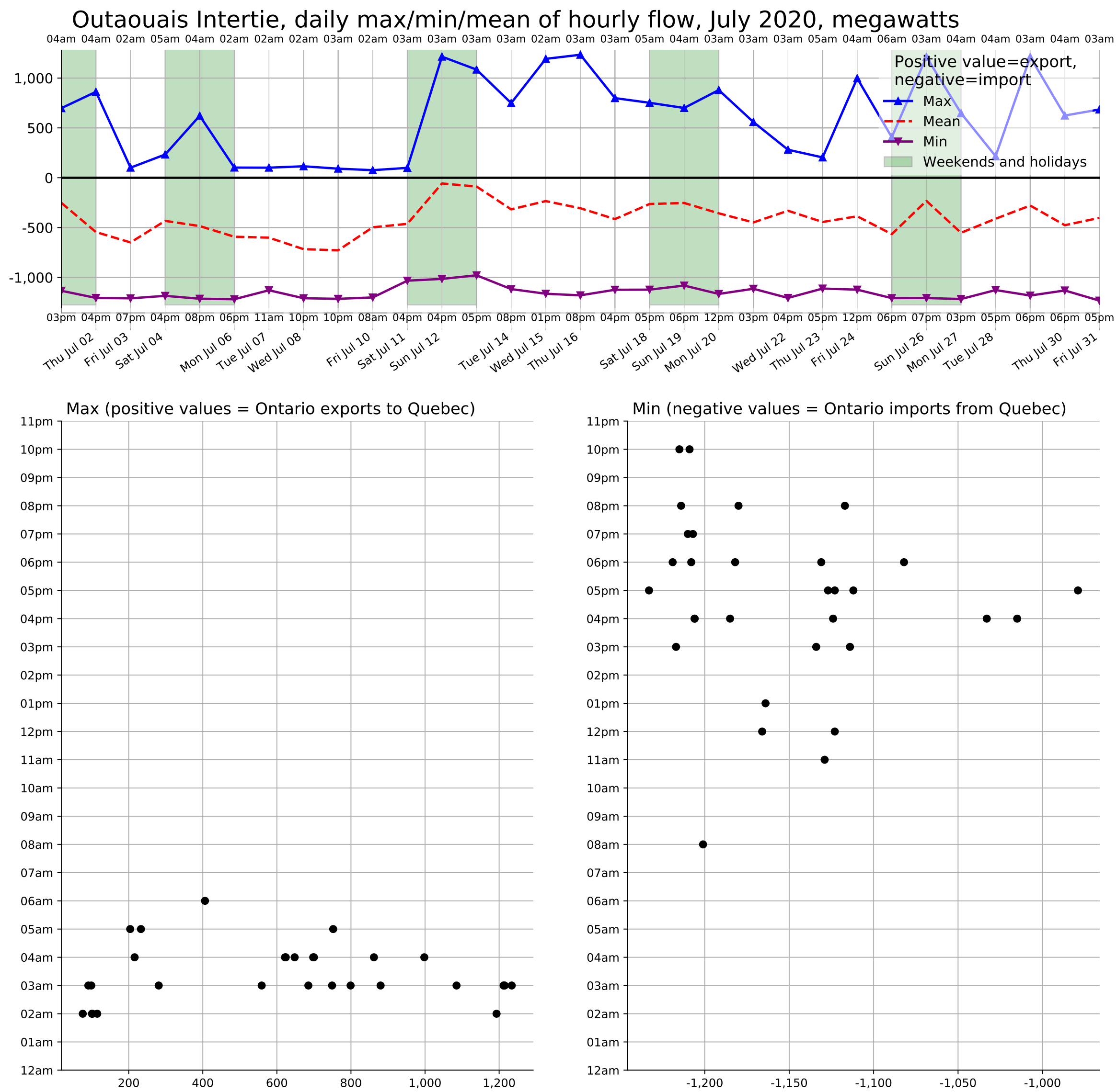

Fig. 2.7: Outaouais intertie flow, July 2020.

2.2.8 August 2020

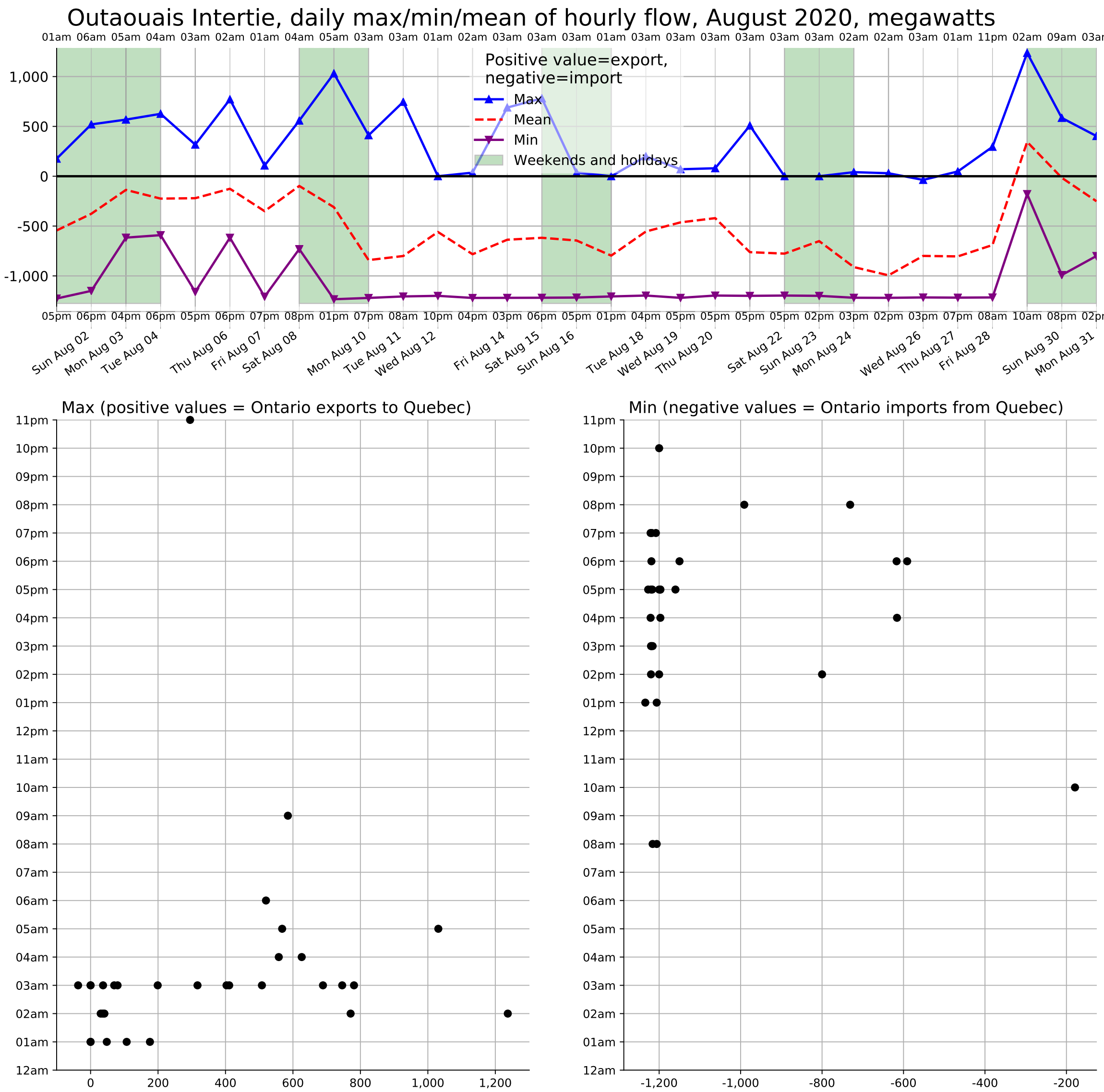

Fig. 2.8: Outaouais intertie flow, August 2020.

2.2.9 September 2020

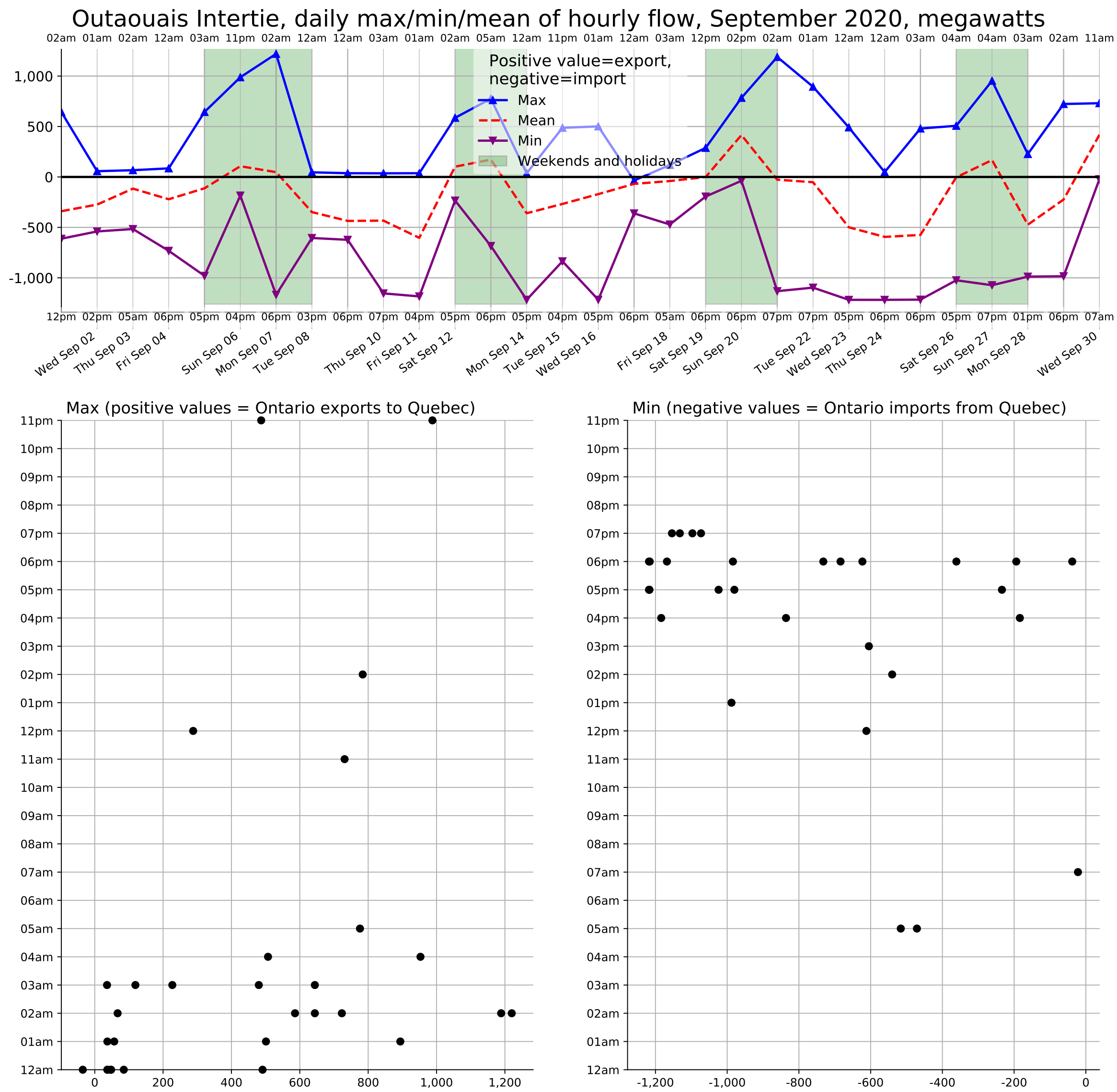

Fig. 2.9: Outaouais intertie flow, September 2020.

2.2.10 October 2020

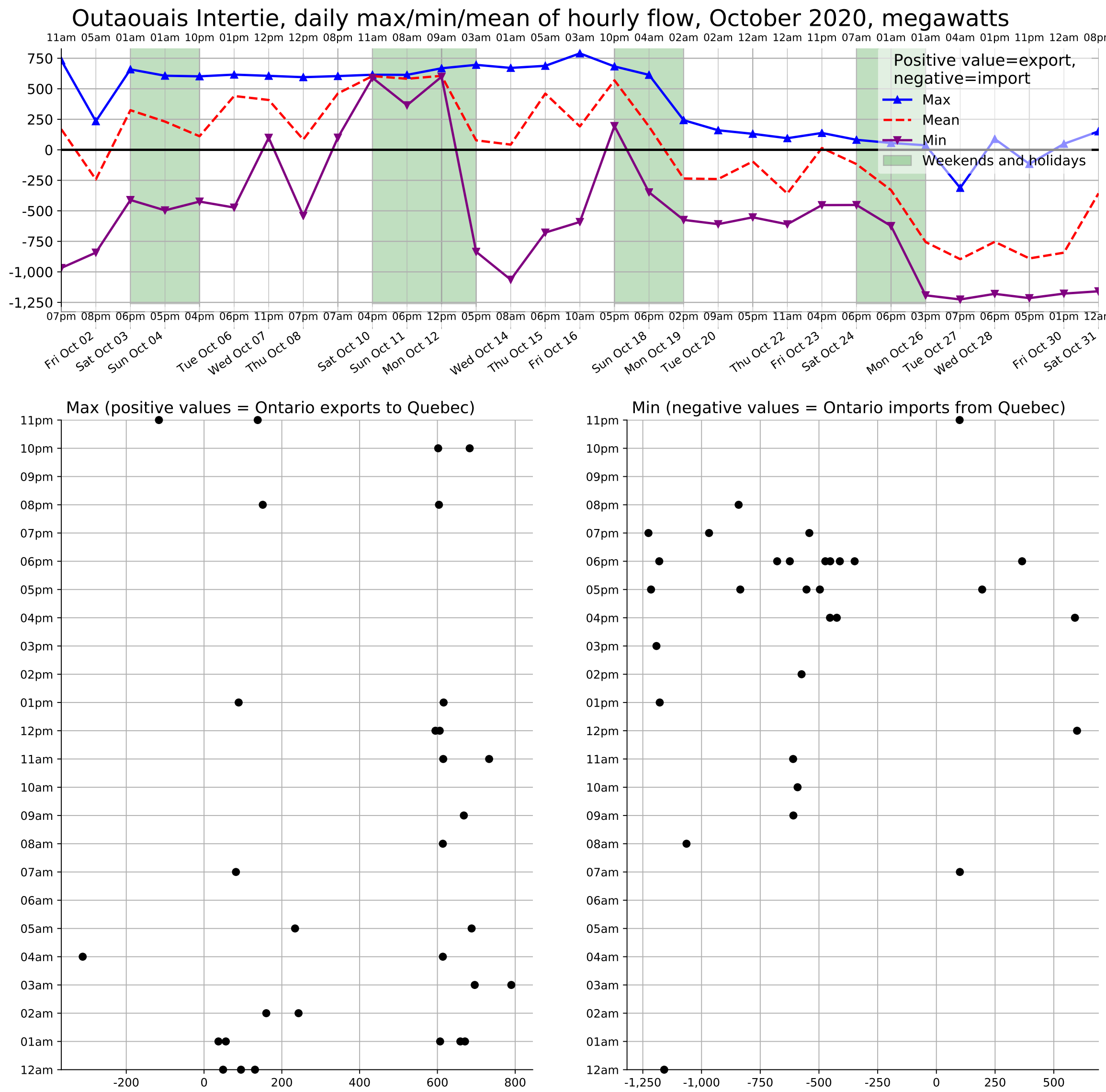

Fig. 2.10: Outaouais intertie flow, October 2020.

2.2.11 November 2020

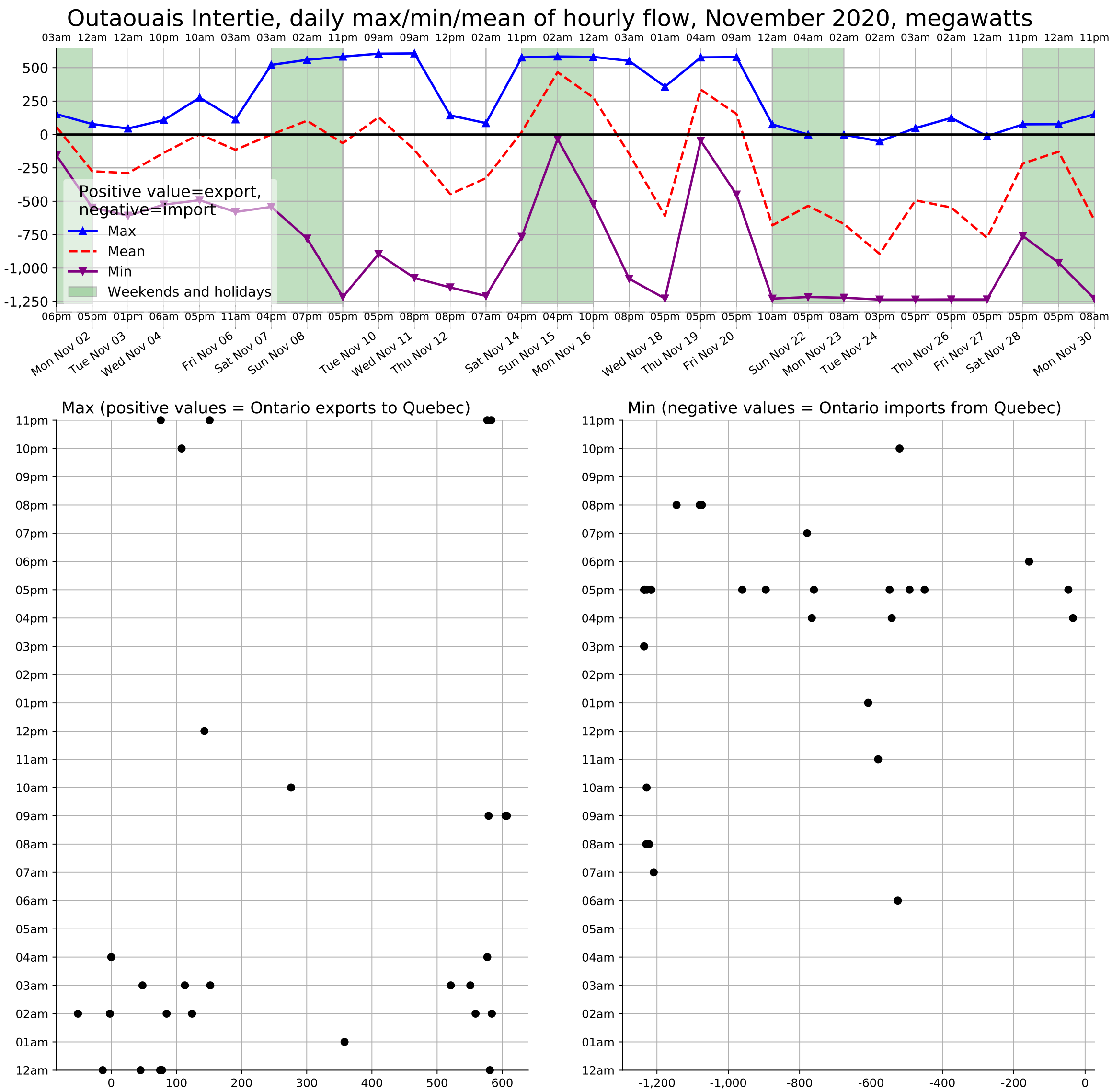

Fig. 2.11: Outaouais intertie flow, November 2020.

2.2.12 December 2020

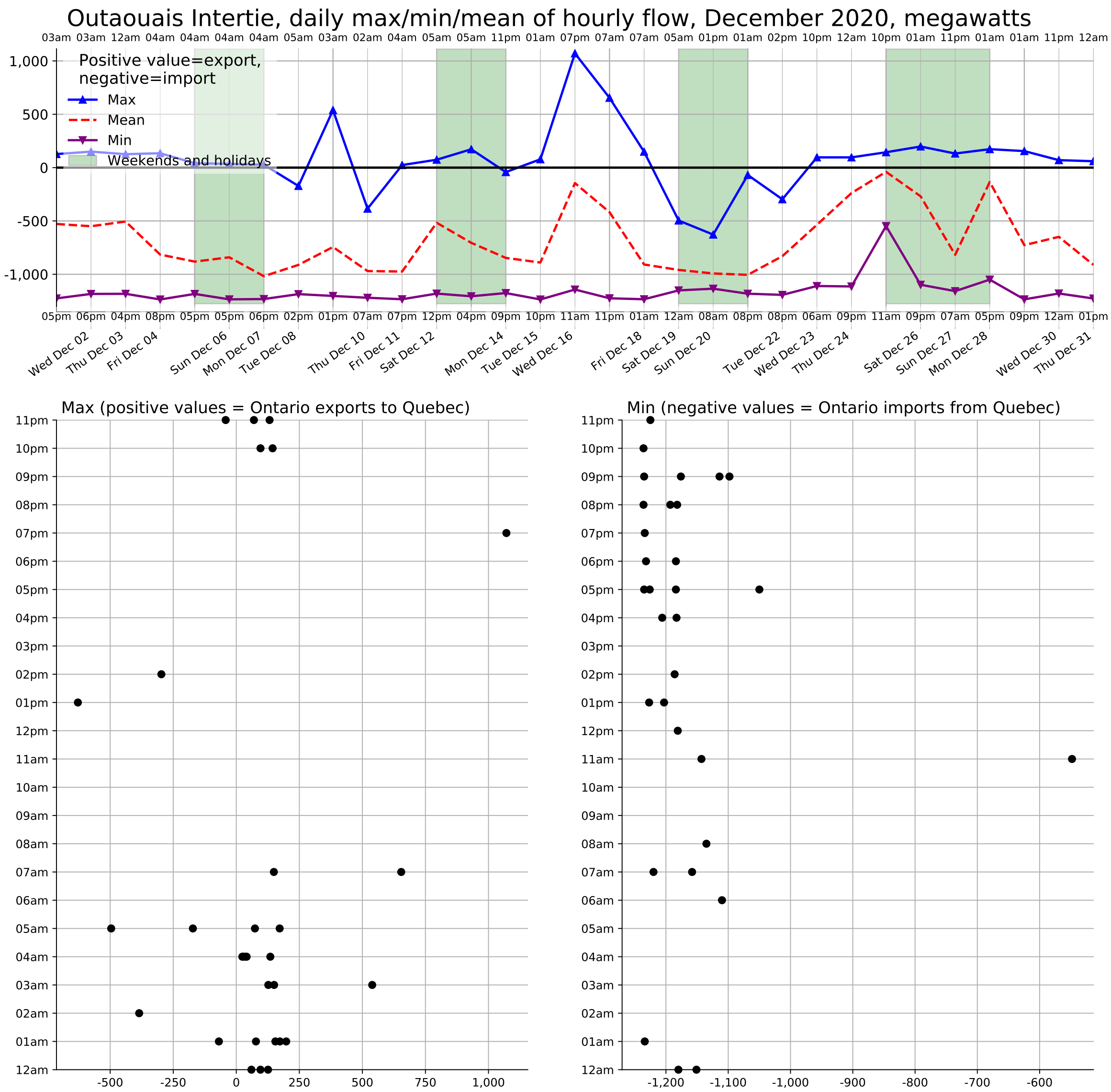

Fig. 2.12: Outaouais intertie flow, December 2020.

PART 3

Conclusion

ELECTRICITY GENERATION–RELATED GREENHOUSE GAS AND AIR POLLUTION will increase in Ontario significantly if and when the Pickering Nuclear Generating Station goes out of service beginning 2025. This is because PNGS's 2,000–3,000 megawatts of round-the-clock electrical power will be replaced with natural gas–fired power.

Claims that PNGS's output could be replaced with a combination of hydropower from Quebec and intermittent renewable sources like wind and solar lack credibility, for the following reasons.

- Quebec currently possesses neither the generation nor transmission capacity to maintain a round-the-clock flow of at least 2,000 MW to Ontario, and Ontario lacks the transmission capacity to bring power of that magnitude from the Quebec border to to load centres in this province.
- Most Quebeckers heat their homes with electricity, and if Quebec were to divert Pickering-scale power to Ontario year round, Quebeckers would lack clean heat in the cold months. Many would be forced to use natural gas or propane.
- Quebec is embarking upon an ambitious program to electrify personal and commercial transportation. This new demand category will account for any major new supply Quebec introduces into its system.
- Highly variable wind and solar output means these sources are physically unable to replace Pickering's steady 24/7 bulk output. They require synchronous generation. Without Pickering, that would be gas.

If Pickering goes out of service without a nuclear replacement of equivalent size, then gas-fired output will replace it. Each year, Ontario would emit a further 10 million tons of CO_2 on top of what it emits now. These additional 10 million tons would incur a carbon tax liability of over half a billion dollars per year, assuming a tax of $50 per ton. That money would be paid into federal coffers.