

Economic comparison of net-metered solar PV operating within the domestic flat rate and time-of-day (TOD) rate electricity tariff offered by NS Power

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Overview

Introduction

- Net-metering allows homeowners to connect solar photovoltaic (PV) systems to the NS Power electricity grid and bi-directionally flow electrical power. During periods of exports the electricity is valued at the prevailing tariff category with no discount.
- Two domestic tariffs are approved
 - **Domestic service** with one fixed value per kWh regardless of season, day of week, or time of day
 - **Domestic service time-of-day (TOD)** with periods of different values per kWh depending upon the season, day of week, holidays, and time of day. The TOD tariff is only applicable to residences employing thermal energy storage, but this does not inhibit them from also installing a solar PV system. Peak and off-peak pricing are meant to encourage consumers to change their electricity usage patterns during times of high/low total electricity grid load.

Objective, hypothesis, and assumptions

- Objective: using multiple years of measured high-resolution power production data from many widely varied residential solar systems, apply the two residential tariffs to determine the economic value to the homeowner
- Hypothesis: the TOD rate is low for the entirety of all weekends, representing $2/7^{\text{ths}}$ of the generating opportunity (29%) and this negative economic performance will outweigh the benefit of high pricing periods during winter season workdays.
- Assumptions
 - Apply the tariffs excluding taxes and connection charges
 - Assume statutory holidays are normal weekdays (benefitting TOD)
 - Assume energy efficiency losses due to export and import are negligible

Method

- Acquire timestep solar PV production data from residences
- Apply prevailing tariff to each timestep of data, one for flat rate and one for TOD rate
- Analyze the economic performance differences between flat rate and TOD rate
 - As a function of timestep in various seasons and day types
 - Monthly performance and annual performance
 - Present average values and the range of values across all residences
- Analyze potential future variants of the TOD tariff
 - Varying tariff on weekend days (seasonally specific)
 - Varying winter workday tariff applied to every day of the year

Data and tariffs

Residential PV power data

- Residential solar PV power data was obtained from the HRM Solar City 2 project¹ via the NSCC Community Solar Data project^{2,3}.
- 2 years of 5-minute timestep power data³ (starting 10 Jul 2018) from the 21 homes that had the complete timeseries was used to analyze the financial impact of electricity rate structures.

1: <https://www.halifax.ca/home-property/solar-projects/about-solar-city-halifax>

2: https://www.nsc.ca/about_nsc/applied_research/areas-of-research/energy-research/project-energy-data-portal.asp

3: <https://data.solardatans.ca/communitysolar/signUp.php>

Analysis done using two tariffs for 2021 (forthcoming year)

Flat-rate: 16.008

ENERGY CHARGE

	Cents per kilowatt hour
Effective January 1, 2020	17.709
Effective January 1, 2021	16.008
Effective January 1, 2022	16.215

Mid only



Note:

- 2021 rates were used since there is a one-year increase in 2020
- Prices shown do not include Fuel Adjustment Mechanism (-1.904 cents per kilowatt hour in 2020, 0 cents in 2021 and 2022)

TOD tariff

ENERGY CHARGES

	December, January and February			
	7:00 am to 12:00 pm	12:00 pm to 4:00 pm	4:00 pm to 11:00 pm	11:00 pm to 7:00 am
	Cents per kilowatt hour			
Effective January 1, 2020	22.067	17.709	22.067	10.782
Effective January 1, 2021	20.366	16.008	20.366	9.081
Effective January 1, 2022	20.573	16.215	20.573	9.288

High



High



Low



The above rates apply weekdays (Monday through Friday inclusive), excluding statutory holidays. For Saturdays, Sundays and statutory holidays, all consumption will be billed at the rate for 11:00 pm to 7:00 am.

Mid



Low



	March to November	
	7:00 am to 11:00 pm	11:00 pm to 7:00 am
	Cents per kilowatt hour	
Effective January 1, 2020	17.709	10.782
Effective January 1, 2021	16.008	9.081
Effective January 1, 2022	16.215	9.288



The above rates apply weekdays (Monday through Friday inclusive), excluding statutory holidays. For Saturdays, Sundays and statutory holidays, all consumption will be billed at the rate for 11:00 pm to 7:00 am.

Results

Single home sample

- To observe where flat and TOD tariffs impact generation value, three days of the year were analyzed for one home
 - Winter workday (low, mid, and high rate)
 - Summer workday (low and mid rate)
 - Weekend day (low rate)
- A plot of the results is shown on the following slide and includes
 - PV timestep power (in kW)
 - Accumulated daily economic value using the flat tariff (\$)
 - Accumulated value using the TOD tariff (\$)
 - The TOD tariff value throughout the day (¢/kWh)
- All days are prototypical clear sunny days but vary due to seasonal solar resource availability

Winter (17 Jan 2019)

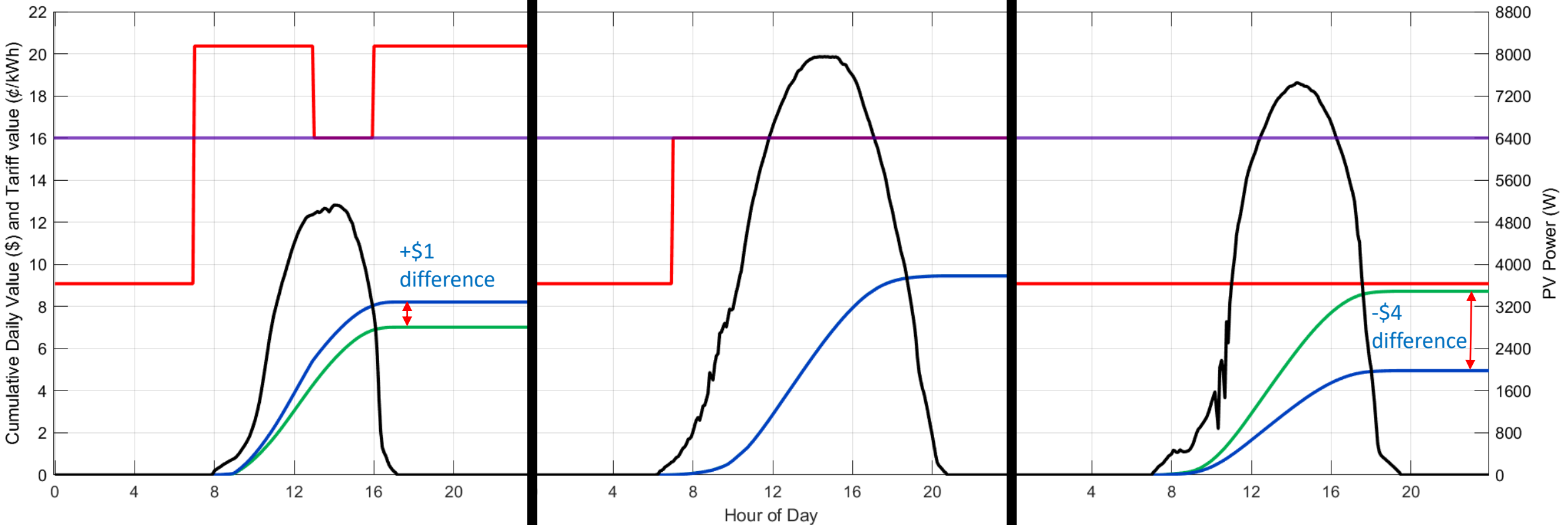
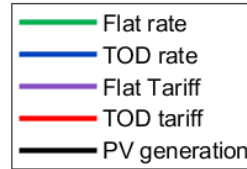
Increased TOD value from power occurring during mid and high price periods

Summer (31 Jul 2019)

No discernable difference in economic value (blue line hides the green line)

Weekend (15 Sep 2018)

Low TOD pricing all day leads to substantially reduced value

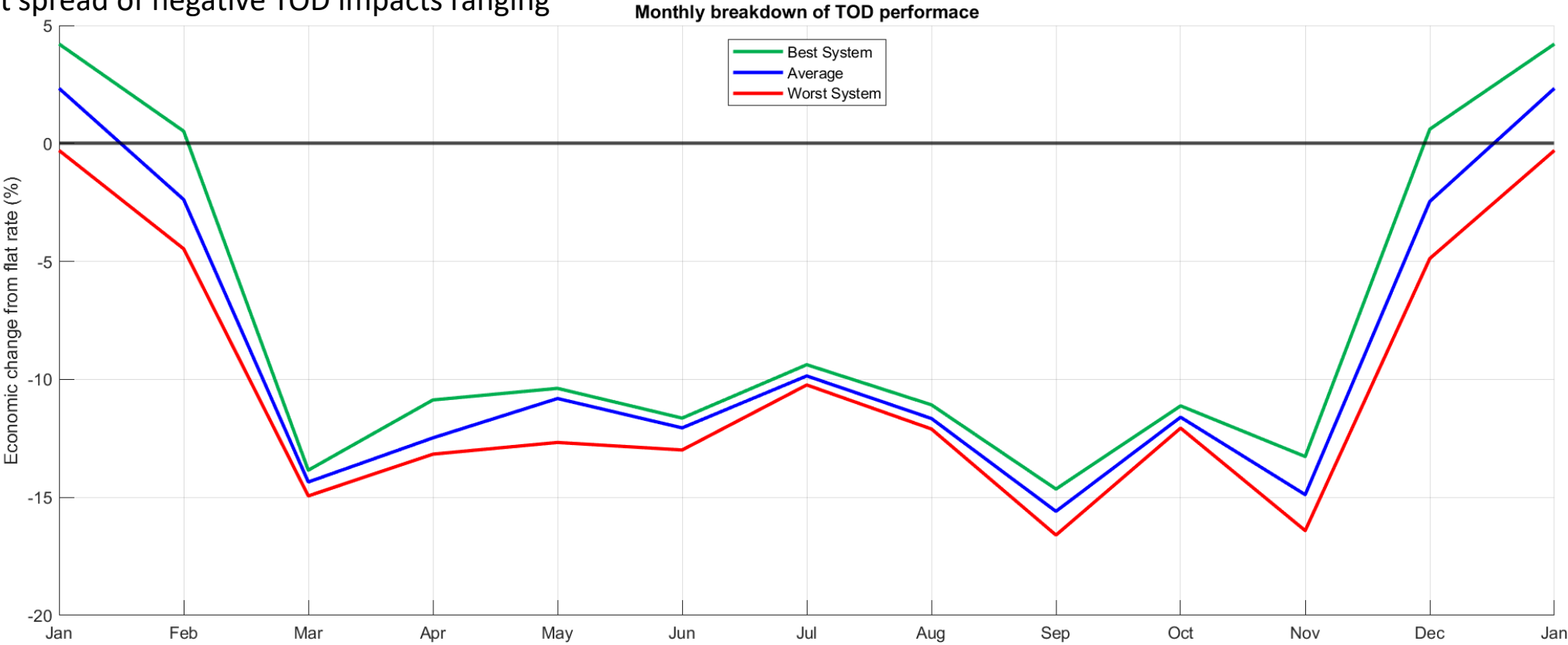


Comparison of tariff structures

- Values are presented as % change from domestic service flat rate on a monthly and annual basis
- Values are also presented as a function of average monthly value in \$
- Monthly analysis identified the best and worst systems for each month, but they are not always the same
 - i.e. the poorest monthly result is plotted, not the worst performing system throughout the year

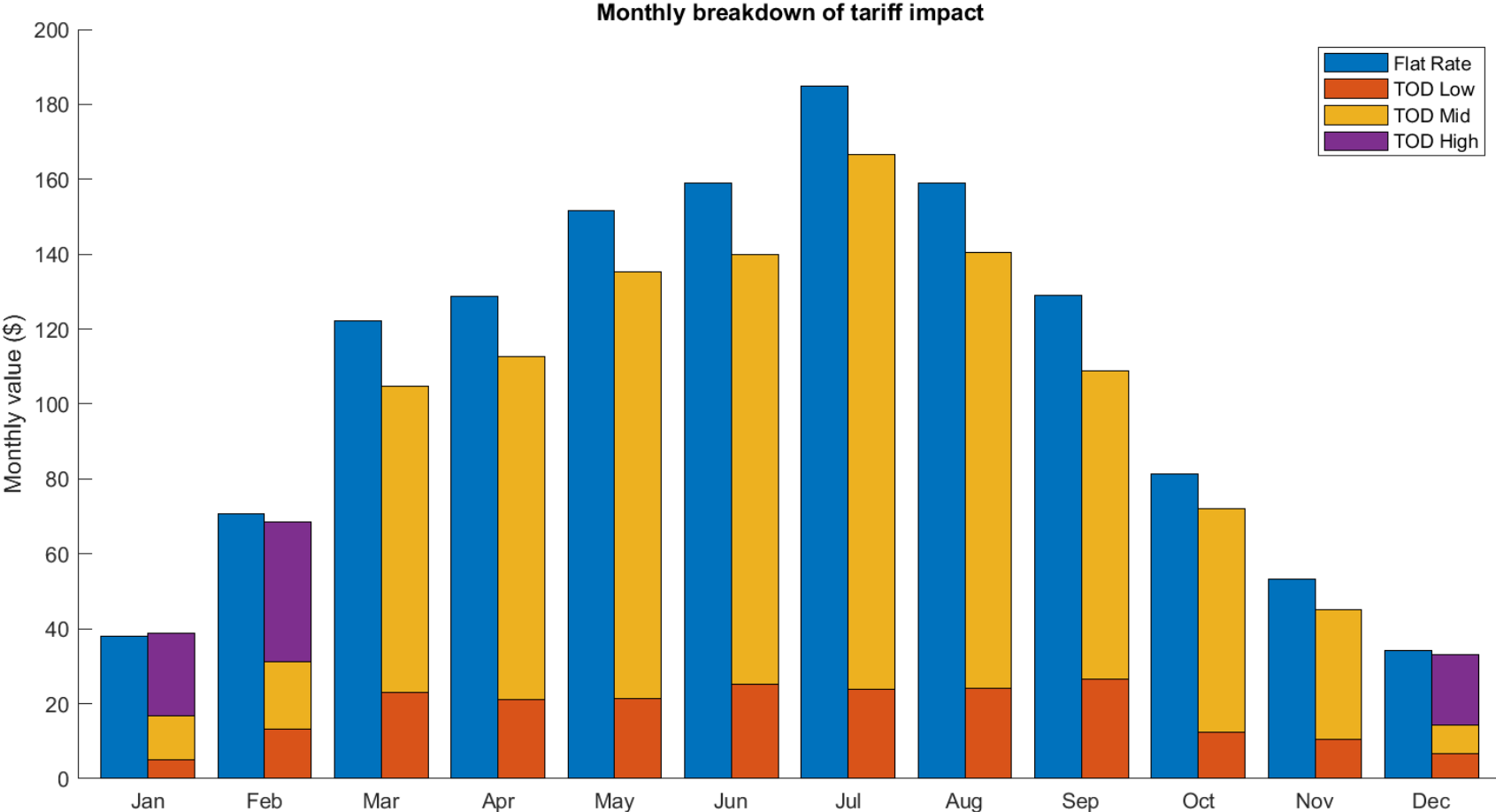
Monthly system performance

- Monthly economic value change is increased by TOD only during Dec-Feb, and for the average system only during Jan
- Winter is low energy production, so gross economic value is heavily weighted to summer months
- Mar-Nov have a tight spread of negative TOD impacts ranging from -10 to -15%.



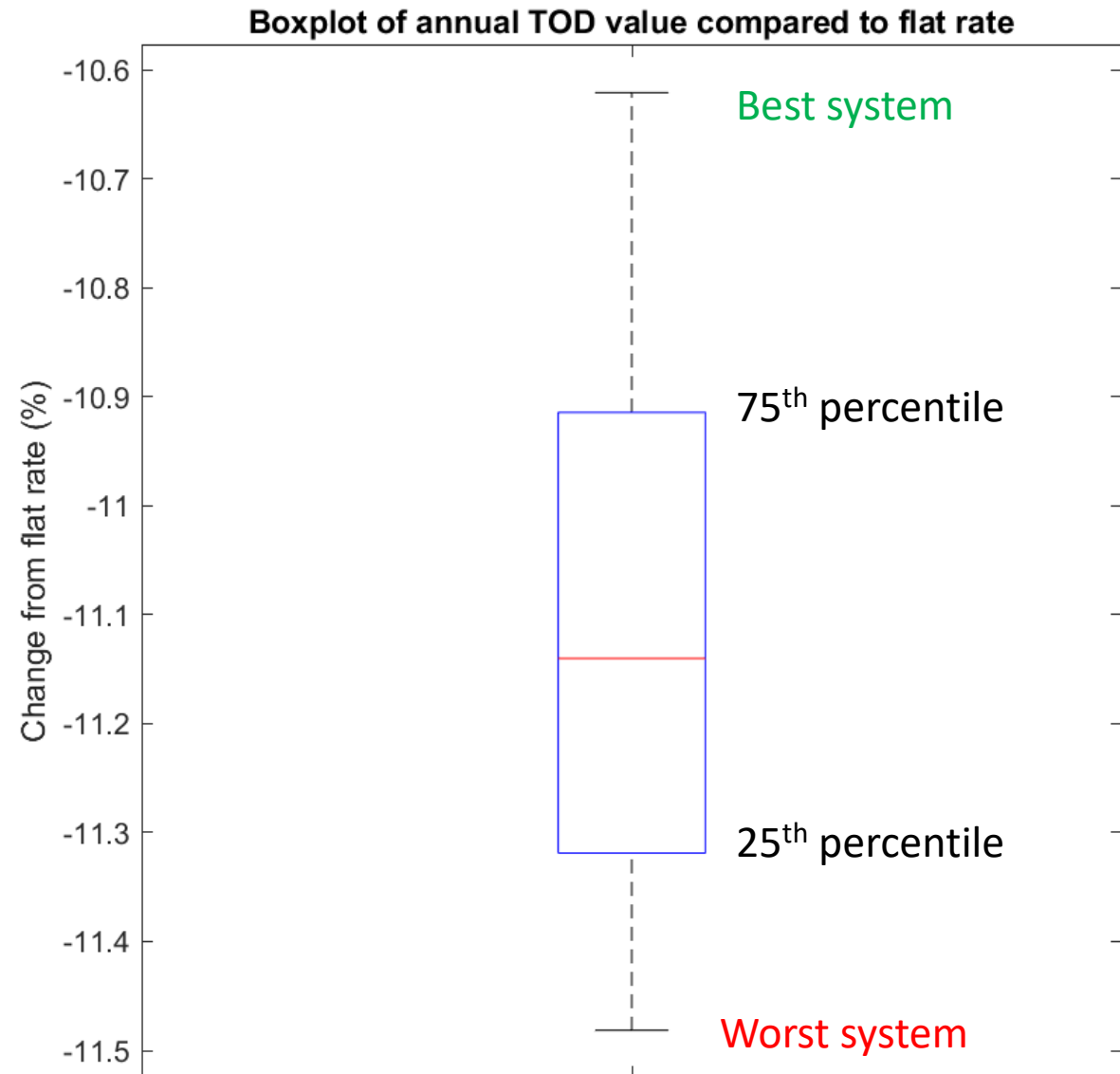
Impact of price periods in terms of total economic value in \$

- Monthly economic value of the average PV system for each month is broken into pricing groups for
 - Flat rate
 - TOD rate
- TOD high rate makes up the majority of value from Dec-Feb
- TOD mid rate makes up the majority of value from Mar-Nov
- Note that from Mar to Nov no TOD high periods occur



Annual performance

- Results present the distribution of annual performance in terms of economic percentage change of TOD from flat rate.
- Percentiles and range bars are shown to indicate the spread between residences
- Very tight distribution
 - Range of -11.5% to -10.6%
- Annually, on average, TOD tariff reduces solar economic value by 11.1%



Potential future variants of the TOD tariff

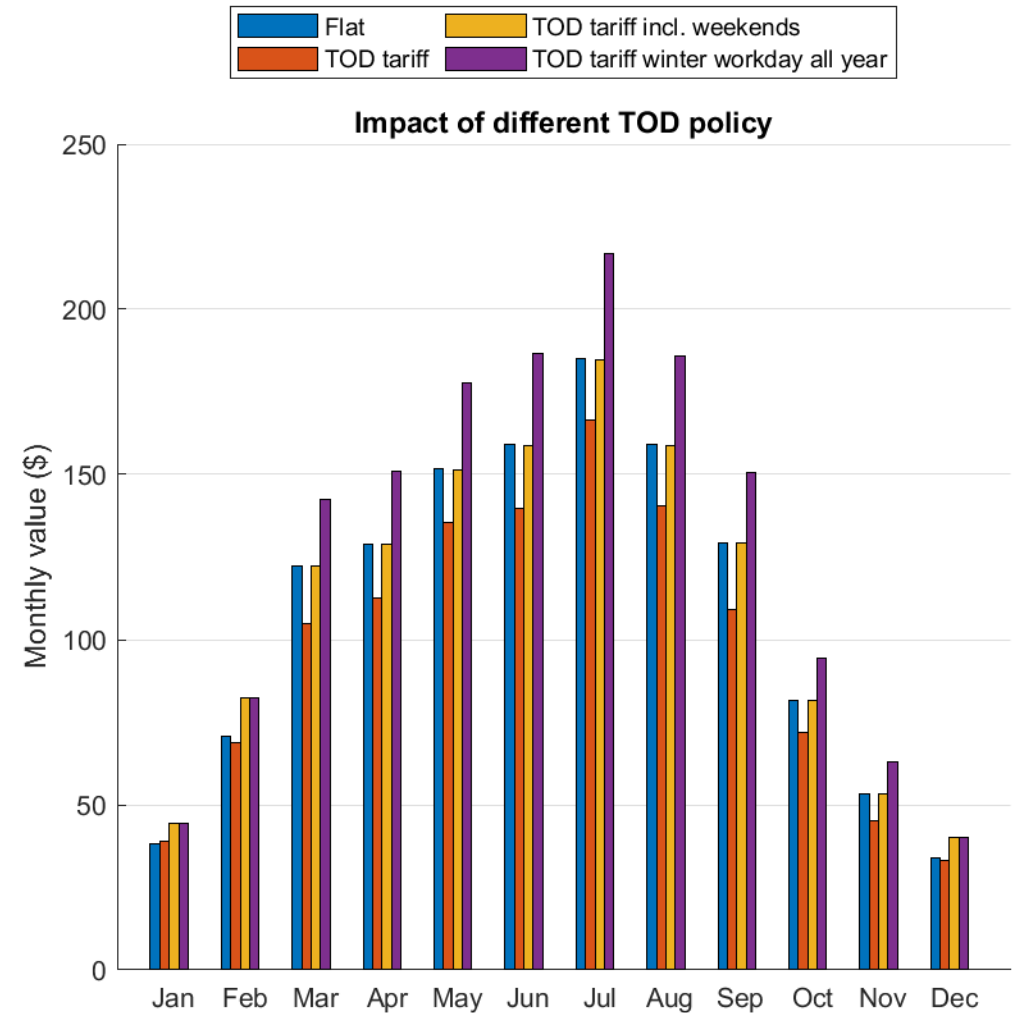
Examining potential variants of the TOD tariff

- The TOD tariff reduces economic of solar PV systems in NS due to two reasons
 - Weekends represent 2/7^{ths} of the time and are at low rate
 - Non-winter season does not have high rate
- We examine two potential variants
 - **TOD tariff including weekends.** This applies the seasonal time period varying tariff to weekend days (Saturday and Sunday). An examination of NS Power load data shows that similar load peaks and valleys occur on weekend days. So a time period varying tariff on weekend days is a reasonable future scenario.
 - **TOD tariff winter workday all year.** This applies the winter workday tariff with low, med, and high periods to all 365 days of the year. An examination of NS Power load data shows similar daily load shape throughout all months, even though total and peak loads are changing. With smart metering there is a potential that a future tariff would respond to load shape regardless of season/day. However, this is likely a generous tariff proposition to homeowners with solar PV.

Impact of potential future variants TOD

Shown as average house performance

Scenario	Annual Impact (%)
TOD tariff	-11.1
TOD tariff including weekends	+1.8
TOD tariff winter workday all year	+17.0



Conclusion

Summary

- 2 years of solar PV power data from 21 residential systems was used to assess system economic value under flat-rate and time-of-day (TOD) rate structures offered by NS Power
- Current TOD rate structures in Nova Scotia have a considerable negative annual impact of approximately -11.1% on the economic value of residential PV systems. Diversity among systems (orientation, size) has an insignificant impact on this value.
- The negative impact of TOD rates is caused by weekends (low rate) and non-winter months (low and mid rates).
- Introducing time varying rates to weekends would overcome this difference and make the economic benefits of solar PV similar for houses on flat rate and TOD rate. This would achieve the objectives of the TOD tariff program (encouraging electricity use in low load periods and PV generation in high load periods) while not disadvantaging solar PV installations.
- Introducing a time varying tariff with low, med, and high pricing periods of each day of the year would economically advantage solar PV systems on the TOD tariff compared with the flat rate tariff by approximately +17% per year