Nodal Pricing in Ontario – Implications for Solar PV

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1. Purpose of Study

To determine if the value of photovoltaic (PV) electricity, a form of distributed generation, would be higher under a nodal pricing scheme than under the current uniform pricing regime in Ontario.

2. A Case for Distributed Generation

The Independent Electricity System Operator (IESO) of Ontario identifies distributed generation as a way to help improve transmission and distribution reliability by reducing losses and congestion on the power lines. In addition to the market price of the commodity itself, the value of distributed energy production can be attributed in non-traditional ways including the avoidance of distribution and transmission costs; reduction of generation capacity capital costs as well as operation and maintenance costs; reduction in generation fuel costs; avoidance of emissions; and an increase in system reliability (Alderfer et. al., 2000; CanSIA, 2005; Duke et. al., 2005).

3. The Ontario Context

Congestion in southern Ontario, and associated transmission issues, are major electricity challenges facing the province. In 2006, the Ontario Power Authority (OPA) identified the Greater Toronto Area, Kitchener-Waterloo-Cambridge-Guelph, Windsor/Essex, and northern York Region as some of the large load centres that currently or will soon have transmission-related reliability and supply adequacy issues.

Electricity markets in Ontario operate under a uniform pricing system that is reflected in the Hourly Ontario Energy Price (HOEP) - a single price for energy across the province that does not account for locational constraints. Operating under such a system, the electricity market does not generally serve to recognize the additional benefits of distributed generation and thus, neither does it encourage increased use of solar PV. Solar PV does receive support from the provincial government's Renewable Energy Standard Offer Program (RESOP) which guarantees $0.42/kWh for grid-connected PV systems up to a maximum size of 10 megawatts (MW).

Transmission congestion tends to be heaviest during the summer when peak electricity demand and solar radiation values in Ontario are found to closely coincide as shown in Figure 1.

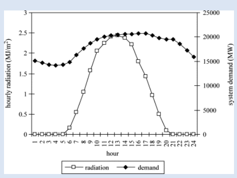


Figure 1 Average hourly solar radiation and system demand, Ontario, July (Rowlands, 2004)

4. Nodal Pricing: Experiences and Assessment

A nodal pricing system considers the cost of providing the next MW of load at a given location (a node) taking three components into consideration: the marginal cost of generation, the marginal cost of losses and the marginal cost of transmission congestion (IMO, 2003). Nodal pricing is becoming the benchmark of electricity pricing in many markets. For example, California, partner to Ontario in a recently announced collaboration to increase energy efficiency and combat global warming, is currently moving to a nodal pricing approach for implementation in late 2007.

In 2006, the IESO studied what locational prices might look like in Ontario using historical shadow prices. The primary reasons for conducting the study were stakeholder interest, increasing complexity of the congestion management settlement credit (CMSC) process, and consideration for use during design of the day-ahead market structure (IESO, 2006). Despite this work, the nodal pricing approach does not appear to be on the province's agenda for near future market conditions in Ontario.

4. Data Collection and Preparation

For 2005 and 2006, hourly global solar radiation data were obtained from two weather stations in Ontario (Mississauga and Kingston). These data were quality-controlled as required for input into HOMER, a PV simulation program developed by the United States National Renewable Energy Laboratory (NREL). Simulated PV-electricity output was generated for each location based on a three kilowatt (kW) grid-connected solar PV system with panels at a tilt angle of 30 degrees and an azimuth of 0 (due south).

Hourly nodal prices were obtained from the IESO for locations with complete 2005 and 2006 data that were closest to the weather stations - these were nodal prices at the Darlington Nuclear Plant located 97 kilometres east of Mississauga, and nodal prices at the Lennox Generating Station located 26 km west of Kingston in Bath, Ontario. It is a limitation of this study that the location of PV-electricity data and the nodal prices do not line up precisely; however, these approximations were as close as possible given available resources at the time of study.

Figure 2 Locations of global solar radiation data collection

5. Results

The total monthly value of PV-electricity generated in each location was calculated under two different pricing schemes. In both Mississauga (Figure 3) and Kingston (Figure 4), the total monthly value of PV-electricity based on nodal prices was consistently higher than the value based on HOEP, with the most considerable spread occurring in the summer months.

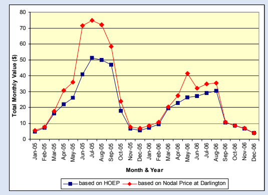


Figure 3 Total Monthly Value of PV-electricity, Mississauga, Ontario, 2005 - 2006

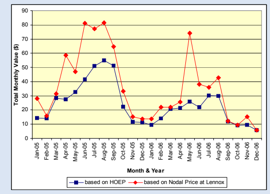


Figure 4 Total Monthly Value of PV-electricity, Kingston, Ontario, 2005 - 2006

Given that PV-electricity is considered to be most valuable in the summer months - when demand, congestion and solar radiation are highest - a visual representation of the relationship among average hourly PV-electricity, nodal prices and HOEP for this time period (May to August inclusive) in 2005 and 2006 is presented in Figures 5 and 6. Peak PV-electricity values coincide closely with peak nodal prices during the midday hours from approximately 10:00 to 15:00 (EST).

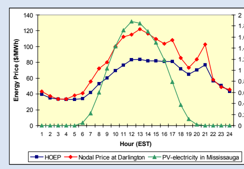


Figure 5 Average hourly PV output, HOEP and nodal prices, Mississauga, May - August

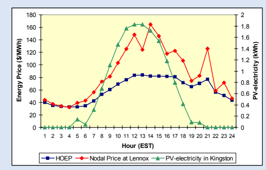


Figure 6 Average hourly PV output, HOEP and nodal prices, Kingston, May - August

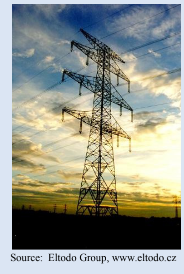
6. Discussion

In 2005 and 2006, there was found to be consistently higher value under a nodal pricing system for PV-electricity produced in areas of high congestion. This answers the research question and reveals that PV-electricity is undervalued by the current uniform pricing system. PV-electricity is advantageous in helping to alleviate congestion most importantly because it can be generated in close proximity to loads, thus avoiding line losses and transmission costs. PV-electricity is also ideal due to the fact that its times of high production correspond with times of high demand and congestion. These conditions occur generally in the midday hours during the summertime.

By utilizing a nodal pricing system, PV-electricity generated in congested areas would be assigned a more accurate market value for the additional benefits it provides. This identification of additional value supports the case for all forms of distributed generation as well as the higher price given for solar PV projects under the RESOP. It could even be suggested that PV-electricity produced in areas of high congestion should receive some additional credit on top of that given by the RESOP.

7. Conclusions and Future Research

Distributed generation sources, such as solar energy, hold more value in areas of high congestion when based on a pricing scheme that takes into account where the energy is produced (versus a uniform pricing system such as HOEP). Nodal pricing is an example of such a system and is increasingly being used in electricity markets throughout the world. Placement of PV systems should be encouraged in areas of high congestion in southern Ontario. This would allow solar PV to become a valuable part of the solution for maintaining system reliability, alleviating transmission and distribution costs and offsetting future capital costs of expanding transmission infrastructure in the province.



Source: Eltodo Group, www.eltodo.cz

Further studies could be improved by using nodal prices and PV panel production that are more closely located to one another, if such data become available; as well as by increasing the accuracy of the PV simulation modelling through the use of the direct and diffuse components of global solar radiation, which is again dependent on the accessibility of such data. Statistical investigation would also be useful to further explore the trends that have been identified in this preliminary visual exploration of the relationship between nodal prices and PV-electricity.

8. Literature Cited

Alderfer, R. Brent, M., Eldridge, M., and Starrs T. (2000). Making Connections: Case Studies of Interconnection Barriers and their Impact on Distributed Power Projects. Retrieved December 4, 2006 from www.eren.doe.gov/distributedpower/barriersreport/

Canadian Solar Industries Associations (CanSIA). (2005). Valuing Grid-Connected Solar Electricity: Priming the Market in Ontario. Retrieved September 20, 2006 from http://www.cansia.ca/downloads/report2005/C17.pdf

Dietrich, K., Hennemeier, U., Hetzel, S., Jeske, T., Leuthold, F., Rumiantseva, I., Rummel, H., Sommer, S., Sternberg, C., and Vith, C. (2005). Nodal Pricing in the German Electricity Sector – A Welfare Economics Analysis. Retrieved December 18, 2006 from http://www.tu-dresden.de/wwbwleeg/publications/wp_ge_08_dietrich_hennemeier_hetzel_et%20al_nodal_pricing_germany.pdf

IESO. (2006). Stakeholder Engagement Plan SE-25, Locational Pricing. Retrieved May 22, 2007 from http://www.ieso.ca/imoweb/pubs/consult/se25/SE25-stakeholder-plan.pdf

IMO Market Operations Standing Committee. (2003). Proposed Scope for Analysis of Historical Nodal Prices. Retrieved December 4, 2006 from http://www.ieso.ca/imoweb/pubs/consult/mktops/mo_pres_histnodalprices_2003dec03.ppt

Ontario Power Authority (OPA). (2006). Ontario's Integrated Power System Plan, Discussion Paper 5: Transmission. Retrieved January 3, 2007 from http://www.powerauthority.on.ca/ipsp/Storage/32/2716_DP5_Transmission.pdf

Rowlands, I. (2004). Solar PV electricity and market characteristics: two Canadian case-studies, *Renewable Energy, 30*, 815-834.

Acknowledgements

This study was completed with support from the Solar Buildings Research Network under the Strategic Network Grants Program of the Natural Sciences and Engineering Research Council of Canada. Thank you to Anton Driesse of Queen's University and Ken Turner of the University of Toronto at Mississauga for their help with solar radiation data collection, and to Didier Thevenard for his advice on PV simulation technology.