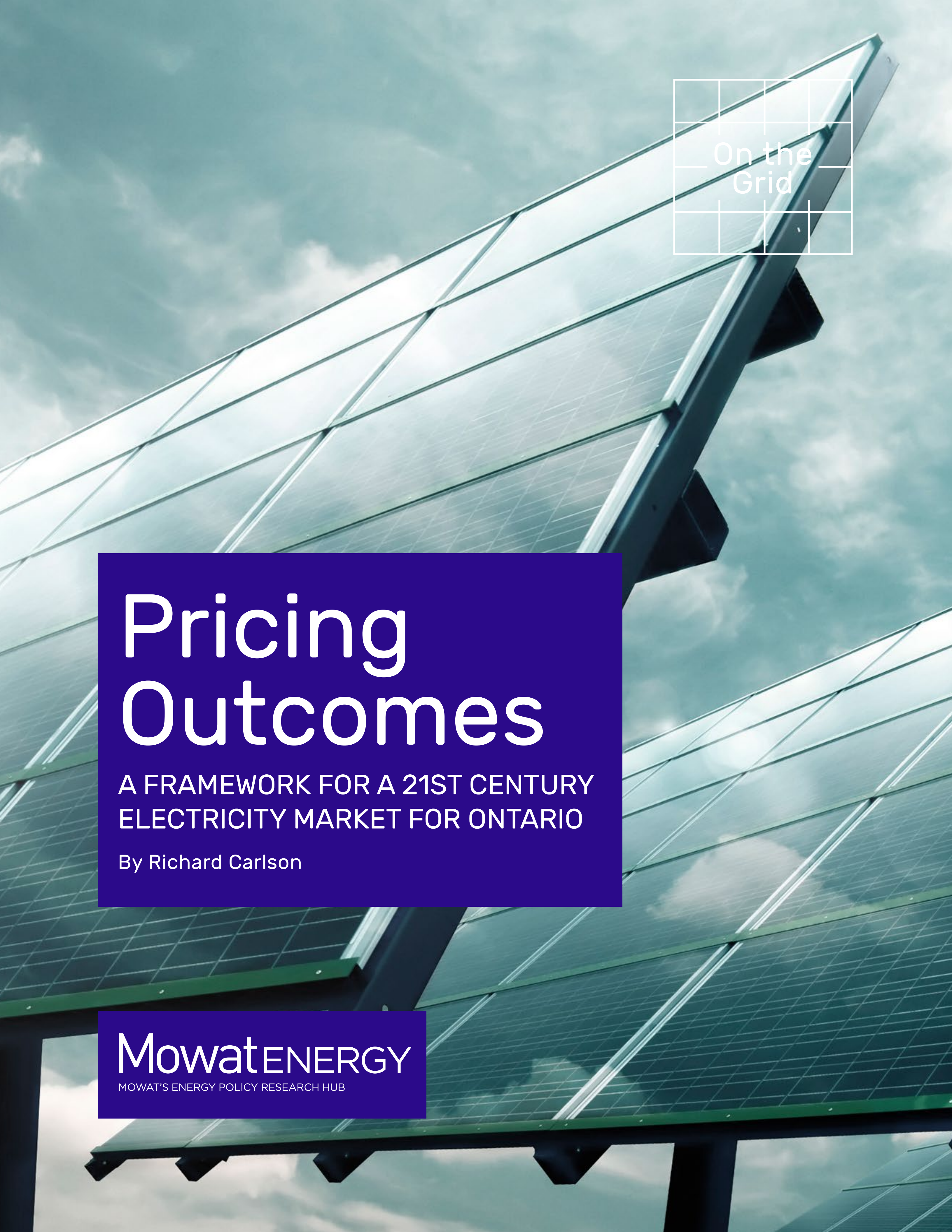

On the Grid

Pricing Outcomes

A FRAMEWORK FOR A 21ST CENTURY ELECTRICITY MARKET FOR ONTARIO

By Richard Carlson

Mowat ENERGY
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Acknowledgements

The author would like to thank Paul Sommerville and Reuven Shlozberg for their valuable comments and editing, and Elaine Stam for her design work.

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MOWAT REPORT #146

APRIL 2017

 ISBN 978-1-77259-047-0

Introduction

For almost 100 years, electricity has been sold as if it were a physical commodity, with customers buying electrons measured in kilowatt-hours (kWh) or megawatt-hours (MWh).

The introduction of competition into the electricity sector in North America and Europe in the late 1990s and early 2000s extended this commodity pricing model to wholesale electricity markets. These new wholesale markets were energy-only markets in that it was only the MWh that was traded between buyers and sellers, without concern for how it was generated.

The retail price consumers pay for electricity is derived from the wholesale price but includes other costs, such as for reliability and transmission and distribution.

The true test of any market is its ability to provide accurate and transparent short- and long-term price signals to enable the efficient operation and planning of the system, while allowing for and even encouraging innovation.[1] As an essential service, electricity also has to meet such public policy objectives as reliability and affordability. In the beginning, this commodity-based electricity market was arguably able to provide that in many jurisdictions.

But policy priorities have changed since electricity markets were opened to competition, and while low-cost reliable electricity is still important, reducing carbon emissions has also become an important goal for the sector. This has led to a shift from fossil fuels to renewables and other low-carbon forms of generation. As a result, how the electricity was generated increasingly matters to both consumers and policymakers.

For reasons explored in this paper, the increase in low-carbon generation, coupled with low natural gas prices in North America, has meant that in many jurisdictions the energy-only price of electricity on the wholesale markets is often below the actual system costs of supplying that electricity. Integrating variable renewable electricity such as wind and

1 PJM Markets, *Resource Investment in Competitive Markets*, May 2016. At http://www.pjm.com/~/media/documents/reports/20160505-resource-investment-in-competitive-markets-paper.ashx.

solar into the current wholesale market is another concern. As a result, the current electricity market is not able to provide the services and price signals needed for efficient planning and operations, which could limit the investment in new low-carbon energy needed to meet emissions reductions targets.

> *The current electricity market is not able to provide the services and price signals needed for efficient planning and operations*

Policymakers in different places have introduced patches – such as capacity markets or subsidies for certain types of technology, primarily renewables and nuclear – as the market alone has been unable to deliver the desired outcomes. But if we assume that markets are the most efficient method of providing signals to consumers and providers,[2] and the current market is not providing the services needed, then rather than apply patches we should move to a new market paradigm.[3]

The need to reform electricity markets is becoming widely recognized. The International Energy Agency argues that the integration of renewable generation requires a transformation in the whole power system.[4] Ontario's Independent Electricity System Operator (IESO), the provincial electricity system and market operator, has recognized the need to reform electricity markets and has started a project to do so.[5]

This paper examines how energy-only wholesale electricity markets

2 Some may argue that markets are the problem and we should re-regulate the sector. While that is an option, this paper assumes that jurisdictions with a market-based system will retain the market. In addition, with an increase in distributed energy resources, there will be more players in the market, and how to integrate small, privately owned distributed energy resources into a publicly owned energy system is a topic for another paper.

3 A similar idea was introduced in Mike Hogan, *What Lies "Beyond Capacity Markets"?: Delivering Least-Cost Reliability Under the new Resource Paradigm*, August 14, 2012. At https://www.raponline.org/document/download/id/6041. This paper builds on that paper.

4 International Energy Agency, *Next Generation Wind and Solar Power: From cost to value*, June 2016, pp. 8-10. At http://www.iea.org/publications/freepublications/publication/NextGenerationWindandSolarPower.pdf.

5 Independent Electricity System Operator, "Market Renewal." At http://www.ieso.ca/Pages/Participate/Stakeholder-Engagement/Market-Renewal.aspx.

developed, the ways in which low-carbon generation is disrupting the current market model[6] and why Ontario is particularly susceptible to these developments. Finally, assuming that a market-based approach is the preferable option, the paper will propose a new framework, moving beyond current market reforms, for thinking about how a 21st century electricity market could provide the outcomes the public needs.

Market Disruption

For most of the 20th century, large vertically integrated power companies, such as Ontario Hydro, generated and supplied electricity. Starting in the 1980s and 1990s policymakers wanted to introduce competition into the electricity market to allow for innovation and reduce costs, leading to deregulation and the rise of wholesale energy-only electricity markets.

In a typical wholesale energy-only electricity market, generators offer bids to supply electricity. The system operator lines up those bids, and the bids are selected from the lowest to the highest, stopping when electricity demand for that period of time is met. The last bid needed to meet demand sets what is known as the "market clearing price" for that time period, and all the generators selected to supply electricity receive that market clearing price, regardless of their initial bid. Generators whose bid is above that last bid do not produce. What technology produces the electricity is not considered.[7]

The theory is that generators compete by bidding at what is referred to as the short-run marginal cost. The short-run marginal cost typically includes the price of the fuel, plus the operational and maintenance costs. By bidding at the marginal cost the generator is guaranteed to at least be able to meet costs if their bids are successful. Many commodity markets, such as oil and natural gas, operate on the same principles. It is expected that generally the market clears at prices above the average marginal cost, thereby ensuring that all costs are covered.

6 Mowat Energy recently undertook a large research project called *Emerging Energy Trends* that examined the potential impact of distributed energy resources in Ontario. For more details see https://mowatcentre.ca/emerging-energy-trends/.
7 There are a number of different pricing models around, such as a greater reliance on bilateral contracts or pool pricing. While they all differ in many key ways, this is a typical set up for a wholesale electricity market.

A large portion of the marginal costs of fossil fuel generation is the variable cost of fuel, directly linking market bids with fossil fuel prices.[8] As fossil fuel plants dominated the market in the 1980s and 1990s, it made sense at the time for the electricity market to respond to the price of fossil fuels.

But the expansion of low-carbon generation, supported by government incentives and other emissions-reduction policies, and fuelled by growing concerns about the effects of climate change, has had unintended market consequences.

Unlike fossil fuel plants, most low-carbon generation has large upfront fixed costs due to the capital-intensive nature of their construction, but low variable operating costs as fuel is either not needed or is a relatively small part of overall costs (see Figure 1). These investments are typically very significant and must be made before electricity begins to be generated. This means that low-carbon generation has low or even zero marginal costs.

Walt Patterson, an energy researcher with the UK's Chatham House, The Royal Institute for International Affairs, describes low-carbon generation technologies as "infrastructure electricity" as they operate more similarly to infrastructure in that there are large fixed upfront costs that need to be paid back over time. But since, for these plants, generating electricity is more of a "physical outcome" of the infrastructure, rather than a deliberate process as with fossil fuel plants, the marginal cost of generating additional electricity is virtually zero.[9]

As a result, infrastructure electricity generators, with low or even zero marginal costs and the need to pay back large fixed capital investments, have the incentive to generate whenever physically possible, such as when wind is blowing or the sun is shining, at any price.

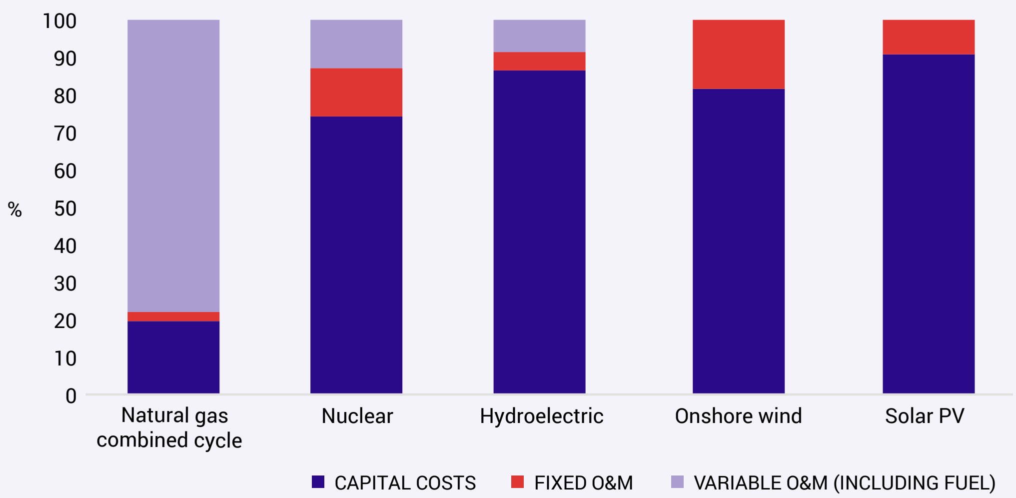
8 See, for example, the role of gas price in the market price in Ontario. *Market Surveillance Panel, Monitoring Report on the IESO-Administered Electricity Markets for the period from November 2014 – April 2015*, Ontario Energy Board, May 2016, p. 13. At http://www.ontarioenergyboard.ca/oeb/_Documents/MSP/MSP_Report_Nov2014-Apr2015_20160512.pdf.
9 Walt Patterson, *Keeping the Lights On: Towards Sustainable Electricity*, Chatham House, Royal Institute for International Affairs, 2010.

With zero marginal-cost generation, infrastructure electricity subverts the wholesale energy-only market. Infrastructure generators can bid low, even zero, as they are willing to sell at whatever the market clearing price ends up at. This can push down market prices for all electricity generators, making it difficult for investors – in fossil fuel or low-carbon generation – to rationalize new investment as the cash flow may not be there, absent some form of subsidy, during the life of the investment to rationalize investment.[10]

While low prices may appear to be a benefit for consumers, in the long term the lack of investment due to low prices could lead to future reliability problems as there might not be sufficient generation to meet demand.

FIGURE 1

Average distribution of costs for new generation plants entering service in 2020



Source: Energy Information Agency, *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2015*, June 2015. At https://www.eia.gov/forecasts/aeo/pdf/electricity_generation.pdf.

Note: Figures are based on Energy Information Agency's report on its projections of new plants entering service in the US in 2020, and original data was expressed in 2013 US$. The figures do not include transmission or distribution investment.

10 Bentham Paulos, "How Wind and Solar Will Blow Up Power Markets," *Greentech Media*, August 11, 2015. At http://www.greentechmedia.com/articles/read/how-wind-and-solar-will-blow-up-power-markets

The Effect of Infrastructure Electricity on the Market

An increase in the share of zero marginal cost infrastructure electricity, along with the current low natural gas prices, in an energy-only electricity market will lead to low prices paid to electricity generators.

While low electricity market prices could be seen as a good thing for consumers, the low prices exacerbate a long-standing market-wide problem with energy-only markets: lack of long-term price signals to ensure new investment. Without new investment, jurisdictions could experience reliability issues and blackouts.[11] Modelling by the International Energy Agency projects even more periods of zero or negative pricing in various electricity markets by 2050, illustrating that this problem is expected to continue.[12]

> *Since the energy-only market has not been able to provide the long-term price signals to incent the new investment policymakers want, different jurisdictions have tried different ways of bypassing the market to ensure there is new investment.*

Long-term stability is needed for investment in long-lived capital-heavy assets. It should be no surprise that 80 per cent of nuclear and hydropower plants in OECD countries were built before market liberalization, when a vertically integrated utility could be assured of its ability to pass the costs along to consumers.[13]

Both low-carbon and fossil fuel investment is threatened by low market prices. In Germany, Alberta and Chile, for example, low market prices - partly due to increased wind and solar generation - are threatening to

11 International Energy Agency, *Re-powering Markets: Market design and regulation during the transition to low-carbon power systems*, 2016, p. 121. At https://www.iea.org/publications/freepublications/publication/REPOWERINGMARKETS.pdf.
12 International Energy Agency, "Chapter 3," *Re-powering Markets*.
13 International Energy Agency, *Re-powering Markets*, p. 29.

limit any new investment in the electricity sector.[14] Nuclear plants in the US are under threat due to low market prices as well, and New York has indicated that nuclear plants will start to receive subsidies so they will not be forced to shut down as the market price has been too low for them to gain a return on their initial infrastructure investments.[15]

Since the energy-only market has not been able to provide the long-term price signals to incent the new investment policymakers want, different jurisdictions have tried different ways of bypassing the market to ensure there is new investment.

Ontario has in the past bypassed the energy-only market by signing long-term contracts with generators, guaranteeing them sufficient revenue to cover costs. Other jurisdictions are introducing capacity markets to ensure reliability. In capacity markets, generators are paid to be available to supply electricity when needed, in addition to the revenue from the supply of electricity. In effect a generator under a capacity market has two revenue streams: one from the actual electricity supplied to market, as calculated in MWh; and a second, from making themselves available to generate when needed, calculated in MW.

The PJM market, a large electricity market in the north-eastern US, has one of the oldest capacity markets in North America. The UK is also establishing a capacity market. Ontario looks likely to introduce a capacity market following on from its market renewal project.[16]

Capacity markets are not necessarily a cure-all for the problems with the wholesale commodity-only market. Where introduced capacity markets tend to encounter frequent political controversies and interference and creeping complexity.[17]

14 Benjamin Thibault, "How solar lowers your power bill: Understanding renewable energy prices in Alberta," Pembina Institute, November 12, 2014. At http://www.pembina.org/pub/how-solar-and-wind-lower-Alberta-power-bills; Vanessa Dezem and Javiera Quiroga, "Chile Has So Much Solar Energy It's Giving It Away for Free," *Bloomberg*, June 1, 2016. At http://www.bloomberg.com/news/articles/2016-06-01/chile-has-so-much-solar-energy-it-s-giving-it-away-for-free; Max Hall, "German renewables pushing wholesale electricity further into negative territory," *PV Magazine*, April 15, 2016. At http://www.pv-magazine.com/news/details/beitrag/german-renewables-pushing-wholesale-electricity-further-into-negative-territory_100019141.
15 Jim Polson, "Exelon, Entergy Nuclear Reactors Win Subsidies From New York," *Bloomberg*, August 1, 2016. At http://www.bloomberg.com/news/articles/2016-08-01/new-york-votes-to-grant-struggling-nuclear-reactors-a-reprieve.
16 Independent Electricity System Operator, *Capacity Market Information Session*, August 13, 2014. At http://www.ieso.ca/Documents/consult/CapacityMarket_InfoDay_Analysis.pdf.
17 Michael Hogan, "Follow the Missing Money: Ensuring Reliability at Least Cost to Consumers in the Transition to a Low-carbon Power System," *The Electricity Journal*, No. 30, 2017, p. 58.

And capacity markets may not provide sufficient income to offset the low prices in energy-only wholesale electricity markets. In the US, revenue from non-energy markets, including capacity markets, generally only accounts for 20-30 per cent of a flexible fossil fuel plant's total revenue.[18] With energy-only wholesale electricity prices close to zero, the share of capacity market revenue to total generating plant revenue may have to increase.

Ontario at the Forefront of the Market Changes

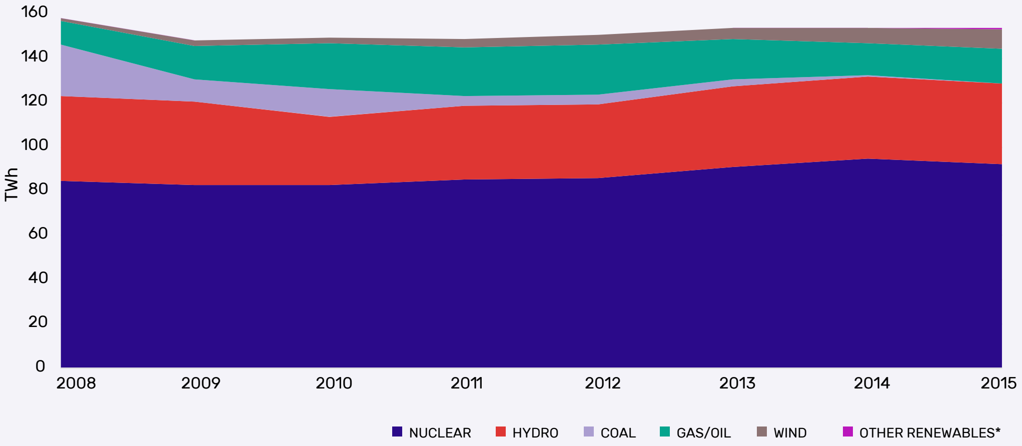
Electricity generation in Ontario has seen a marked shift towards infrastructure electricity generation over the last decade. The share of fossil fuels in Ontario's electricity generation halved between 2002 and 2015, replaced by nuclear and renewable generation (see Figure 2).

Ontario has what is referred to as a hybrid market, and there are in effect two components of the total wholesale price of electricity. The first component is the Hourly Ontario Electricity Price (HOEP), which is set through bids on the wholesale market, as in other markets.

Unlike other deregulated markets, however, almost all generation in Ontario is under long-term contract or receives set regulated prices. To make up the difference between the contracts and the HOEP there is a second component of the overall wholesale price for electricity, the Global Adjustment (GA; the GA also covers the costs of other programs, such as conservation and demand management).

18 IEA-RETD, *RE Transition: Transition to Policy Frameworks for Cost-Competitive Renewables*, 2016, p. 39. At http://iea-retd.org/wp-content/uploads/2016/03/IEA-RETD_RE-TRANSITION.pdf.

FIGURE 2
Ontario electricity supply overview (2008-2015)



Source: Derived from Independent Electricity System Operator, "Supply Overview." At http://www.ieso.ca/Pages/Power-Data/Supply.aspx.

Note: "Other renewables" only includes transmission-grid connected renewable generation, and not output from generation connected to the distribution grid. Most solar power, for example, is connected to the distribution grid and would hence not appear here.

In other words, the sum of the HOEP and GA generally equals the total system cost of generation in Ontario. This reduces the volatility of the overall return recouped by generators: in a non-hybrid market, the total system cost would fluctuate with the market, in Ontario losses in the HOEP can be made up through increases in the GA.

The way the Ontario electricity market price is set is changing due to the move to infrastructure electricity. In the early days of liberalization of the market in 2004-05, coal-fired generation set the HOEP almost half the time, as those assets bid in at their marginal cost.[19] The elimination of the coal fleet means that infrastructure electricity is playing a larger role in setting the HOEP. As result of this move, as well as changes in demand, the HOEP is seeing an increase in the number of zero or negative pricing events.[20]

19 Michael J. Trebilcock and Roy Hrab, "Electricity Restructuring in Canada", in Fereidoon P. Sioshansi and Wolfgang Pfaffenberger, *Electricity Market Reform: An International Perspective*, Elsevier, New York, 2006, p. 422.
20 Market Surveillance Panel, *Monitoring Report on the IESO-Administered Electricity Markets for the Period from November 2014 – April 2015*, Ontario Energy Board, May 2016, pp. 65-66.

Yet as noted above, since Ontario has a hybrid electricity market, these lower HOEP market prices simply shift a greater portion of total systems costs into the GA. The increase in low wholesale prices due to the change in technology can be seen in the shift in the ratio of HOEP and GA to the total system costs of supply. The share of GA has increased over time, and now accounts for over two-thirds of the system price of electricity (see Figure 3).

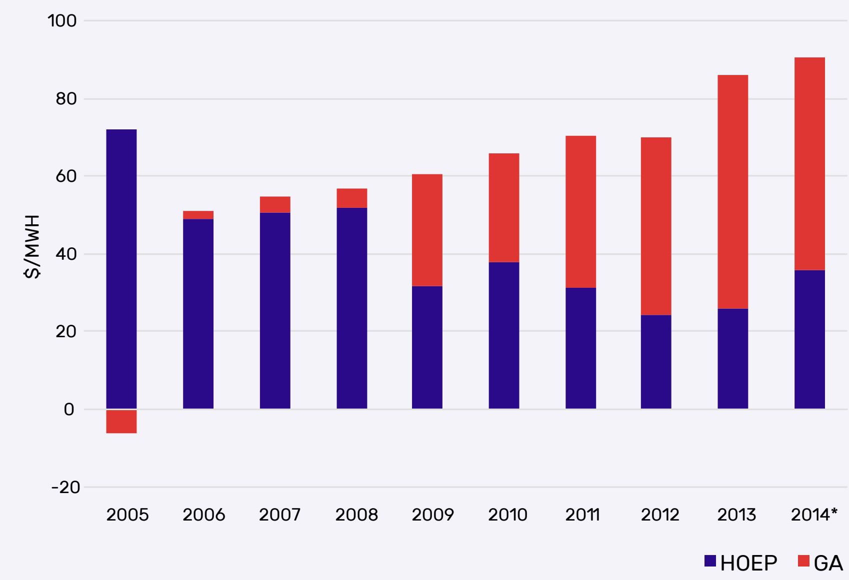
Natural gas generation is effectively the only non-zero marginal cost producer in Ontario, and it is not used extensively. On average, natural gas plants have only operated around 10 per cent of the time in a year, with some plants designed for only meeting high periods of demand operating for only a few hours a year.[21] Despite operating infrequently, a number of these gas plants still provide significant value to the system as they can quickly respond when there is an urgent need for electricity to increase reliability. Their value is that they are able to turn on quickly when needed, as in a capacity market.

As a result of the shift on the costs allocation to the GA, the HOEP is now primarily used by the system operator to optimize the economic dispatch of some resources – that is, as a signal for which available generators the IESO should dispatch first in order to meet demand.[22] While the use of the HOEP for dispatch is a valuable service for the system, the HOEP no longer provides what is the primary function of a wholesale market, namely acting as a price discovery tool for efficient planning and investment.

21 Independent Electricity System Operator, *Preliminary Outlook and Discussion: Ontario Supply/Demand Balance to 2035*, March 23, 2016, p. 66. At http://www.ieso.ca/Documents/consult/sac/SAC-20160323-Ontario-Planning-Outlook.pdf.
22 IEA-RETD, *RE Transition*, p. 36.

FIGURE 3

The changing importance of the HOEP and GA in the total system price



Source: Derived from Independent Electricity System Operator, "Understanding Global Adjustment," June 2014. At http://www.ieso.ca/Documents/Understanding_GA_June_2014.pdf; *Ontario Energy Report*, "Q4 2014: Electricity," p. 11. At http://ontarioenergyreport.ca/pdfs/Energy%20Quarterly_Electricity_Q4.pdf.

Note: 2015 and later figures are not included as the accounting for HOEP and GA changed in the reports that year, making comparisons difficult.

A 21st Century Market Framework: A Flexible Outcomes-based Electricity Market

Jurisdictions in Canada and around the world are interested in promoting the development of low-carbon energy sources, and most of these energy sources are low marginal cost infrastructure generators. There are many ways to achieve this desired outcome in the electricity sector. While some jurisdictions rely on vertically integrated state-owned companies to develop the energy sector, for many others, including Ontario, the market approach continues to be preferred.

But wholesale electricity markets, as they are currently structured, make it hard to rationalize investment in infrastructure electricity without incentives or subsidies. As a result, jurisdictions are required to distort the market through incentives and subsidies to get this desired outcome.

Electricity markets are tools and should be designed to ensure that desired outcomes are efficiently arrived at. With a changing electricity sector, the electricity market likewise needs to change. When system costs were directly related to the cost of the fuel, an energy-only market based on marginal costs made sense. But the shift to infrastructure electricity generation, with its low marginal costs, requires a 21st century electricity market.[23] A 21st century electricity has to be built around the policy goal of creating an electricity mix that relies on low/non-carbon generation first, foremost and to the greatest extent possible while assuring the availability and reliability of electricity. And it has to be able to send reliable price signals that make investments in such generation economically rational. To achieve this dual goal, a 21st century electricity market needs to be able to discover the system values of different technologies.

Electricity markets have tended to define the means with which desired outcomes could be achieved. For example, because renewable electricity sources such as wind and solar are variable, their generation is not aligned to system demand, meaning that they may not be able to always satisfy demand, and that their generation may drop or surge at short notice. The growth in generation from such sources therefore creates a need for greater flexibility in the generation mix to ensure the reliability of the system.

Such flexibility has traditionally been provided by rapid-response generating plants, primarily those based on natural gas or diesel. As a result, a number of jurisdictions have developed capacity markets to ensure such plants are available when demand surges or supply lessens at short notice.[24]

While capacity has and can achieve flexibility, capacity is just one method to do so. Other methods of increasing flexibility, such as demand response or adding storage, can be more effective depending on the context.[25]

23 Walt Patterson, *Keeping the Lights On*.
24 Mike Hogan, et al, *What Lies "Beyond Capacity Markets"?.*
25 International Energy Agency, *Next Generation Wind and Solar Power: From cost to value*, June 2016, p. 22. At http://www.iea.org/publications/freepublications/publication/NextGenerationWindandSolarPower.pdf.

Yet by defining the means to achieve flexibility around capacity, and then creating a market for that capacity, these other means of ensuring flexibility may be sidelined and not be allowed to participate in the market. A capacity market treats all participants the same, as flexible MWs, thereby tending to prefer natural gas-fired plants. A better solution would be to create a market for the desired outcome – namely, encouraging low/non-carbon generation and rationalizing the long-term infrastructure investment this would entail while maintaining system reliability – and then allow the market to discover the most efficient technology to achieve this outcome.

There is great uncertainty about the future of the electricity system. Emerging trends in the energy sector, which point to both increased infrastructure electricity generations and small-scale distributed generation,[26] will require new tools to get the needed price signals.

A 21st century electricity market for Ontario would continue to encourage low-carbon energy sources, but will first need to meet the IESO's market reform objectives:

» stability

» flexibility

» efficiency

» transparency

» certainty.[27]

While the IESO's market reform process is a good start, and a recognition that the market in Ontario needs to change to reflect new realities, it needs to go further if it to create a 21st century market.

Ontario should begin with unbundling the GA and pricing its components separately. Rather than capacity, the IESO should focus on flexibility. After unbundling the GA, the IESO could introduce a flexibility market, whereby developers compete to provide short- or long-term periods of electricity

26 For research on emerging trends in the energy sector, see Paul Sommerville, Richard Carlson and Petar Prazic, *Emerging Energy Trends: Regulatory Responses to Ontario's Energy Future*, Mowat Research #141, December 2016. At https://mowatcentre.ca/emerging-energy-trends-report/.
27 Tom Chapman, "Future Market Design Considerations," Independent Electricity System Operators Presentation, April 19, 2016, p. 7. At http://www.ieso.ca/Documents/consult/ME/ME-20160419-Market-Design-Considerations.pdf.

at various times and at various locations. An example of such a market now would be California's flexible ramping product, which is designed to enable economic bids to meet the need for greater flexibility.[28]

Such a flexibility market could include temporal and seasonal components, so that solar power could compete during the day in the summer. It would need to have a locational element as well, since meeting peak demand for a few hours in the summer in a congested and dense urban area such as Toronto may be more valuable to the overall system than doing the same in a sparsely populated rural community.

Another element of the GA unbundling would be to offer more system services, such as frequency or voltage regulation or for reactive power, which are needed to ensure stability of the grid, on the market.

An energy-only market could continue to play a role – it can continue to be useful for economic dispatch – but it would lose its centrality in the electricity sector.

If the value of markets to electricity is to be realized, a rational market pricing system is needed to secure the electricity services needed by society. Without such a rational pricing system non-market interventions will continue, further distorting the market.

The proliferation of zero marginal cost infrastructure electricity is disrupting the energy-only wholesale electricity market, just as technological change has upset many other established markets, from telecommunications to transportation.[29] As such, electricity markets need to be reformed in order to ensure that they continue to satisfy the goal for which they were created – to ensure an efficient, transparent and reliable supply of electricity.

28 California ISO, "Flexible Ramping Product." At https://www.caiso.com/informed/Pages/StakeholderProcesses/FlexibleRampingProduct.aspx.
29 See, for example, Sunil Johal and Noah Zon, *Policymaking for the Sharing Economy: Beyond Whack-A-Mole*, Mowat Centre, February 2015. At https://mowatcentre.ca/policymaking-for-the-sharing-economy/.

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