Seattle City Light

MEMO

MARCH 14, 2017

TO
Mayor Edward Murray

Seattle City Councilmembers

FROM
Larry Weis, General Manager and CEO, Seattle City Light

SUBJECT
Energy Imbalance Market Participation Analysis

Recommendation

The Energy Imbalance Market (EIM) offered by the California Independent System Operator (CAISO) offers Seattle City Light (City Light) the unique opportunity to do well, by doing good. City Light's participation in the EIM will not only decrease regional Greenhouse Gas (GHG) emissions, it will help minimize the curtailment of wind and solar projects that would otherwise be forced off the grid, and City Light will make the delivery of that wind and solar energy more cost-effective. Equally, if not more importantly, we will improve the reliability of the service we provide our customers, and we will do so more cost-effectively by producing additional, net wholesale revenue. By participating in the EIM we will be furthering Mayor Murray and the Council's goals for a clean energy economy for the City of Seattle, while improving the environment in measurable ways. For these reasons, City Light recommends that Mayor Murray and the City Council support our participating in the EIM.

Organizational Issue

Why does City Light believe there are compelling benefits to joining the expanding EIM?

There are four areas of potential benefits to City Light participation in the EIM - environmental, financial, reliability, and risk management. The environmental benefits of EIM to the Western United States are well recognized, through both the displacement of thermal generation (avoided CO_2 emissions), as well as the more cost-effective integration of wind and solar power, and avoided curtailment of renewable generation (and associated GHG savings). By working with the CAISO through the EIM, participating utilities are creating a dynamic ability to share the ramping capabilities of their resources and minimize the risk of system operators having to curtail wind and solar to maintain grid stability.[1]

[1] The CAISO performs quarterly EIM benefits assessments that review both the financial and environmental benefits. See: http://www.caiso.com/Documents/ISO-EIMBenefitsReportQ4_2016.pdf . Additionally, City Light

Financially, with City Light's flexible hydroelectric generation (Skagit and Boundary) we are better positioned than most utilities to take advantage of the within-day arbitrage opportunities presented by the EIM (buy low/store water, sell high/use water). We estimate a net annual benefit of **$2.6 million**[2] after implementation, which repays the initial start-up costs ($8.8 million capital and $3.6 million O&M) in five (5) full years of operations.[3]

From a reliability perspective, EIM participation will allow the City Light's system operators access to a broader set of tools and information than they have access to today, providing them an improved "view" of the real-time state of the bulk electric system beyond the area where we provide service, and providing additional system stability through the EIM redispatch. These benefits are difficult to quantify or place a financial value on, but there is a consensus that these benefits are real and a strong reliability incentive to EIM participation. As mentioned above, expansion of the EIM also minimizes the risk that the CAISO or other participating EIM entities would have to curtail wind or solar resources to maintain grid stability and reliable retail service to their customers.[4]

Viewing EIM through a risk management lens, participation in a relatively new market segment (within the hour) increases certain financial risks. However, the structure of this market places firm limits on those risks and allows City Light to cease market participation, within the following hour, if being in the market places undue risk on the utility. Additionally, City Light's risk management culture has evolved tremendously since 2000-2001, as has the CAISO market. We now have internal capabilities, policies, procedures, and control systems in place to substantially mitigate the exposure to identified market risks.[5] We have also built a significantly more robust and flexible portfolio. Together, this puts City Light in a both qualitatively and quantitatively vastly different position from the market exposure City Light faced in 2000 and 2001. Likewise, the CAISO has significantly modified its market design and rules, fully implementing them by 2009. In terms of project execution risk, the implementation schedule provides significant time for software testing, process testing and two months of parallel operations to identify

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commissioned a GHG study from Energy and Environmental Economics (E3) that focused on the potential environmental benefits of City Light's EIM participation, which is appended to this analysis.

[2] See attached SCL EIM.xlsx | Base Case) $5.4 million is the expected revenue from the 2020 Planning study, $2.8 million expected cost from cost summary, leaving a $2.6 million net benefit. Other studies produced similar results, this one was selected.

[3] The different modeling of potential benefits is described in greater detail later in this analysis, and the summary results papers are attached for reference. It is important to note that the different modeling efforts do not approach the problem in the same way. City Light has taken the different approaches and tried to represent them in a manner that allows comparison. So, for example, one model reflects the actual operational limits and capabilities of City Light's hydroelectric generation projects, and optimization of that capability, while another does not.

[4] City Light does not face its own intrinsic stability risks from wind or solar since our large-scale wind resource is in another utility's Balancing Authority Area (BAA). It should also be noted that roof-top solar in Seattle does not currently pose such a risk. However, PSE has very significant wind resources in its BAA and our joining PSE as a fellow EIM entity may have a meaningful stability benefit for our neighbors PSE serves throughout the Puget Sound area.

[5] Other risks, such as the volume of snow and rain received in a given year, or how much solar or wind power will be produced, are "objective risks" which we mitigate. Prior to City Light's EIM participation additional risk management policies and procedures will be developed.

and resolve potential issues in advance of "go live". From a non-financial risk perspective, EIM participation will facilitate City Light improving the professional skillset of its employees, its business systems and business practices so that it is more resilient to the market evolutions now occurring across the West. The EIM offers City Light a range of quantitative and qualitative benefits to City Light as an institution, and to the service we provide our customers.[6]

Background

Why are Energy Imbalance Markets growing and why is Seattle City Light interested?

Zero marginal cost wind and solar changes everything.

Over the last several years, there has been a sea-change in the generating resources across the West. Renewable portfolio standards like Washington state's Energy Independence Act ("I-937") have spurred the development and deployment of thousands of megawatts of wind and solar, both utility scale, and at the "roof top" level. The deployment of "zero marginal cost energy resources"[7] have also affected the wholesale energy markets, generally depressing prices, and making thermally fired generation (primarily coal, but some natural gas fired generation as well) uneconomic to run, and thus incenting the owners and operators of those facilities to either close them or begin planning for their closure.

However, the variable nature of wind and solar also requires system operators to have flexible resources available to "shape" to their variable generating profile throughout the day. This "integration" cost can be quite high if the BAA where the wind or solar is located does not have sufficient flexible, fast resources available to match to the minute-by-minute generation profile of the wind and solar resources. Also, our current bilateral wholesale energy markets in the West traditionally transact only on an hourly basis. Hourly transactions do not match the needs of utility-scale wind and solar. In the last few years, wholesale energy markets have allowed modifying transactions every fifteen minutes, but due to this being a manually intensive operation, fifteen-minute schedule changes are not widely used. This is an improvement from the perspective of reliably integrating wind and solar, but it does not go

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[6] There are a wide range of potential future City Light initiatives which the EIM could support. Dispatchable load, and the "transactive" energy business model are examples of areas where having a fifteen- and five-minute wholesale market price signal through EIM could facilitate future strategic initiatives within the utility which are not currently contemplated, or feasible absent Locational Marginal Prices (LMPs) and fifteen- and five-minute price signals.

[7] Wind and solar are deemed "zero marginal cost resources" because they have no fuel cost once operational, and their on-going operating and maintenance expenses are very low by comparison to traditional forms of generation. Due to these very, very low operating costs, when these resources participate in wholesale energy markets based on the marginal cost of production, they tend to be the cheapest resources available and are almost always dispatched first.
When there is a surplus of energy available in the wholesale markets (i.e. more generating capacity is available and ready than there is load that needs to be served) wind and solar will often bid in to the market at $0 or negative prices. This is possible due to the federal tax credits that will allow them to remain profitable in wholesale markets even when they must pay someone to take their energy. This market dynamic is relatively new and is having significant effects on wholesale energy markets across the West, and globally.

far enough. This interplay (and tension) between the operational requirements of wind and solar and the wholesale energy markets that facilitate its delivery to retail customers is part of what has driven the interest, development and deployment of automated, within-hour energy markets across the United States. The only operational, automated, within-hour energy market in the Northwest is the EIM offered by the CAISO.

City Light's overall generating portfolio of owned and operated resources, as well as contracted resources provide our customers an almost carbon-free portfolio of generating resources to meet their needs. City Light has gone further and made our service to our retail customers Greenhouse Gas neutral for over a decade.[8] In a very practical sense, City Light cannot make its generating portfolio "greener" without wasting money. However, through the EIM, City Light can assist other utilities across the West in making their portfolios greener by allowing our fast-ramping hydroelectric generators to more cost-effectively integrate their wind and solar, and displace thermal resources when they are on the margin.

The EIM is a rare, new wholesale revenue opportunity.

In 2000 and 2001 a record-low water year combined with a net deficit energy portfolio and well-documented market abuses led Seattle to incur unprecedented costs to maintain reliable service to our retail customers. The Mayor and City Council decided at that time that City Light would plan to be able to serve its retail customer needs even in a low-water year. City Light then expanded its BPA power purchases, and thus, City Light has approximately 2 million megawatt hours (MWhs) of energy surplus to our retail customer needs in an average water year.[9] City Light sells that surplus into the wholesale markets and uses the resulting wholesale revenue to lower our retail customers' rates. However, the wholesale energy markets have been continuously depressed since 2006, making achieving our perennially lower budget targets difficult to achieve.[10] Through our City Light Strategic Plan we have been gradually lowering the amount of revenue that our retail rates rely upon.

The EIM represents a rare new, incremental opportunity to earn wholesale revenue from the Western energy markets. City Light's participation in the EIM represents an opportunity to monetize the inherent flexibility and storage capability of our portfolio to offset costs for existing and new customer programs. Absent EIM participation, there are few prospects for City Light to accrue additional new wholesale revenue for the benefit of our customers.

Why is the CAISO EIM the only viable within-hour energy market option?

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[8] http://www.seattle.gov/light/enviro/carbonneutral.htm

[9] This is a combination of winter snow pack and rain the rest of the year in the Skagit, Columbia and Clark Fork drainages that supply both City Lights' and BPA's hydroelectric generating resources.

[10] This is widely attributed to the combination of both the wind and solar joining the regional energy portfolio and the low price of natural gas, resulting from the use of hydraulic fracturing techniques ("fracking") in oil and gas exploration. It is now expected that natural gas prices will remain suppressed for years or decades to come due to the proven reserves of natural gas now available. Similarly, the 50% RPS standards recently adopted in California and Oregon will continue to add large quantities of zero marginal cost resources to the Western region's total energy portfolio.

Perfection has been the enemy of the good.

There have been four major efforts in the Pacific Northwest to evaluate and consider an "organized market" that could include a within-hour market like the EIM.[11]

- IndeGo – An early effort to examine whether to establish an ISO in the West.
- RTO West – Beginning in March of 2000, a coalition of transmission owners across the Pacific Northwest, British Columbia, Utah and parts of Wyoming, Nevada and Montana evaluated whether to establish an RTO. Because of significant disputes among the participants, this effort was modified in late 2003.
- Grid West – From 2003 to 2005 the participants attempted to take a different approach and were similarly unsuccessful. Offshoots of this effort include ColumbiaGrid and NTTG which now perform coordinated regional transmission planning for Northwest utilities. City Light is a member of ColumbiaGrid.
- NWPP MC – From 2012 through the end of 2015 a wide range of Northwest and Northern California utilities sought to develop a within-hour wholesale energy market and other tools that would be customized to their unique needs. This was occurring in parallel to the CAISO's development of its EIM. City Light was simultaneously monitoring the CAISO EIM initiative in its formative days, while also helping to lead the NWPP MC effort. By 2014 the EIM had developed into a stable, auxiliary market to the CAISO, with known rules and fee structures. In 2014 and 2015 several of the NWPP MC participating utilities, seeking that type of market stability, left the MC initiative to join the CAISO EIM. By the fall of 2015, it was clear that the MC initiative no longer possessed the "critical mass" to be successful and the effort was formally ended in January 2016. City Light then pivoted its focus to the EIM.

To understand the context for the above efforts, and the eventual success of the CAISO EIM, it is important to understand what the EIM is and is not. The EIM is an expansion of the CAISO's pre-existing real-time market to utilities that are not within its market footprint. The EIM allows voluntary participation in the CAISO market without disrupting the existing market structure or the existing customers within the CAISO footprint. Each participating EIM entity remains responsible for maintaining its own reliability, including reserve and capacity requirements.[12]

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[11] Two phrases are sometimes used interchangeably when discussing an "organized market" – Regional Transmission Organization (RTO) and Independent System Operator (ISO). RTOs and ISOs share the common characteristics of being a non-profit, neutral, third-party that operates a collection of individual transmission systems in a coordinated fashion, they plan for transmission expansion, and they operate wholesale energy markets, without being a direct participant in the wholesale energy market (with only limited, reliability driven exceptions). RTOs and ISOs effectively become a "wide-area BA" through the combination of the pre-existing BAs. Most of the United States are served by an RTO or ISO, with the exception of the deep South and the West. https://www.ferc.gov/industries/electric/indus-act/rto.asp . This is increasingly true globally. For example, Mexico is currently in the process of de-nationalizing its energy sector and establishing an ISO, while the Republic of Chile was the first nation to establish an ISO in 1983.

[12] Energy in the EIM is locationally priced and incorporates transmission scarcity and reliability concerns into the pricing and dispatch of generation and loads. EIM entities participate in both the fifteen- and five-minute

Participation in the CAISO EIM is voluntary, and is not subject to an exit fee, if an EIM entity wishes to withdraw from EIM participation. While there is a six-month notice requirement for withdrawal, operationally, on any given day, an EIM entity can cease to participate by stopping submission of bids and offers, and simply settling the charges and any financial obligations that were incurred during the period of its participation. This "easy in, easy out" is a significant difference between EIM participation and joining an RTO or ISO.[13]

The EIM is not an energy or capacity supply mechanism. All EIM entities are required to come to the market with sufficient resources to meet their own needs and must pass a series of resource sufficiency tests as they get closer to a given operating hour. The EIM does not perform transmission service functions, and is not an RTO or ISO, as discussed above. Therefore, the EIM uses only "as available" transmission where capability exists in real-time and will maximize the utilization of the transmission capacity that is available to it in real-time.[14]

As discussed above, the EIM has seen substantial growth over the last few years, within the investor owned utilities. While City Light was the first publicly owned utility to announce its intent to participate, three other equally substantial public power utilities have now done so. The following map represents both current and pending EIM participants. Portland General Electric is planning to go live in Fall 2017, with Idaho Power joining in Fall of 2018. Both City Light and the Balancing Area of Northern California (BANC)/Sacramento Municipal Utility District (SMUD)[15] are scheduled to join in the Spring of 2019. Salt River Power (SRP) will likely join in the Spring of 2020 along with the Los Angeles Department of Water and Power (LADWP). Two other entities have stated publicly that they are evaluating whether to join the EIM - Northwestern Energy (NWE) and CENACE, the grid operator for Baja California Norte. By 2020, the net effect of this market transition is that over half of the load in the West will be involved in the EIM market. There are several additional entities evaluating whether to join the EIM, but they have not made public statements regarding their intent.

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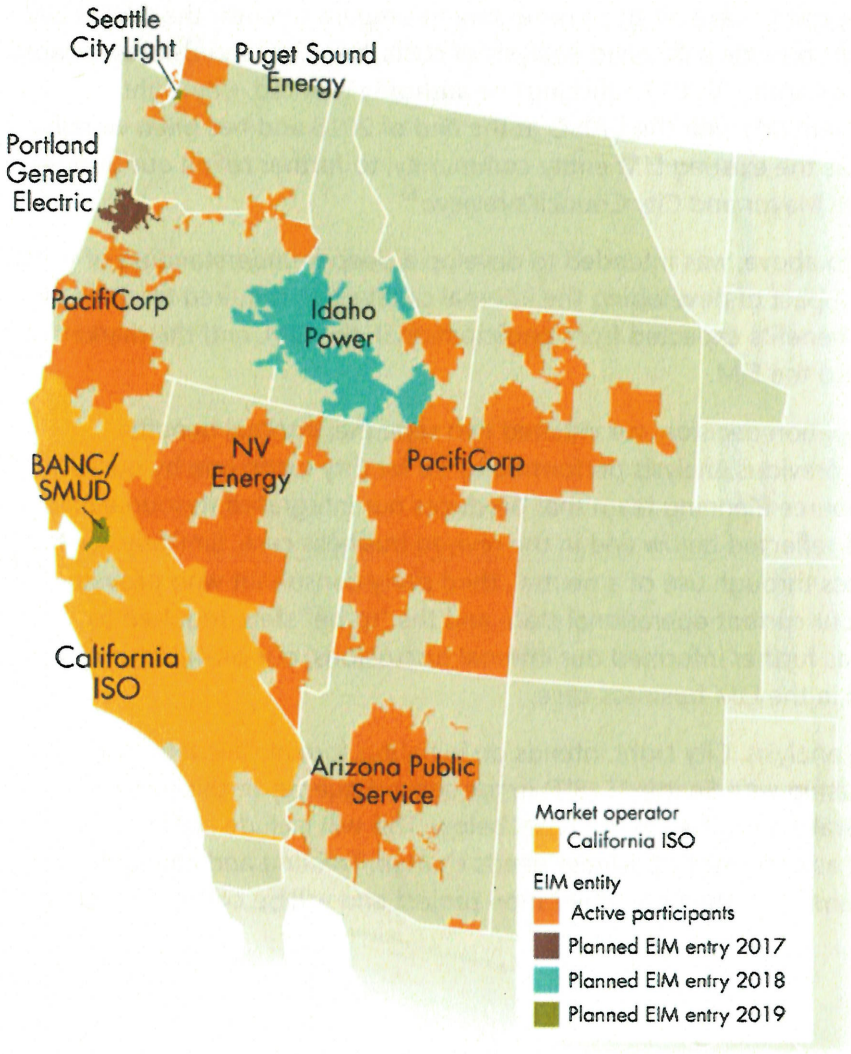
dispatches of the CAISO real-time market. EIM entities do not participate in the CAISO day-ahead or ancillary services market.

[13] It should be noted that currently 10 Colorado utilities are considering joining the Southwest Power Pool (SPP), an RTO that serves a large segment of the Midwest, including the Upper Great Plains region of the Western Area Power Administration (WAPA). The CO utilities intend to make their decision this summer. If they join SPP, as they are expected to do, this would be the second RTO/ISO in the West after the CAISO and there would be a high probability that SPP would seek to expand further, either into the desert Southwest, into the Pacific Northwest or both.

[14] The EIM takes into account all scheduled uses of transmission and inadvertent interchange prior to maximizing usage, i.e., the difference between system operating limits and actual real-time flows. EIM entities have typically made transmission available to the EIM on a contract-path basis to establish firm transfer capacity on a given path, which the EIM then uses along with any additional available capacity in real-time.

[15] BANC is the BA for four Northern California public power utilities, including SMUD. SMUD is the largest of the BANC members, and is joining the EIM as "phase one". Whether some or all of the remaining BANC members do so in "phase two" will be determined thereafter.



Please note - the EIM entity map above only reflects those parties which have executed an Implementation Agreement with the CAISO indicating their intent to join their EIM, are in the implementation process itself, or are now active EIM participants.

Overview of City Light's EIM Project

With the near-certain demise of the NWPP MC initiative in the fall of 2015, City Light began pivoting its attention to the CAISO EIM. We established a team to begin due diligence investigation with PacifiCorp (the first EIM entity) to better understand their experience and approach to joining the EIM. We also started an internal assessment of potential start-up costs and ongoing operational requirements. In early 2016 we began investigating the potential benefits of EIM participation for City Light by commissioning a benefits study from Energy+Environment Economics (E3). These efforts culminated in

Ordinance 125176 that the City Council approved on October 31, 2016, and the Mayor signed on November 4, 2016, authorizing City Light to take all steps necessary to prepare to enter the CAISO EIM. The ordinance also required City Light provide a detailed analysis of costs, benefits, and risks associated with entering the market no later than April 10, 2017. Utilizing the authority granted, City Light executed its Implementation Agreement (IA) with the CAISO at the end of 2016 and has been working with the CAISO and its staff, as well as the existing EIM entity community, to further refine our business case and develop this analysis for the Mayor and City Council's review.[16]

The project GAPS analysis, referred to above, was intended to develop a deeper understanding of three primary project areas; the cost and impact of developing the internal capabilities required to enter the EIM, the financial and non-financial benefits expected from participation in the EIM, and the market and project risks associated with entry into the EIM.

In support of City Light's EIM participation decision, we initiated two separate, internal benefits modeling efforts to supplement the previous analysis performed by E3 for City Light; one by our Risk Oversight team, and one by the Resource Planning team that produces our Integrated Resource Plan (IRP). The results of those efforts are reflected below and in the revised business case. Similarly, we have continued to refine our cost estimates through use of a neutral, third party consultant who provided a "gaps analysis".[17] This feedback on our current operational state and the "to be" state required to successfully participate in the EIM has further informed our internal discussions, our on-going dialogue with the CAISO and is now reflected in the EIM business case.

Based on the results of the updated analysis, City Light intends on initiating formal solicitations for required business systems in partnership with Seattle IT (SIT) in the second quarter of this year and proceeding with the project as generally described in the chart below. This will include staffing adjustments throughout the project as City Light's business needs change. Training and change management will be a significant element of the implementation project and will be critical to assuring our employees' success.

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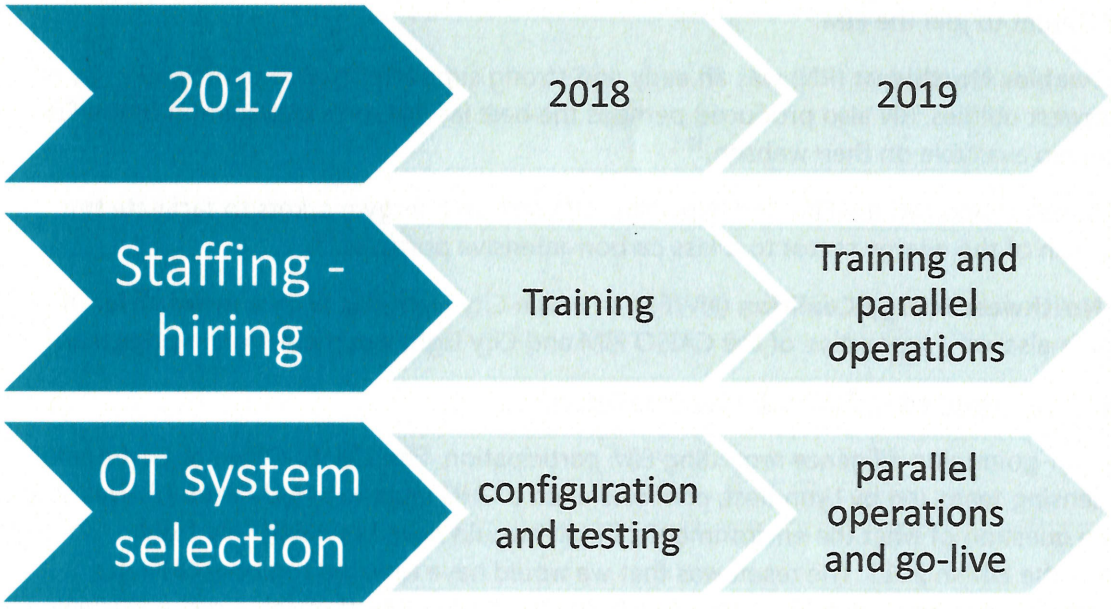
[16] This paper and the updated business case participation analysis is the culmination of that work and constitutes the requested briefing. A summary presentation of this material is also available.
It should be noted that an unexpected benefit of executing the IA in 2016 was the invitation to join the EIM Implementation and Policy Forum (EIM IPF). This is a working group comprised of the existing EIM entities and those who are currently preparing to join. Through monthly conference calls and quarterly in-person meetings at the different EIM entity's home offices, City Light staff have had the benefit of many "lessons learned" and we anticipate continuing and deepening our engagement with this group who have been incredibly supportive of City Light's future EIM participation.

[17] City Light selected Utilicast to perform its gaps analysis. Utilicast has done significant work for many of the existing and pending EIM entities, and does not have an association with any one software vendor in the "bid-to-bill" energy market sector. Executive and staff level review of Utilicast's draft recommendations are reflected herein and in the revised business case analysis.

Project timeline



The above timeline reflects the major bodies of work required for a successful EIM implementation and go-live on April 1, 2019.

Benefits

What are the quantitative and qualitative benefits from City Light's participation in EIM?

Environmental benefits include avoided CO_2 emissions and more cost-effective integration of wind and solar.

As discussed at the beginning of this memorandum, the environmental benefits of a within-hour EIM are widely recognized. As part of its quarterly EIM benefits reports the CAISO calculates not only financial benefits, but also the quantity of CO_2 emissions that were displaced as a result of the EIM.[18]

By bringing its hydroelectric generating resources to the EIM, City Light will not only enable the delivery of wind and solar that would otherwise be curtailed (turned off to maintain reliability), we reduce the region's need to rely on thermal generators to meet the ramping needs within the hour, and reduce the need for other utilities to dispatch their inefficient natural gas fired generators during constrained periods of the day.

[18] See: http://www.caiso.com/Documents/WesternEIMProducesSignificantSavingsDespiteLowDemand.pdf

A range of environmental advocacy organizations have recognized the importance of the EIM and have been strongly supportive of City Light's participation in EIM as the first public power utility to announce its intent to join the EIM.

- **Renewables Northwest** (RN) was an early and strong supporter of EIM participation by all Northwest utilities. RN also produced perhaps the best lay-person's explanation of the EIM in a video available on their website.[19]
- **NRDC** has supported the EIM and expansion of Western energy markets to facilitate the transition of the energy sector to a less carbon-intensive portfolio.[20]
- The **Northwest Energy Coalition** (NWEC), of which City Light has been a member for many years, is also very supportive of the CAISO EIM and City Light's participation in particular.[21]

City Light has quantified its EIM environmental benefits.

As part of its on-going due diligence regarding EIM participation, City Light's Office of Environment, Land and Licensing team, led by Lynn Best, commissioned a GHG emission study from E3. This study examined the question of what the environmental impact would have been had City Light participated in the EIM in 2015. The result was that we would have reduced regional GHG gas emissions from EIM participants by 32,000 to 65,000 metric tons of CO_2 through a more efficient dispatch of resources.[22] The study also indicates that City Lights participation in EIM would reduce renewable generation curtailments (or hydroelectric spill) by 50,000 to 117,000 MWh per year, thus preserving the ability of those wind and solar plants to efficiently serve the loads of the utilities that have contracted for their output, rather than seeing them turned off.

Financial benefits will include incremental revenue not available elsewhere.

As stated above, City Light is uniquely situated to take advantage of the EIM design, given our fast and flexible hydroelectric generators and our proximity to other utility BAs that rely upon higher cost thermal resources to meet their needs. While there are several areas of potential financial opportunities our current financial analysis has focused only on opportunities to more efficiently

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[19] See: http://www.rnp.org/eim – we highly recommend you watch this video.

[20] See: https://www.nrdc.org/experts/carl-zichella/start-something-big , https://www.nrdc.org/experts/carl-zichella/big-step-taken-toward-more-coordinated-grid , https://www.nrdc.org/experts/sierra-martinez/sharing-clean-energy-our-neighbors-saving-us-millions , and https://www.nrdc.org/experts/noah-long/west-clean-energy-rising .

[21] See: http://www.nwenergy.org/news/clean-energy-advocates-provide-action-plan-for-climate-change-solutions/

[22] See E3 GHG Impacts of EIM Participation report appended to the end of this analysis. It is worth noting, that the E3 estimate would have been 2.5 to 5 times the total avoided GHG emissions reported by the CAISO in 2015 (thus reflecting the potential positive impact of bringing our carbon-free hydroelectric generation to the EIM).

optimize our portfolio and within-day arbitrage where there is no assumption of a net sale or purchase of energy.[23] City Light estimates a net benefit from its EIM participation at **$2.6 million per year after start-up**.

This estimate is predicated upon the ensemble of benefits modeling work – both internal and external – which has been performed in the last year.[24] In each of these modeling exercises a conservative set of assumptions were used to derive the results produced by the models. Further reinforcing our confidence in the potential for net benefits from EIM participation is the experience of the existing EIM entities, all of whom have seen millions of dollars in benefits each year.

Not all potential benefits were modeled.

Given our 2 million MWhs that are available in an average water year as surplus generation, there will be additional financial opportunities where we will be able to take advantage of the optionality that the EIM provides relative to the existing, bilateral forward, day-ahead, and hour-ahead markets.

All three models City Light used produced similar, though differing results with an overlap that supports the existence of benefits from EIM.

City Light initiated its benefits modeling efforts in 2016, by commissioning a benefits study from E3, as all other potential EIM entities did.[25] The results of the E3 study indicated a potential gross benefit to City Light from EIM participation of **$8-23 million per year**. This range was derived by the model optimizing a day's worth of hydroelectric generation to the most advantageous economic use in the fifteen- and five-minute market. The initial estimate of $23 million was based on 300 MW of sub-hourly hydro fleet flexibility and actual 2015 pricing. The lower range of $8 million was from lowering sub-hourly hydro fleet flexibility to 150 MW and significantly "collaring" high and low pricing and "clipping" out 40% of all pricing volatility. E3 also modeled 2020 benefits based on simulations done for Portland General Electric which had much lower market volatility than are likely to occur and produced the lowest annual gross benefit of $4 million per year.

City Light's Risk Oversight Division then sought to improve on the E3 modeling by developing its own time-sequence model which would simulate EIM bids anchored to a Mid-C price and introduce

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[23] As mentioned above, there will be additional opportunities to utilize the optionality the EIM will provide relative to our existing bi-lateral trading tenors. Since this opportunity "cannibalizes" existing revenues, and would be dependent upon the EIM providing an arbitrage opportunity relative to existing transactions, they have not been analyzed herein.

[24] Final reports/presentations on each of the modeling efforts are attached at the end of this analysis for the reader's convenience.

[25] Energy and Environmental Economics (E3) is a widely respected consulting firm based in California that has done extensive work modeling the intersection of energy markets and the environment. The City of Seattle has commissioned work from E3 in a variety of contexts, and it is our understanding that the City Council has retained E3 in the past as well. Arne Olson, a Partner at E3, and lead on City Light's benefits studies, is well known to City Light and many in the Northwest energy and environmental communities from his time working in Olympia at the then Washington State Energy Office, and its successor agencies. E3 has done the most extensive and thorough modeling of Western energy markets outside of, perhaps, the DOE national labs.

a degree of randomness by constraining market depth.[26] This modeling effort was focused on eliminating the "perfect foresight" element of E3's linear optimization model. The Risk model produced a range of results, tied largely to the quantity of generation made available by the model. Across the more than 200 scenarios run, the model's results ranged from a **negative $4.4 million to a positive $14.5 million** per year, relative to the revenues that would otherwise be generated in the traditional Mid-C market. The negative values, while theoretically possible, assume we are buying back energy at a higher price in the EIM than what we have sold it for that day, without taking corrective action. This is a scenario that City Light actively manages in the present bilateral markets, and there is no reason to believe that EIM participation would change how we actively manage these risks.

Finally, City Light's Power Management Division developed a modeling methodology to estimate EIM benefits in 2020 by using the flexibility and storage that City Light has with its hydro resources. An advantage of this methodology is that it could very specifically dispatch City Light's generation considering hydro plant operating restrictions and City Light's supply and demand balance. To perform the evaluation, Power Management used a combination of existing models and a re-dispatch method to calculate the difference in City Light's wholesale revenue operating in the current bilateral market compared to the EIM sub-hourly market. The difference in wholesale revenue represents City Light's EIM benefit. The models used included a comprehensive electric market simulation model (AuroraXMP) [27] and City Light's Short-term Operations Planning Model (STOMP).[28] The re-dispatch method adjusts generation operations from today's bilateral hourly wholesale market to achieve benefits of participating in a sub-hourly wholesale market. The re-dispatch method was designed to minimize wear and tear on the generating units operating in a 15-minute sub-hourly market. To ensure the re-dispatch method worked as intended, City Light's Generation and Engineering division reviewed the sub-hourly re-dispatch. Using this methodology, City Light estimates EIM gross benefits at **$7 million per year**.[29] These benefits were conservatively

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[26] Mid-Columbia (Mid-C) is the Northwest trading hub for wholesale energy and is the location with the highest volume of bilateral energy transaction in the country.

[27] Aurora XMP is an economic dispatch model that contains all of the generation and loads across the West, and Western transmission system limits. It simulates the operation of the grid across the West and can also include impacts of regulatory changes such as the 50% renewable portfolio standards adopted in California and Oregon. For this reason, it is the primary tool City Light and many other utilities use in their Integrated Resource Planning (IRP) work and commercial resource acquisition decision-making. See: http://epis.com/aurora_xmp/ . City Light's internal optimization model, Short-term Operations Planning Model (STOMP) to seek real world dispatch of City Light's hydro generation. STOMP includes the actual inputs of the true restrictions and capability of our hydroelectric generation.

[28] This includes very granular detail like planned unit outages in the future, and weekly variations in individual generator capabilities that might be constrained, for example, to support endangered species at different times of the year.

[29] It is important to note that not only did the various models use different assumptions, but they studied different years of market activities. In the attached Business Case Analysis we have revised all modeling financial results to use 2016 dollars, hence some of the differences that will be observed in the "raw" results of the various studies, and our aggregation of those results.

estimated using only the 15-minute pricing and did not use the 5-minute pricing which may provide additional value to City Light.

How much can we rely on these modeling results?

All modeling results are determined by the assumptions that are made in creating or running the model. In EIM, the modeling results, to varying degrees, are sensitive to the assumptions made, and to the volume of generation City Light has or will make available, the depth of the market, the range of the sub-hourly prices seen in a day (pricing volatility) and the absolute value of those prices (from negative prices up to $1,000/MWh). In each of the studies summarized above the models were constrained in various ways to provide a conservative "bias" to the results. Some of the limitations that are applicable to this modeling effort include the following:

- Future market pricing dynamics may not follow our historic experience (i.e., the historic data set we rely on may not have the predictive value we think it will);
- Models are simulations of systems of behaviors and outcomes and can only imperfectly simulate the "real world"; and
- Financial models such as these are sensitive to the assumptions, including the quantity of resources brought to the market, market depth and pricing volatility.

These caveats aside, City Light is very confident that with reasonable control on its implementation costs and a careful eye on the on-going operation and maintenance costs there are few reasonable scenarios where we do not accrue additional, net wholesale revenue.

What have been the real-world results experienced by the other EIM entities to date?

Modeling specific financial results is challenging. All EIM entities who have gone live and are actively participating in the EIM have not only experienced financial benefits but in fact, they have commonly exceeded the estimated benefits they made public in advance of "go live".[30] City Light is confident that given our flexible hydroelectric generation at the Boundary and Skagit projects (and the storage capabilities at Skagit) we are very well positioned to take advantage of the opportunity the EIM presents.

The existing EIM entity benefits have been well documented by the CAISO and the individual EIM entities themselves. The CAISO has reported the following benefits for Q4 2016.[31]

1. CAISO Benefits: - $8.7 million
2. PacifiCorp benefits – $9.0 million
3. Nevada Energy benefits - $3.1 million

[30] Notably, APS's first quarter of EIM operations met their pre-EIM forecast of total annual financial benefits.
[31] It should be noted that these are avoided costs to the CAISO and the utilities it serves in California, as opposed to incremental revenue to those utilities. http://www.caiso.com/Documents/ISO-EIMBenefitsReportQ4_2016.pdf

4. APS benefits - $6.0 million
5. PSE benefits - $1.6 million
6. Environmental benefits- reduced renewable curtailments and greenhouse gas reductions of 23,390 MWhs, equivalent to 10,011 tons of CO2.

Another comparator relevant to this discussion is the profitability of Seattle's existing transactions with the ISO market. We currently transact in the ISO via a third party who acts as our "scheduling coordinator." In 2016 we obtained $3.4 million in margin above what would have accrued had we transacted the same quantity of energy at Mid-C. This is equal to a premium of $6/MWh over the Mid-C price. It is also worth noting that most of these transactions were sales, and not purchases due to the $12/MWh CAISO export fee. This fee is not applicable to the EIM and would presumably allow additional surplus solar and wind to reach City Light at low and negative prices, further enhancing the value of our EIM participation. These facts are a solid indication that the optionality provided by EIM participation will be revenue positive for City Light.

As City Light joins the EIM and becomes a scheduling coordinator itself, we would expect these CAISO transactions to continue and expand. These transactions, day ahead and others, would provide additional, incremental revenue to that we expect from EIM. Thus, the real-world experience of the existing EIM entities, as well as our current ISO transactions, support the business case for City Light's EIM participation.[32] We expect that the EIM will offer a greater opportunity to benefit from the CAISO markets than we do today, or than we can achieve absent the EIM.

Reliability benefits will come from greater system visibility for our System Operators.

Looking at the EIM from a reliability perspective is very different than considering the potential costs, benefits and net present value. System Operators are concerned with maintaining reliable service to our customers and preserving the stability of the bulk electric system ("the grid") to prevent black-outs from propagating from a small problem to a large one that can encompass many states. EIM participation will allow City Light's System Operators access to a broader set of information than they have access to today, through access to the tools the CAISO's system operators use themselves. This improved visibility into the actions of the CAISO and the other EIM entities (all EIM entities share their data via the CAISO systems) enhances their ability to do their job effectively. This benefit is difficult to quantify or place a financial value to, but there is a consensus that the benefit is real and is itself a solid reason for EIM participation.

[32] It is worth noting that most existing EIM entities are deriving "avoided cost" benefits through their owned, higher cost resources being displaced by the lower cost resources of other EIM participants. The modeling work City Light has done to date is of a pure arbitrage opportunity through displacing others resources and not through displacement of our own. While there may be limited circumstances where another EIM entity's resources could displace City Light's resources on a cost-basis, it will likely be a rare occurrence given the low-cost nature of our hydroelectric generation. City Light's resources will almost always be the cheapest resources in the EIM.

A number of entities have evaluated the reliability benefits that can accrue through EIM participation, including the staff of the Federal Energy Regulatory Commission.[33] These benefits include the following:

- EIM better manages imbalance across multiple BAs and enhances operators' ability to manage flows within system operating limits,
- EIM provides a Security Constrained Economic Dispatch (SCED) model to manage and solve constrains of regional transmission grid,
- EIM enhances situational awareness,
- EIM potentially decreases the number of Energy Emergency Alerts,
- EIM accelerates the delivery of replacement resources after contingency reserve sharing assistance ends at the top of the hour, and helps address contingencies beyond reserve obligations, and
- EIM assists with the reliable integration of variable energy resources.

In sum, City Light's EIM participation will enhance the reliability of the service we provide our customers and the reliability of the region.

Risk Management Benefits of EIM Participation

Risk management benefits from EIM participation will derive from both the current design of the CAISO market and the contracts for EIM participation. Additional enterprise risk mitigation will derive from the improved skill set of our employees; and the systems and tools they will have available to them.

How do we know we won't have another Enron situation?

Given City Light's history with California markets 16 years ago, it is important to note that much has changed in the interim, which provides substantial risk mitigation. Congress passed the Energy Policy Act of 2005 which made reliability standards mandatory for the first time, and provided the Federal Energy Regulatory Commission (FERC) enforcement authority backed by very substantial penalty authority in the event of market manipulation. To date, FERC has been quite aggressive in exercising that authority when bad behavior has been identified. By 2009 the CAISO had completed a substantial change to its market design and market rules to address previous shortcomings. The CAISO itself and its Department of Market Monitoring (DMM) is very engaged and has the tools

[33] See:
http://www.caiso.com/Documents/QualitativeAssessment-PotentialReliabilityBenefits-WesternEnergyImbalanceMarket.pdf ;
http://www.nrel.gov/docs/fy13osti/57115.pdf ; and
http://www.westerngrid.net/2011/07/26/how-a-westwide-eim-helps-reliability/ .

they need to effectively identify anomalous behavior and if unexplained, refer the matter to FERC for enforcement. This isn't to say that "bad actors" do not occasionally still arise. They do. However, the CAISO, DMM and FERC have been quick to address it, and equally importantly from City Light's perspective, gone back and re-run the market to strip out the negative impacts of that behavior. Collectively, this leads City Light to believe that the CAISO of 2017 is a very different organization in terms of market design, market monitoring and enforcement capabilities than existed in 2000 and 2001.

In general, there are three aspects to consider in the context of EIM: financial risk management associated with market participation, operational or enterprise risk management associated with EIM, and project risk management associated with getting prepared to participate in the EIM. The EIM is a relatively new market and this carries with it some degree of risk. Mitigating that risk, is the fact that it is an extension of the CAISO's existing market, and that the fifteen- and five-minute, within-hour dispatch that the EIM allows has been reliably operating now since 2009. Additional risk mitigation is derived from the contractual relationship that underlies the EIM and would control the financial and operational relationship between City Light and the CAISO, as it does the other EIM entities. These agreements provide for an extremely fast means of stepping out of the EIM in the event something anomalous were occurring within the market itself, or there were system issues that caused the market to behave in an unexpected and negative fashion. The rules allow for this "stepping out" to be for either the short term, to react to a market anomaly or instability, or long-term, ceasing participation in the EIM.

As mentioned above, market depth and liquidity is critical to City Light's wholesale power marketing activities. One aspect of the on-going evolution of wholesale markets across the West is the risk of declining counterparties. The "great recession" saw energy markets lose a number of significant participants, primarily the investment banks, but also some of the energy trading organizations that were either independent or associated with utilities. Several Western utilities, including public power utilities, have chosen to join organized markets when their previous counterparties did so first.[34] While City Light does not face this crisis today, we are aware of it occurring to others and are cognizant of the operational and financial risk to City Light.

The final area of risk to City Light's EIM participation is our ability to effectively manage the risks associated with implementation. This risk is primarily mitigated through active, professional project management (PM). Having recently completed the deployment of a new Energy Management System (EMS) at the system control center, City Light has the opportunity to transition the successful EMS PM team to the EIM project. In addition, the project is supported by an executive sponsor and EIM Steering Committee structure, supported in turn by a "Core Team" of staff level subject matter experts in the primarily affected divisions of City Light. The expectation is that with active project and change management support and a robust training program, City Light will be in a position to effectively mitigate the risks of successful project implementation.

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[34] Basin Electric Cooperative, a WAPA customer serving the Dakotas region saw their trading partners decline from 55 in 2002, to 21 in 2012, to 11 in 2014, to 5 by the end of 2014. This was the primary motivation for the WAPA – UGP region joining SPP in 2014/2015.

How will City Light's EIM participation support its employees?

In order to effectively participate in the CAISO EIM City Light will have to substantially change what it does and how it does it in a number of areas. Whether in system operations, power production, power marketing or risk management/settlements, City Light must continue to do the good work it does today, while also embracing a new set of challenges and opportunities. EIM will force City Light to address institutional barriers to communication and build new work flows and business practices to engage the EIM productively. This will require employees across the organization to learn new skills and be ready to embrace the change that EIM will bring to our organization. By enhancing the professional skills of our employees and engaging them in new ways of doing business we will be enhancing the employee experience of these employees as well modeling the behaviors we are seeking as part of our Utility Operational Excellence initiative.

Training will be a critical foundation for successful EIM participation. The CAISO supports the EIM through a set of two dozen Computer Based Training (CBT) modules and a variety of in-person classes.[35] Because of EIM participation, our people at City Light will be ready and resilient to the changes that are now sweeping through the utility industry – whether it is zero marginal cost energy like wind and solar, electrification of transportation, or the accelerating rate of change in energy markets themselves that the EIM exemplifies.

<u>There are substantial quantitative and qualitative benefits to City Light with EIM participation.</u>

As reflected above, there are a range of benefits that will accrue to City Light, and by extension to our retail customers, above and beyond the net, incremental revenue that will be derived from participation in this market. Every EIM entity that has "gone live" or is nearing their go-live date has shared their experience of improving their existing operations. The process of implementing EIM forces a wide range of underlying issues to the surface. The project also provides the affected staff the tools to address the issues identified, and improve the existing business practices and work flows they use. City Light anticipates we will experience a similar improvement in our existing market transactions and performance because of preparing to join the EIM.

Other unquantified benefits include the following:

- More efficient use of the regional transmission system. In the EIM, optimized and automated dispatch facilitates the most economic dispatch of resources to serve loads. Currently City Light is limited by its own resources and transmission. The ability to leverage a larger pool of resources and transmission equates to greater efficiency which results in better economics for City Light customers;
- The opportunity to arbitrage the bilateral markets and the EIM. City Light will have the ability to analyze and select which market, or a combination of, will yield the most value for its resources and transact accordingly. The EIM is only continuing to grow; the ability to access

[35] City Light is exploring with the CAISO and City Light's training staff whether the CAISO CBTs can be ported to our Cornerstone training system.

a larger pool of buyers and sellers gives a new opportunity to maximize economic opportunities;

- The EIM could also open up the ability for City Light to sell new products, such as flexible ramping products, or frequency response to CAISO participating utilities. In several different market segments, the CAISO's flexible ramping requirements create an opportunity to leverage City Light's resources in new ways which can result in additional revenue;
- EIM participation can also reduce City Light's internal costs incurred for the requirement to hold regulating reserves. This benefit, like the others discussed above, again comes from the pooling nature of the EIM. In the EIM, regulating reserve obligations are pooled, shared, and spread over numerous entities. The net result of sharing this responsibility is that each entity is required to hold fewer reserves than would be required without access to this pool;[36] and
- EIM participation comes with a potential reduction in the cost of managing load and weather forecast uncertainty. Shifting part of this forecasting obligation not only reduces management costs, but allows City Light access to more expansive, larger scale, and continually improving forecasts. The CAISO is actively expending resources and increasing modeling inputs which allows for more comprehensive forecasting across the region and reflects a greater allocation of resources than City Light could justify on its own.

Costs

Are the financial benefits sufficient, and sufficiently certain, to outweigh the costs of implementation and on-going operations?

City Light is confident that EIM participation will be cash-flow positive in the first year of operations, and thereafter.[37]

While there is some degree of uncertainty inherent in modeling potential benefits, costs are an area where we can have greater certainty. The primary area of risk associated with the cost of preparing to join the EIM relates to Operational Technology (OT) systems that support power marketing activities. Thankfully, since several EIM entities have already gone through this process, we have the benefit of their experiences. While all OT projects run the risk of exceeding the anticipated budget, a careful use of contingencies can quantify that risk and limit it. In EIM the primary question we will face is whether our existing power marketing and trading risk management systems are capable of being augmented to meet our needs (low cost) or whether they need to be replaced comprehensively (higher cost). Also, a hydro-optimization tool will likely be required, which will also increase OT costs.

One area where prior EIM entities faced significant additional cost and implementation risk was in updating or replacing the Energy Management System (EMS) that their system operators use to control generation, transmission, and distribution systems. City Light recently completed its EMS replacement

[36] This is similar to, though different from, the existing contingency reserve sharing program managed by the Northwest Power Pool.

[37] See "2017 Detailed Business Case Analysis Report" attached below.

project, did so successfully, and therefore is better positioned than most of the other current and future EIM entities were at this stage of the project.

The cost of implementing EIM at City Light will be primarily one of OT infrastructure, consultant services, and training. The on-going operation and maintenance costs will be primarily driven by increased staffing expense and on-going licensing fees for software systems.

As the detailed EIM Project Business Case that is attached hereto reflects, City Light believes we are likely to incur less up-front capital costs associated with upgrading generation and transmission meters due to recent regulatory changes at the CAISO, but may have higher OT costs if our power marketing systems require replacement. However, with increased automation we foresee a potentially lower long-term staffing requirement, with associated labor savings occurring after EIM implementation.

Recently, CAISO has indicated a potential avenue by which they would acquire and host the required "Bid-to-Bill" systems that EIM entities have, to date, been required to obtain and operate on their own as a precondition of effective EIM participation. If this opportunity eventuates there is the possibility for very substantial savings on up-front capital and long-term O&M expenses by effectively "splitting" the cost of the Bid-to-Bill system with other EIM entities (50-75% savings are possible). Neither this analysis nor the City Light "2017 EIM Project Detailed Business Case Analysis Report" that accompanies this participation analysis reflect this opportunity, as it is still very nascent and lacks the requisite specificity for purposes of financial planning. However, we are very confident that both City Light as well as other current and future EIM participants will be supportive of the CAISO taking this new, innovative approach to supporting EIM entities and we expect to have greater details in the coming weeks and months.

What staffing changes are you anticipating as a result of this project?

City Light currently estimates the EIM project will require eight incremental additions to our represented positions in the affected divisions of the department. While the exact makeup of these staffing needs will involve tradeoffs between the specific OT systems and internal processes that we develop to meet the requirements of this market, current information indicates that the staffing needs may be as follows. Four positions (in addition to an existing vacancy) may be used to allow the creation of a 24/7 desk to support EIM at the system operations center. Two positions may be required in the settlements team within Risk Management to manage settlements, shadow settlements, and metering data upload and validation activities. Power Management may need two additional positions to develop and submit bids to the EIM and engage in bid analytics to iteratively improve our bidding behavior.

Won't EIM increase the wear and tear on City Light's generating units and therefore increase your operating costs?

Increased wear on the generating units is a significant concern and one we have been addressing. City Light's Power Production team has done an initial study to estimate possible impacts and the preliminary conclusion is that they will likely be minor.[38] While this result may seem counter-intuitive, it

[38] Phase 1 Study - Estimated Operating Cost Increase in Turbine/Generator Maintenance from Load Cycling in EIM Market, January 27, 2017 draft.

is important to remember that all our modeling assumptions to date about the dispatchable range of our hydroelectric generating units made available to the EIM modeling efforts have been conservative, and were approved by Power Production before they were modeled. A 300 MW dispatchable range is well within the capabilities of our units collectively, and equally importantly, is well within the range of current operations. At a high level, the most critical factor in generator wear and tear is the number of "cold starts" and "cold stops". So long as the units are set up in advance to be able to respond to the EIM dispatch instructions in a manner that minimizes the number of cold starts and stops per day, the O&M cost will change, but should not change significantly from current operations. The initial power production study results are preliminary and will be continuously updated during EIM implementation and thereafter to assure we are appropriately reflecting actual costs of generation in our EIM bids.

Are there other opportunity costs associated with EIM participation that you have considered?

City Light anticipates redirecting a yet-to-be-determined amount of our existing BPA Point-to-Point transmission rights to support EIM transfers with the other EIM entities and the CAISO. This is effectively a "sunk cost" and will not change our BPA transmission expenses. However, transmission rights "redirected" for purposes of EIM will no longer be available for re-sale, so there may be an opportunity cost of EIM participation. The resale value of transmission on the BPA system is quite low, and often buyers are not available in the bilateral market today for our staff to remarket surplus transmission to in all hours of the year. We have embedded a $900,000 transmission opportunity cost in our financial analyses. City Light has already commenced internal and external discussions regarding how we might optimize our transmission rights in the context of EIM. We expect that even after that decision is made and implemented, it will be subject to reevaluation on a routine basis.[39]

We do not anticipate an opportunity cost associated with energy sales or capacity sales as our anticipated daily EIM arbitrage activities are energy and capacity neutral at the end of the day. If we were to make net sales into the EIM, we would only do so where it was financially more beneficial for City Light to do so, as opposed to existing forward, day-ahead or hour-ahead transactions. As discussed above, City Light currently transacts in the CAISO day-ahead market via a third party and accrues several million dollars a year by doing so. One consequence of EIM participation would be to position our Pre-schedule desk in Power Marketing (day-ahead) to engage in additional CAISO transactions directly, thereby potentially saving the relatively small payment we make to the current third party for doing so on our behalf.

[39] It should be noted that EIM transfers are not limited by the amount of transmission rights on BPA we choose to redirect. For example, we can use our existing points of interconnection with PSE to facilitate EIM flows between City Light and PSE. Similar opportunities may exist with Idaho Power regarding Lucky Peak, and other contracted resources we have that reside in other utility BAs.

Results of Financial Analysis

The following table is a summary of the results of our 2017 Detailed Business Case Analysis Report. Please see the attached report and associated .xls workbook for the detailed financial information.

	Range of Estimates			Source of estimate
Key Variables	Low	High	Expected	
CIP	$7.4 million	$12.3 million	$8.8 million	Internal estimates and Utilicast review
O&M	$1.7 million	$4.4 million	$2.8 million	See above
Net Revenue after Transmission	$1.7 million	$10.3 million	$5.4 million	Risk study (high, low),[40] Resource Planning study (base)
Payback	None	3 years of operations	5 years of operations	

[40] The 25% and 75% probabilities for 2015 pricing and the hourly trading model are the low and high revenue cases, respectively.

Attachments

1) 2017 Energy Imbalance Market Project Detailed Business Case Analysis Report, March 14, 2017:
    a) Updated business case; and
    b) SCL_EIM.xlsx Excel workbook of supporting data
2) Energy & Environmental Economics Reports:
    a) EIM Study and Appendices
    b) EIM GHG Study
3) City Light's Risk Oversight Division Benefits Analysis
4) City Light's Power Marketing Division Benefits Analysis
5) Utilicast Reports:
    a) Seattle City Light EIM Gap Analysis
    b) Metering and Communications
    c) Organizational Structures