

The projections herein are preliminary and will change based on further investigation. See Slide 3 for more information.



Kentucky Municipal Energy Agency

Assessment of Renewable Resource Options (Screening Level Analyses)

December 14, 2016

Revised 12/19/2016

Public Information

Status Report – Renewable Resource Assessment

The objectives of this presentation are:

- Review initial results of comparative analyses;
- Review input received during Frankfort stakeholder meeting; and
- Provide our conclusions based on the analyses prepared.

To accomplish the above objective, the following topics will be discussed

1. Goals of current assessment;
2. Alternatives and key assumptions;
3. Results of the Comparative Analyses; and
4. Preliminary conclusions.

Goals: Assessment of Renewable Energy Resources

The goals of this assessment of renewables were to:

1. Identify the types of renewable energy resources that might be considered further for incorporation into KyMEA's Portfolio as soon as May 1, 2019;
2. Develop high level estimates of the magnitude of the impact on the Members' costs of all requirements power supply of those renewable resources; and
3. Identify appropriate next steps based on the results of the study.

Note:

The analyses presented in this Assessment of Renewable Resource Options are intended to be used to screen potential options, narrow the list for further consideration, and provide a greater understanding of the key issues that will need to be considered in structuring procurement processes and evaluating proposals received from prospective suppliers.

The analyses are not intended to be a basis for a final decision to proceed (or not proceed) with any particular resource or to provide a definitive assessment of the projected increase or decrease in costs that may be incurred by KyMEA and its Members by implementing any particular resource.

Renewable Energy Options

The following 4 categories of renewable resources were investigated.

Wind

- TX and OK resources via Clean Line DC transmission project
- MSIO Zone 6 resources (IN/KY)

Solar PV

- Utility-scale solar project constructed in one or more Members' systems
- Small Scale solar projects connected to Members' systems

Hydro Energy

- New projects under development in MISO

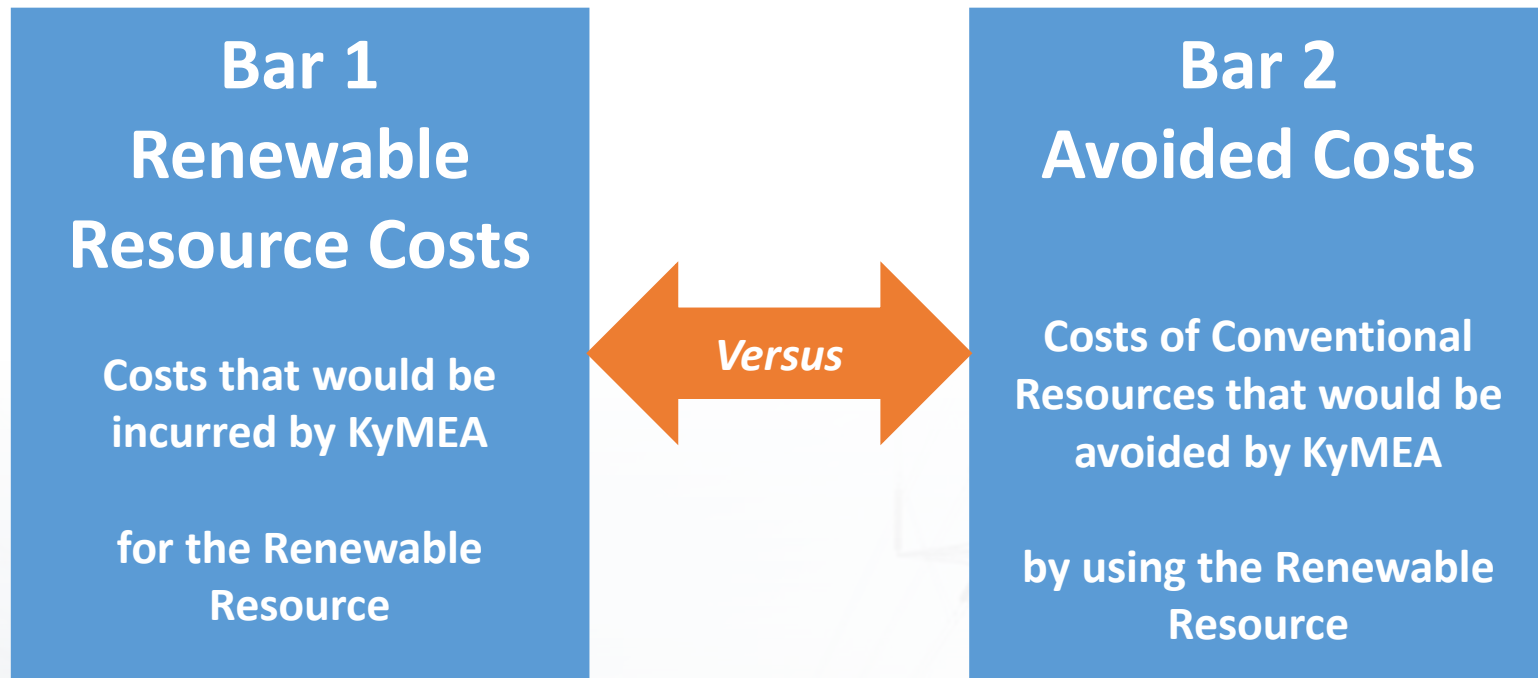
Alternative Fuel Sources

- Landfill gas (LFG) internal combustion engine
- Biomass-fired steam generators

Comparative Quantitative Analysis

The following comparison was made for each type of Renewable Resource

To determine the potential impact on KyMEA's costs of each renewable resource, we compared:



For a renewable resource type to lower the costs of KyMEA's AR Members, the bars representing the renewable resource costs would need to be shorter than the bars representing the costs of conventional resources that could be avoided on Slides 19 - 22.

Comparative Quantitative Analysis

We considered both Capacity and Energy Costs

Capacity Costs Are:

Costs or charges incurred to have rights to the capacity of a generation resource or a system of resources. The capacity of the resource would be used by KyMEA primarily to:

1. Meet resource adequacy requirements, and
2. Provide energy.

Capacity costs are often fixed monthly or annually and do not vary with the amount of energy produced or purchased. Capacity costs are similar to a car payment. It gives you the right to use a car.

Energy Costs Are:

Costs or charges incurred to purchase or produce energy.

Energy costs typically vary with the amount of energy purchased or produced in a period.

Determining the Amount of Energy Produced or Purchased

- For conventional resources, the amount of energy produced or purchased typically may be scheduled daily or hourly by the Buyer. Sellers typically make a separate charge for capacity and energy.
- For wind and solar resources, the amount of energy produced or purchased depends on the extent to which the wind or sun is available to make energy production possible. For these resources, Sellers typically specify that Buyers must take all energy produced and Buyers are charged an energy price that covers the Seller's capacity and energy production costs. Buyers have to use a different source of energy if the renewable energy is not available.

Components of Resource Cost and Avoided Cost Computations

Cost Component	Renewable Resource Costs include	Avoided Conventional Resource Costs include
Costs of Capacity	<p>For owned options, debt service on capital costs and fixed O&M</p> <p>For solar and wind PPAs, typically N/A</p> <p>For hydro PPAs, capacity charges</p>	<p>Avoided costs of purchasing peaking capacity</p> <ul style="list-style-type: none"> ➤ In the amount of the resource's Accredited Capacity ➤ Times an avoided cost rate based on the Paducah contract capacity rate
Cost of Energy	<p>For owned options, fuel and variable O&M, if any</p> <p>For PPAs, assumed charges determined based on a specified energy rate.</p> <ul style="list-style-type: none"> ➤ Expect must-take provisions for wind and solar 	<p>Avoided costs of purchasing energy from the MISO market</p> <ul style="list-style-type: none"> ➤ For projected pattern of output of the resource. ➤ At the interface between MISO and LGE/KU
Delivery Costs	Assumed costs of transmission service and losses and congestion charges to the LGE/KU interface	For resources located on Member systems, any avoided costs of transmission on LGE/KU system
Replacement Capacity and Energy Costs	For owned options, the assumed cost of replacing capacity and energy lost due to resource degradation over time	N/A

Key Assumptions Concerning Renewable Resource Options

See next slide for explanation of key terms.

Description	Purchased ("PPA") or Owned ("Resource") by KyMEA	Accredited Capacity as % of Installed Capacity	Modeled Annual Capacity Factor %	Example Project Installed Capacity MW	% of AR Energy (Assuming Example Project Size)	Installed Facility Cost (2016 \$ Million per MW of Installed Capacity)	Resource Life/ Potential PPA Term (Yrs.)
Wind OK	PPA	15%	55%	50.0	17.19%	-	20
Wind IN	PPA	10%	33%	50.0	10.25%	-	20
Solar PPA	PPA	59%	16%	5.0	0.51%	-	20
Solar Large	Resource	59%	16%	5.0	0.51%	\$2.1 M	20
Solar Small	Resource	59%	16%	0.1	0.01%	\$2.6 M	20
Hydro - Exist Dam	PPA	57%	56%	10.0	3.53%	\$4.8 M	40
Hydro - New Dam	PPA	57%	56%	10.0	3.53%	\$6.2 M	40
LFG - Exist Sys	Resource	100%	88%	2.0	1.10%	\$1.9 M	15
LFG - New Sys	Resource	100%	88%	2.0	1.10%	\$2.6 M	15
Biomass – Boiler	Resource	100%	88%	50.0	27.44%	\$3.6 M	25

Explanations of Special Terms on the Key Assumptions Slide

1. **Installed Capacity**

- The pace at which energy can be produced during peak load hours in the summer (i.e., MWh's per hour)
- For instance, a conventional resource with a capacity of 10 MW could produce 10 MWhs (which is the same as 10,000 kWhs) in each hour it runs during typical summer conditions.
- The installed capacity would drive the costs to KyMEA of the capacity.

2. **Accredited Capacity**

- The amount of the installed capacity of a renewable resource that a regulatory agency allows a load serving entity to count toward meeting the entity's capacity requirements.
- For solar and wind resources, the accredited capacity is much lower than the installed capacity.
- For conventional resources, the accredited and installed capacity ratings are typically the same.
- The accredited capacity would determine the reduction in other capacity resources achievable by KyMEA.

Explanations of Special Terms on the Key Assumptions Slide (Continued)

3. Annual Capacity Factor

- The amount of energy assumed produced as a percentage of the amount that could be produced if the resource operated at its summer installed capacity rating in each and every hour of a year.

4. % of AR Energy

- The percentage of the total energy needed by all of KyMEA's members in a year that could be provided by one resource of the size shown in the column headed "Example Project Installed Capacity MW"

Overview of Data Sources

We obtained data for this study from the following types of sources.

1. Indicative wind prices in OK/TX were provided from multiple sources.
2. Indicative pricing of the Clean Line DC Project was provided by the developer.
3. Indicative pricing of energy from wind resources located in Indiana was provided by a prospective owner/operator.
4. Indicative pricing of energy from solar resources was provided by a developer/owner/operator.
5. Data was used from recent solar projects undertaken by other clients.
6. Information was obtained from National Renewable Energy Laboratory (NREL) publications.

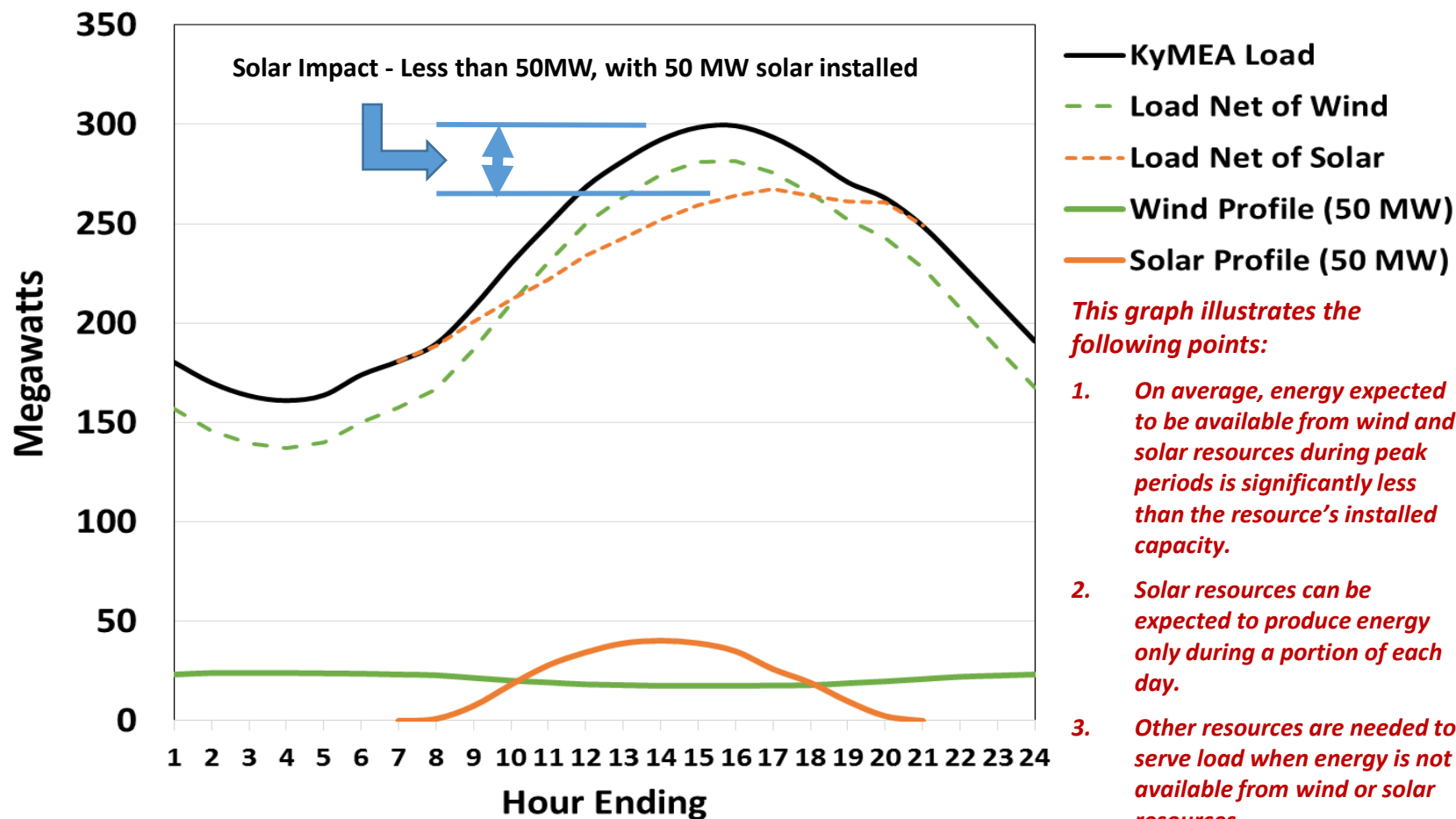
Availability of Energy from Solar and Wind Resources

The following four Slides illustrate important characteristics of the production of energy by solar and wind resources that impact the use of renewable resources in physically serving the loads of KyMEA's Members.

These characteristics must be taken into account when determining the feasibility of using renewable resources.

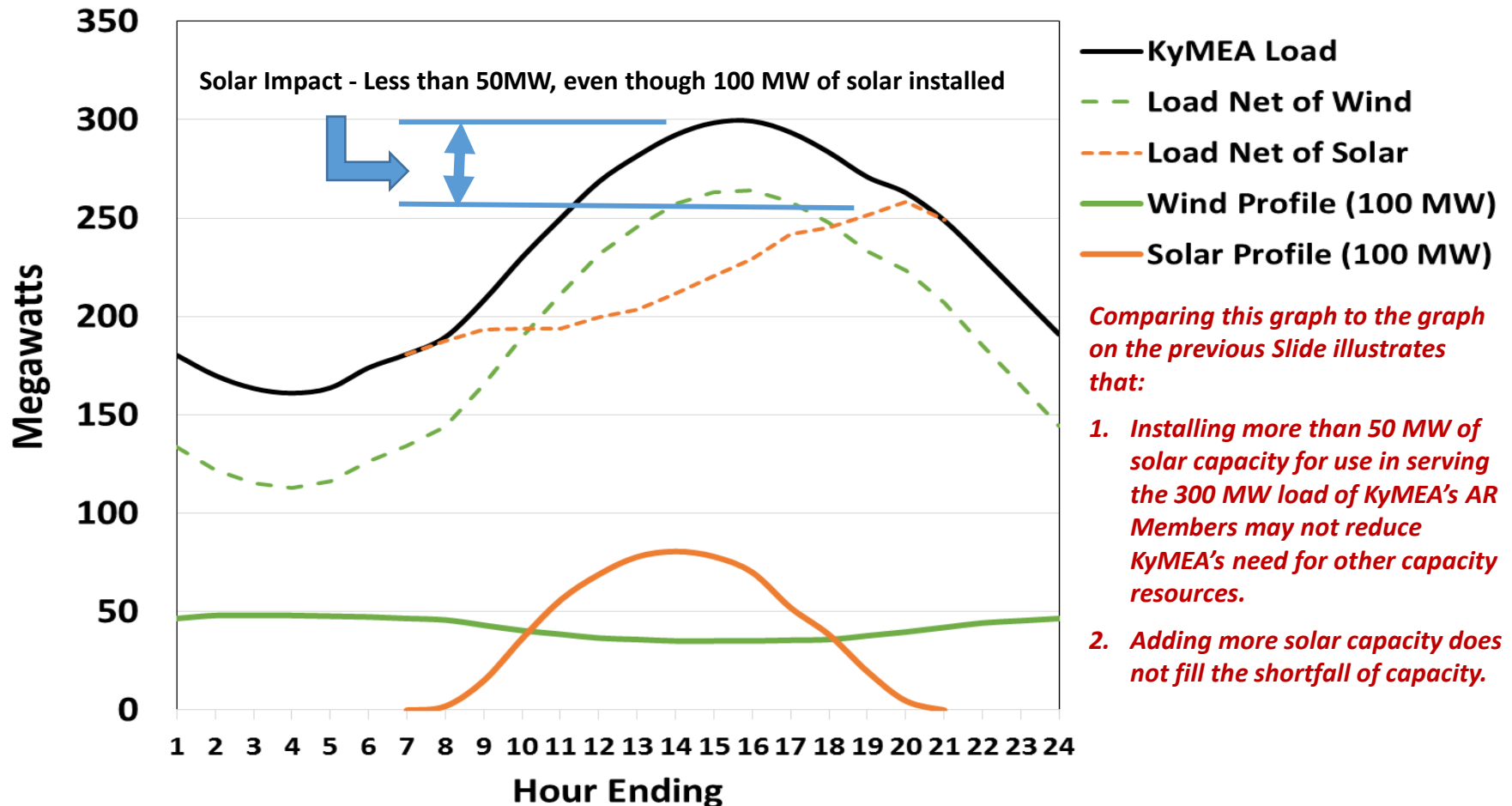
Hourly Energy from Solar and MISO Wind Resources – 50 MW

Comparison of KyMEA System Summer Hourly Load Profile and Indicative Renewable Resource Profiles



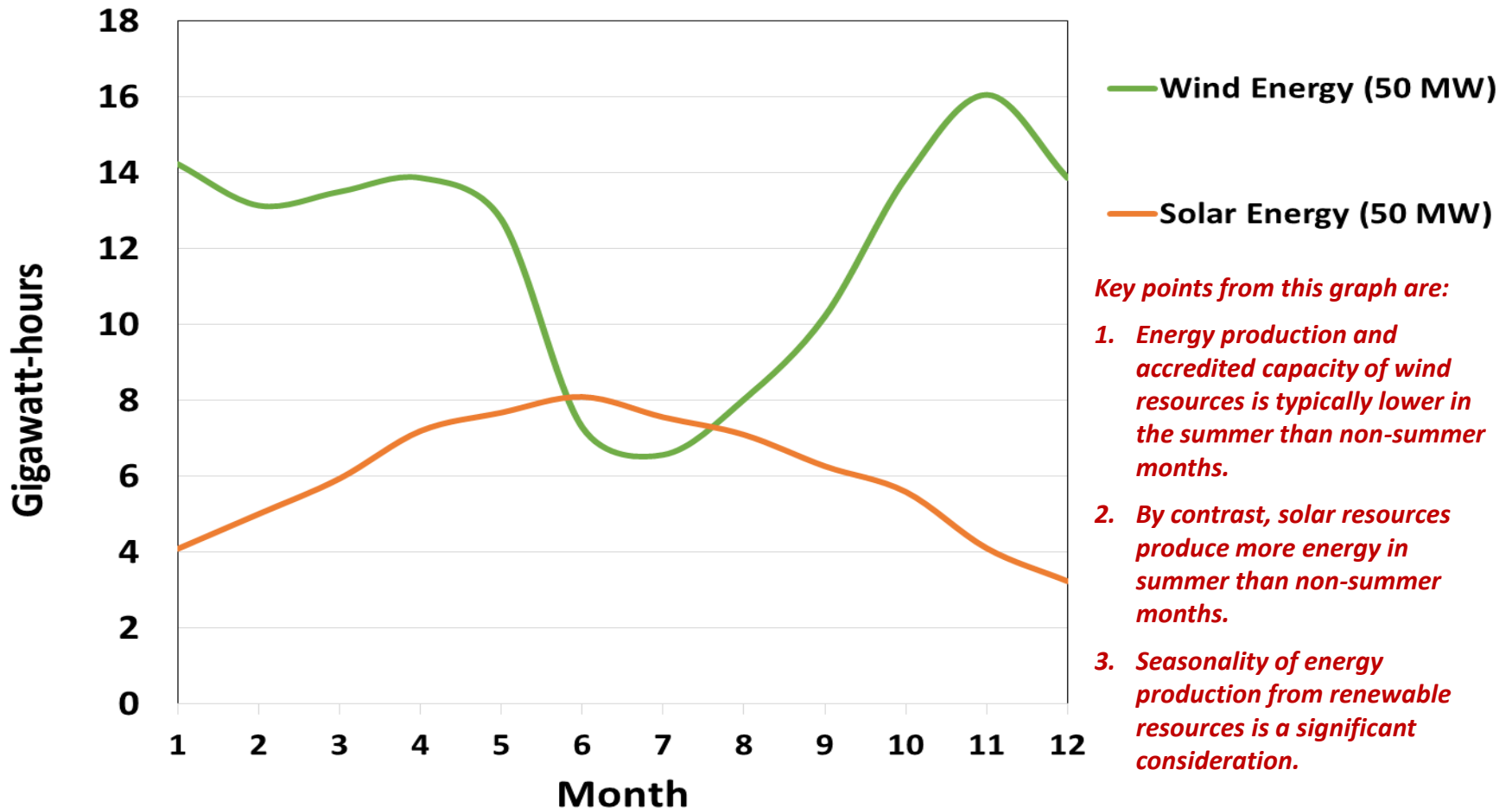
Hourly Energy from Solar and MISO Wind Resources – 100 MW

Comparison of KyMEA System Summer Hourly Load Profile and Indicative Renewable Resource Profiles



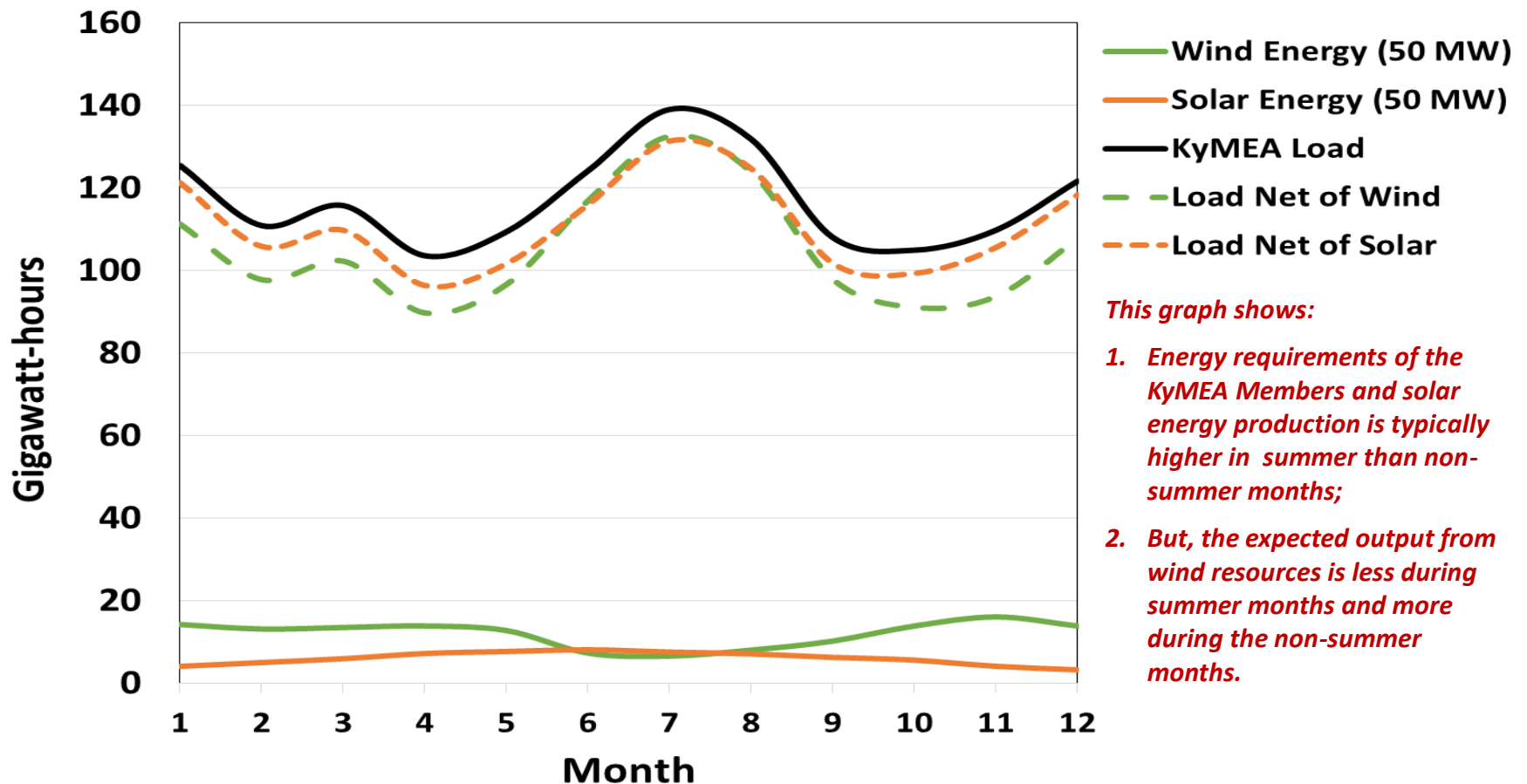
Monthly Energy from Solar and MISO Wind Resources – 50 MW

Comparison of KyMEA Monthly Load
and Indicative Renewable Resource Monthly Energy



Monthly Energy from Solar and MISO Wind Resources – 50 MW

**Comparison of KyMEA Monthly Load
and Indicative Renewable Resource Monthly Energy**



Initial Understandings regarding Customer Priorities

1. Interest in Renewables Varies Among the AR Members' Customers

- a. Industrial and commercial customers tend to be most interested in lowest price of electricity.
- b. Some residential customers are very interested in renewables, but only a portion of those interested will participate if there is much impact on their cost of electricity or a capital outlay required.
- c. Some stakeholders would see renewables as adverse to the interests of KY coal businesses and jobs.

2. KyMEA should continue to place a high priority on affordability and adequacy of its AR power supply portfolio

KyMEA should seek to Identify renewables that:

- a. Are attractive in terms of total costs;
- b. When integrated into KyMEA's portfolio, are consistent with KyMEA's goal of remaining competitive with KU under a wide range of circumstances; and
- c. When integrated into KyMEA's power supply portfolio, do not:
 - a. reduce the assurance that adequate power supply resources will be available during peak demand periods;
 - b. increase the chance of power curtailments; or
 - c. expose KyMEA's Members to spikes in costs during periods in which the renewable resource is not available to meet the energy requirements of the Members' customers

3. KyMEA may also consider implementing renewable resources on a subscription basis

- a. Such that the resource is used and paid for only by those AR Members that choose to participate in the resource
- b. This strategy is likely to be most applicable to very small renewable projects

Comparative Analyses Results

The following 4 Slides show comparisons of the cost of renewable resources to the cost of conventional resources that would be avoided by KyMEA by using that type of renewable resource. Results are shown for the following type of resources:

Slide 19 – Wind

Slide 20 – Solar

Slide 21 – Hydroelectric (“Hydro”)

**Slide 22 – Land Fill Gas (“LFG”) and
Biomass (Boilers that would burn biomass products such as wood)**

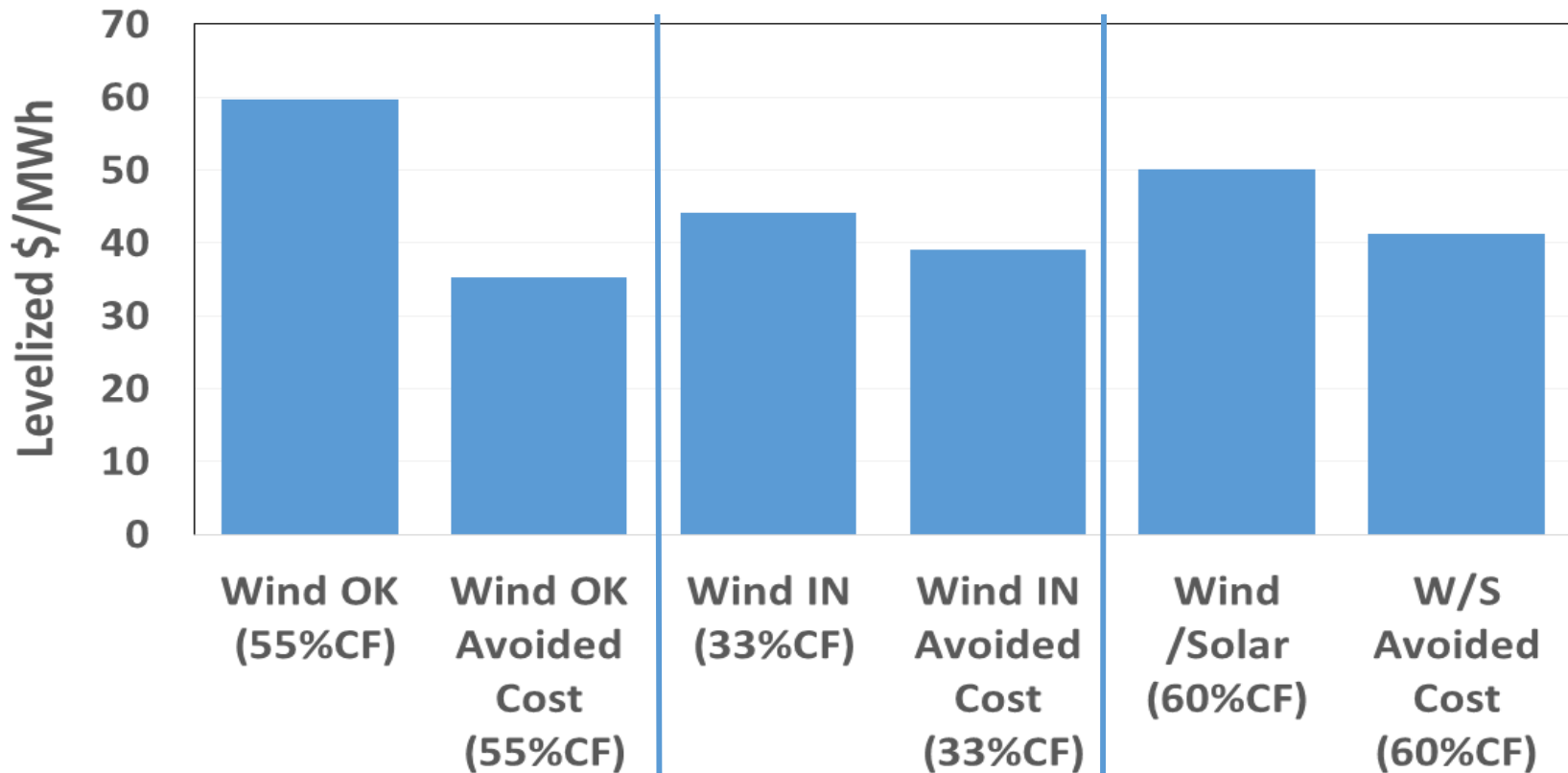
For each resource type shown on each Slide, the bar or bars to the left represent the projected total cost to KyMEA of the renewable resource and the bar to the right represents the projected avoided cost of conventional resources.

If the height of the renewable resource cost bar is higher than the avoided cost bar, implementing the renewable would increase KyMEA’s costs.

Comparative Analysis – Wind Resources

The projected cost of purchasing wind from resources in Indiana is the most competitive of the wind resources considered.
(See middle two bars.)

Renewable Resource Analysis Average Levelized Cost (2019-2029)

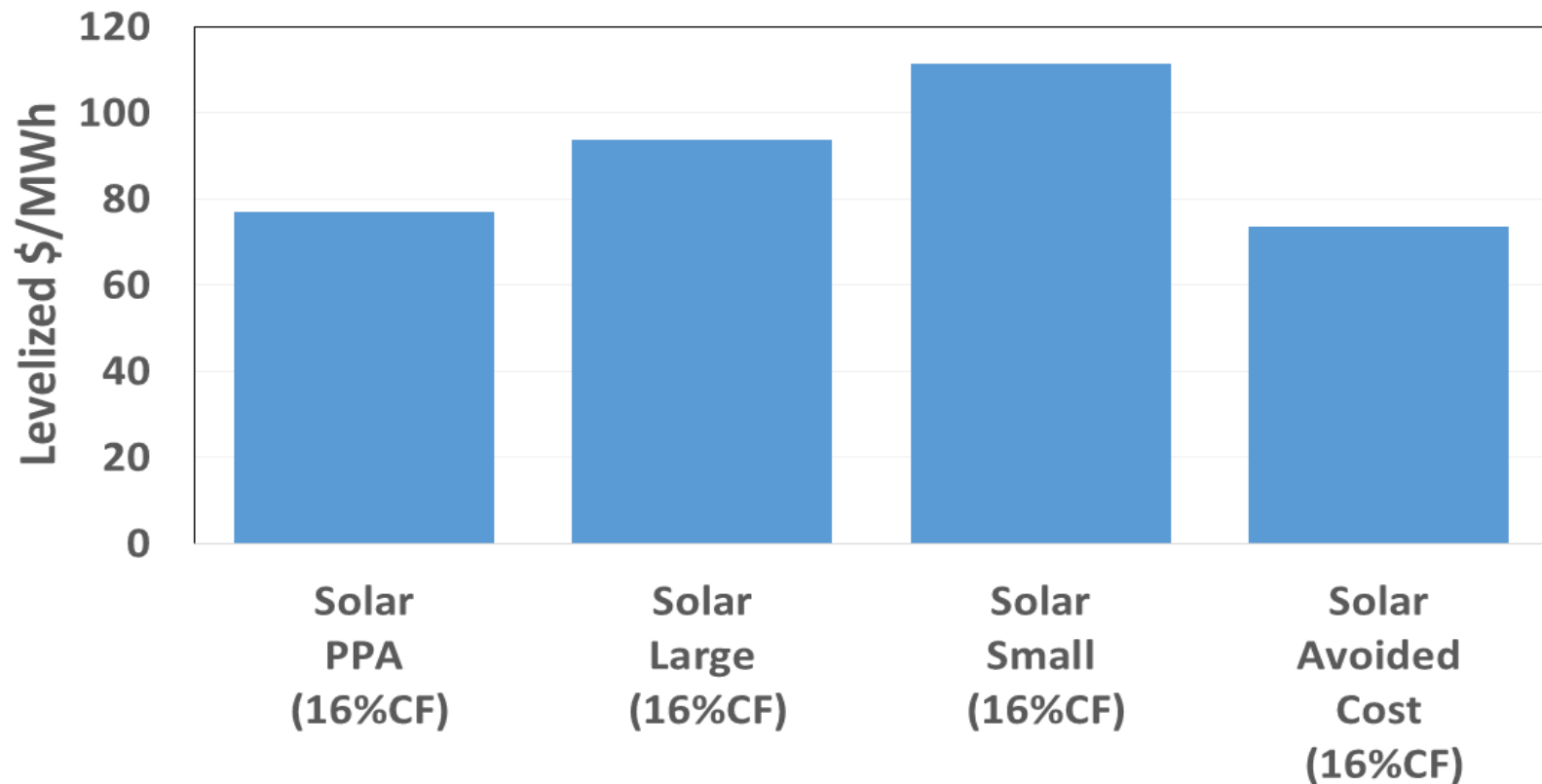


Comparative Analysis – Solar Resources

The data available indicates that purchases from utility scale solar plants developed by others may be most cost competitive.

There are significant economies of scale in developing solar resources.

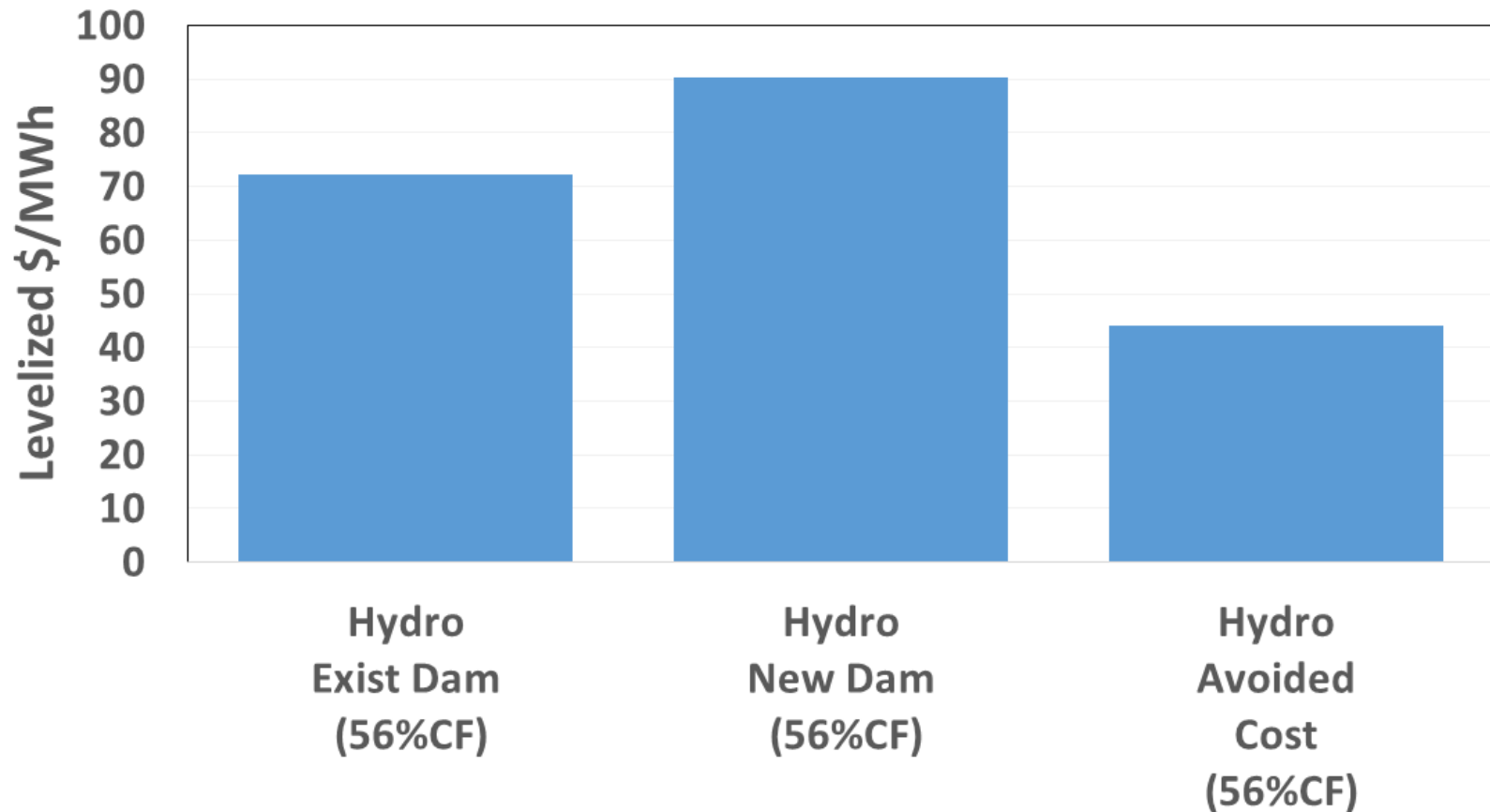
Renewable Resource Analysis Average Levelized Cost (2019-2029)



Comparative Analysis – Hydro Resources

The cost of hydro resources in the area appears to be high relative to conventional resources.

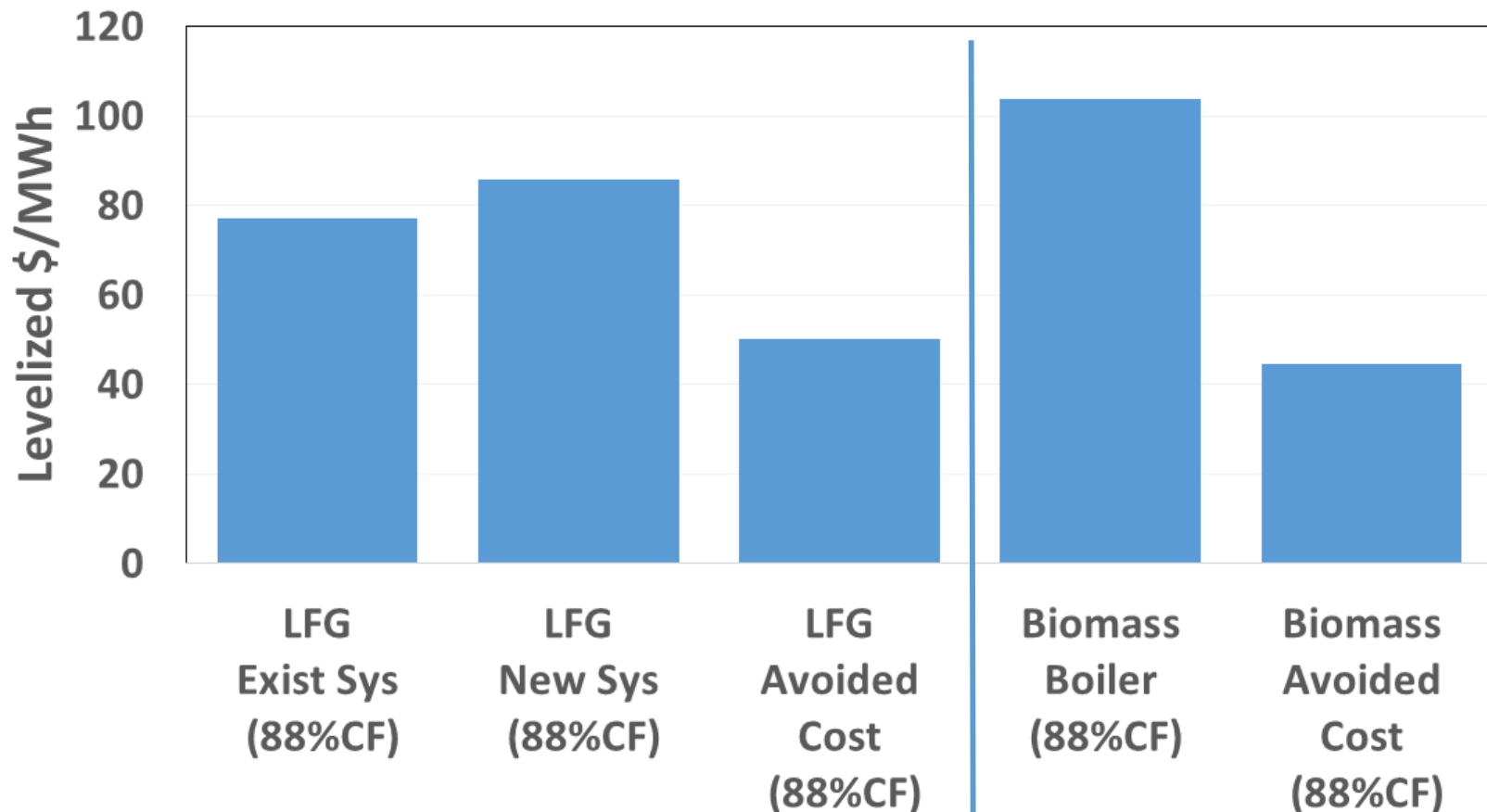
Renewable Resource Analysis Average Levelized Cost (2019-2029)



Comparative Analysis - Alternative Fueled Resources

Landfill gas (LFG) is more cost effective if gas can be used from the landfill without charge (which would lower the bar to the far left by 20% to 25%) and there is an adequate existing collection system in the landfill.

Renewable Resource Analysis Average Levelized Cost (2019-2029)



Results of the Comparative Analyses

Of the options assessed, the annual costs of the following Renewable Resources would compare most favorably with KyMEA's avoided costs over the 10-year period May 2019 through May 2029. Other renewable options considered appear to be much higher in cost relative to comparable KyMEA avoided costs. None of the options assessed are projected to result in lower costs for KyMEA.

1. Purchase of wind capacity and energy

- a. A purchase of wind energy from a project within MISO – Indiana appears to be the lower cost option for wind available to KyMEA at this time.
- b. Seller's expectations regarding the minimum transaction capacity may impact the decision – sellers seem most interested in 50 MW or more, which may be a larger commitment than KyMEA should make at this time.
- c. More investigation of congestion, losses, curtailment exposure, pricing, project size, and output patterns would be needed to confirm or modify our initial assessment.

2. Purchase of solar capacity and energy

- a. Our initial assessment indicates that purchasing the output of a solar project may be lower in cost than the self build option.
- b. More investigation of PPA terms and new project costs would be needed to confirm or modify our initial assessment.

3. Develop landfill gas project(s)

- May be cost effective if landfill gas can be obtained without charge and/or we can verify a substantially lower O&M allowance.
- Economics are very dependent on the specifics of the landfill design and fixed O&M allowances deserve more investigation.

For each option, the longer term comparative cost analysis typically will be more attractive than the comparison for the first 10 years.

Qualitative Considerations

Consideration	Wind 25 to 50 MW	Solar 1 to 5 MW	LFG 1 to 3 MW
Practical for Member Locations?	No	Possibly, 5-6 acres per MW	Depends on Locating an Existing Site(s) with Certain Characteristics
PPA or New Build?	PPA	PPA or New Build	New Build
Could be Available by 2019?	Indiana – potentially OK/TX – not until early 2020's	Probably but dependent on planning and construction schedule	Probably but dependent on planning and construction schedule
Minimum size usable by KyMEA?	50 MW normal minimum needs more careful analysis, 20-25 MW expected to be useable	1 to 5 MW would allow reasonable economies of scale and be usable by KyMEA	Likely useable, normally will be 1-3 MW
Requires financing by KyMEA?	No	For a PPA, no. For a small scale project located on a Member's system, potentially.	Expected

Qualitative Considerations -- Timing

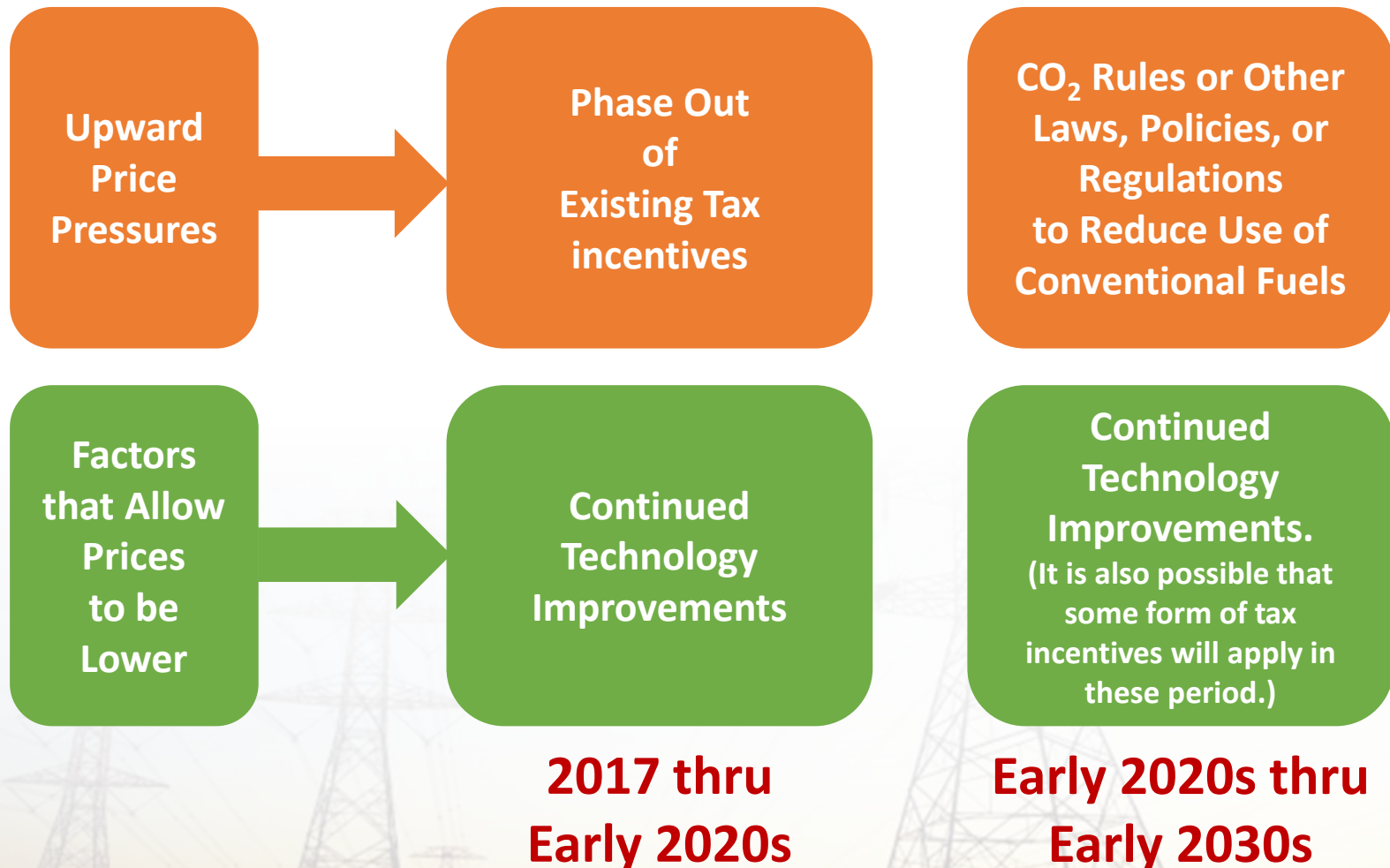
1. Tax incentives under Current Law

- a. Production tax credits (PTCs) for wind resources will decline by 20%, 40% and 60% for projects commenced in 2017-2019, respectively.
- b. An investment tax credit (ITC) of 30% remains applicable to solar projects commenced through 2019, and declines thereafter.
- c. Tax incentives reduce the cost of energy from wind and solar resources significantly, but do not fully offset differences in costs relative to conventional resources.
- d. A small PTC is available for LFG and Biomass projects that commence construction by the end of 2016. (Given timing, we have not considered this tax incentive to apply in the analysis.)
- e. Implications: Unless tax incentives are extended, the cost under PPAs of energy produced from wind and solar resources may increase in the near future. This will also depend on CO₂ legislation.
 - a. Wind PTCs are believed to reduce current prices paid under PPAs by as much as 40% to 50%.
 - b. Solar ITCs are believed to reduce current prices paid under PPAs by as much as 25% to 30%

2. Technology Improvements

- a. Wind resource costs are projected to continue to decrease through the 2020s. One study indicates wind costs/MWh of energy produced from new projects built in 2030 would be lower by 24% to 30% than costs/MWh of energy produced from recently built projects.
- b. In the most recent 2 years, PPA prices for solar energy appear to have decreased at a somewhat slower pace than in the immediately prior two years. This may have resulted from multiple factors.
- c. Construction of proposed DC high voltage transmission projects to transmit wind and solar energy from Oklahoma and Texas may be completed in the early 2020's.

Factors Expected to Influence Prices for Renewable Energy over the Planning Period



Discussion of Primary Conclusions

Attractiveness of Potential Renewable Resources

1. None of the options assessed are projected to result in lower costs for KyMEA under our base case set of assumptions regarding the projected cost of the renewable resource types considered and the cost to KyMEA of capacity and energy from conventional resources during the 2019-2029 period.
2. Of the renewable resource types studied, purchases of energy produced from wind resources in Indiana or from a solar project in MISO owned by a taxable entity are the closest to being competitive with conventional resources.
3. A landfill gas project under very favorable conditions (i.e., no charge for gas and suitable gas collection system already in place - see part 3 of Slide 23) may also be competitive. Determining if such a situation exists would require KyMEA and its Members to review nearby landfills to assess whether the favorable circumstances may be present. Additional effort to make a project specific O&M estimate also would be required.
4. There are significant economies of scale involved in solar resources. Solar resources can be implemented on a very small scale (~1,000 kW or less) that may be appropriate for a community solar project or on a utility scale level (~1,000 kW or more) that can be expected to provide significantly lower costs per unit of energy produced as compared to small scale projects.

Discussion of Primary Conclusions (Continued)

Renewables will Impact KyMEA's Risk Profile – Relative to KU's

Adding a renewable resource to KyMEA's portfolio can be expected to affect KyMEA's risk profile.

- All of the renewable resources studied are anticipated to involve commitments of 15 years or longer. So far, KyMEA has contracted for conventional resources for periods of 3 and 10 years.
- Relying in part on renewable energy would reduce the risks to KyMEA of higher natural gas or coal prices and the potential for higher costs that could result from CO₂ or other new environmental legislation. New environmental legislation is expected to impact KyMEA's costs of conventional resources to a similar or lesser degree than KU's costs.
- Significant reliance on renewable resources may also increase the risks to KyMEA of becoming less competitive with KU in the event that fuel and market prices are lower in the 2020s than assumed at this time.
- The as-available, must-take nature of the energy provided from wind and solar resources requires effective integration with a portfolio of conventional resources to manage the potential impact of the resource on assurance of adequate power supply and volatility of energy costs.

Discussion of Primary Conclusions (Continued)

Recommend Proceeding to Further Consider Renewable Resources

Considering the results of this initial assessment, it would be reasonable to give further consideration to certain renewable resources as discussed below.

- The KyMEA Board has placed a very high priority on assembling a portfolio that provides a favorable cost of power to the KyMEA AR Members and is structured to remain competitive with KU under a wide range of future conditions. This initial assessment indicates that additional and continuing consideration of renewable resources is important to KyMEA's efforts to achieve this goal.
- This Assessment has been based on indicative prices received from certain renewable energy providers and publicly available data. Actual data provided through a competitive procurement process would provide a more accurate basis for further efforts to identify the most cost effective renewable resources actually available to the KyMEA Members and may identify cost effective resources not identified in this Assessment.
- KyMEA's AR Contract and PPAs provide flexibility to:
 - Integrate into KyMEA's portfolio some level of renewable resources with as-available, non-dispatchable energy availability characteristics; and
 - Implement a renewable resource only for individual, or groups of, Members that choose to use and pay for that resource.

Recommended KyMEA Directions

Based on the conclusions summarized on the preceding slide and the results of the assessment summarized in this presentation, we recommend the following course.

1. KyMEA should Give Further Consideration to Purchasing or Otherwise Obtaining Capacity and Energy from Renewable Resources

- Solicit Proposals through a formal competitive procurement process
- Consider both utility scale and smaller community solar projects
- Consider resource integration costs
- Consider energy from projects connected to MISO, the LGE/KU transmission system, and one or more Member Systems

2. Work with any KyMEA Member or Group of Members that Decide to Consider Renewables Independently

- Would allow consideration of that Member's unique priorities
- Options include:
 - Member-Owned Resources
 - Customer-Owned Resources

Recommended KyMEA Directions (Continued)

Recommended Process for Further Consideration of Renewable Energy Resources

We recommend the following steps to obtain the information KyMEA and its Members should have to support their collective and individual decision processes.

1. Using a formal RFP process, obtain specific proposals from potential sellers of energy from renewable resources including:
 - Large utility-size renewable projects (10,000 kW to 50,000 kW of KyMEA installed capacity entitlement) connected to the MISO or LGE/KU Transmission Systems, and
 - Community Solar Project-size (~100-1,000 kW Class) or Small Utility Project-size (~1,000 kW to ~10,000 kW Class) solar projects connected to one of more of the KyMEA Members' systems.
2. Prepare appropriate analyses to identify any proposal(s) most likely to be deemed susceptible of award, based on key proposed terms and conditions of applicable Power Purchase or Other Agreements (PPAs) and reasonable initial allowances for other cost impacts.
3. Assuming potentially attractive proposals are identified:
 - Further assess potential transmission congestion costs, other transmission costs, and any other potential impacts on KyMEA and its Members of sellers' proposals to deliver the energy to MISO or the LGE/KU transmission system;
 - Project the net benefits from or net costs of the particular resource(s) upon integration into KyMEA's power supply portfolio for use in meeting the load serving obligations of KyMEA's Members, specifically addressing the impact on other resource costs of any applicable as-available, non-dispatchable characteristics of the proposed renewable energy resources;
 - Assess the impacts of the proposed renewable energy resources on KyMEA's risk profile relative to KU's; and
 - Finalize PPA Terms and conditions and update pertinent analyses.