

## Microgrids with CHP - Improving campus and community resilience

Webinar May 2<sup>nd</sup>

### Questions from attendees:

#### 1. What is the average LCOE for CHP system sub 500kW, sub 1MW, and around 2-5MW?

As we answered during the presentations a typical LCOE for a gas turbine is \$0.07/KWh. But this value usually oscillates depending on different factors, decreasing for example as the size of the CHP system increases. LCOE depends also on the technology and local prices for fuel and electricity. Anyway, a good reference for CHP technology costs can be found in the publication EPA's catalog of CHP technologies: [https://www.epa.gov/sites/production/files/2015.../catalog\\_of\\_chp\\_technologies.pdf](https://www.epa.gov/sites/production/files/2015.../catalog_of_chp_technologies.pdf)

#### 2. Can you talk about the importance of system design (including controls) to achieving reliability?

A defined level of reliability and resilience are some of the goals to satisfy along a CHP based-microgrid planning process. Both goals are usually achieved installing redundant power generation equipment, energy supply systems, energy sources (diesel and gas for example), transmission lines, etc.. In addition, a CHP-based microgrid is expected to be operative for more than 15 years but market prices change every day. That is why different operational modes must be considered during the design stage.

A good introduction to microgrid controls and how critical are they for achieving reliability goals can be found in sections III and IV of the paper title: Trends in microgrid control. This paper is available for download in the following link: <http://repositorio.uchile.cl/bitstream/handle/2250/126993/Trends-in-Microgrid-Control.pdf?sequence=1>

#### 3. What are key barriers (regulatory & business models) to market-wide adoption of CHP?

We would say that CHP business models are mostly well defined, but some of the most common regulatory barriers are cited below:

- Complicated interconnection process for systems over 10MW (up to 3 years)
- Lack of standardization in interconnection
- Stand-by rates are usually negotiated with the utility, so it is not possible to consider them from the beginning of the feasibility study.

#### 4. What do you mean by concern over future electric prices?

Future electricity prices have to be considered both in feasibility studies and engineering designs. A CHP-based microgrid is expected to be operative for more than 15 years but market prices change every day. That is why sensitivity analyses must be developed, and the bigger the microgrid the more the profitable operational modes to be considered during the design stage.

#### 5. What is spark spread?

The spark spread is a common metric for estimating the profitability of natural gas-fired electric generators. The term was first coined by Tony West's trading team on the trading floor of National Power Ltd in Swindon, UK during the late 1990s and quickly came into common usage as other traders realized the trading and hedging opportunities. Spark spreads are calculated using the following equation:

$$\text{Spark spread} \left[ \frac{\$}{\text{MWh}} \right] = \text{Power price} \left[ \frac{\$}{\text{MWh}} \right] - \left( \text{Natural gas price} \left[ \frac{\$}{\text{MMBTu}} \right] * \text{Heat rate} \left[ \frac{\text{MMBTu}}{\text{MWh}} \right] \right)$$

The spark spread concept has been extended to power generation technologies assessment, including other costs, as in the following example.

**CHP Cost to Generate Power \***

Operating Cost to Generate		
CHP Fuel Costs, \$/kWh	\$0.0539	<i>The cost of fuel consumed by the CHP system, per kWh</i>
Thermal Credit, \$/kWh	(\$0.0343)	<i>The fuel cost avoided by having CHP provide thermal energy to the site, per kWh</i>
Incremental O&M, \$/kWh	\$0.0200	<i>The non-fuel operation and maintenance cost for the CHP system, per kWh</i>
<b>Operating Costs to Generate Power, \$/kWh</b>	\$0.0397	<i>The total operating cost to generate power, per kWh</i>
Capital Charge, \$/kWh	\$0.0470	<i>The capital investment charge for the CHP system per kWh - based on cost of capital, annual operating hours, and a 20 year economic life</i>
<b>Total Costs to Generate Power, \$/kWh</b>	\$0.0867	<i>The total cost to generate power, per kWh</i>
Current Average Electricity Price, \$/kWh	\$0.0608	<i>Current average price paid for electricity, per kWh</i>
<b>Spark Spread, \$/kWh**</b>	<b>(\$0.0259)</b>	<i>The difference per kWh between the current delivered electricity price and the total cost to generate power with the CHP system</i>

\* See the CHP Spark Spread Results section in the Documentation for more information.

\*\* A numerically positive spark spread result indicates that the CHP project returns more than the cost of capital indicated on the Inputs page. The greater the spark spread, the higher the return on investment.

**See Additional Results on Energy Use and Operating Costs**

6. What is a "Favorable spark spread"?

The higher the spark spread is, the better. But this economic indicator must be considered jointly with other technical and financial indicators to find the best solution for each customer. An alternative way to see the spark spread is to compare it with the cost of electricity. For example, if the spark spread is a 50% of the electricity price, the facility would have a good margin to lower the costs of buying this electricity. But a high spark spread in a high volatility scenario for energy prices might not guarantee the profitability of the project.

7. How can I get a copy of today's presentation ASAP? Can it be e-mailed to me?

The presentation can be downloaded from IDEA's web site:

8. What are the typical design approaches for MG resiliency in case of natural disasters - Stored NG on site or what?

As we have cited in the previous answers, resiliency is usually achieved by redundancy of power equipment, energy sources, transmission lines, etc.. In case of a natural disaster the most common solutions are based on preparing the facilities for operating using different fuels or for obtaining their fuel from different energy sources including distribution grids (usually electricity and natural gas), or on-site storage. On-site storage can provide the facility some hours or days of autonomy, but the use of different distribution grids can offer the system up to weeks of autonomy, based on grid's availability. On-site thermal energy and fuel storage are some of the most common systems but many pilot projects based on batteries and other electric energy storage technologies are being developed in the present.

9. Is CHP capable to participate in traditional or fast regulation market?

Yes, there are many examples in the market of CHP systems supplying this kind of services to the market. But the system must be specifically designed to provide them. For example, a system just designed to provide energy to a customer could not be able to take part of a fast regulation market and to follow the on-site demand.

10. What would be the methodology to calculate the Total Cost of Ownership for MG system?

There are different methodologies on the internet, and specially a lot of papers in research databases such as [ieeexplore.ieee.org](http://ieeexplore.ieee.org) or [www.scopus.com](http://www.scopus.com) . Different authors have published methodologies but

there is no a standardized one. We are finalizing the development of our own methodology, and we will try to have it published this year. Until it is published, we can help you along the planning process of your microgrids, so please feel free to contact us.

11. Who would be the leading companies able to do a turn-key microgrid project?

We do not usually provide names of any company, but there are many of them. The higher the capacity of the system the lower the number of companies, but most of the companies that manufacture CHP systems could address you to some of these engineering companies or even to develop a turn-key CHP project for you.

12. Once we install a CHP and MG (heat and power), and there is still excess in power generated, is there a policy or law or mandate that requires a local utility to pay for additional power? or covering the costs for distribution lines or interconnection?

Utilities use to buy excess power from customers, but the price they pay may be very different from one area to another. There are no regulatory requirements for the utility to pay a fixed price nor for the excess power, neither for the interconnection costs.

13. Exergy stores, which store both electricity and heat, provide an alternative to regular CHP's that use fuels. Can you comment on the relative advantages of these competing CHP's? For the 2nd question, either contractors or consultants?

I think this is out the scope of this webinar. We try to promote CHP, not make a deep analysis of the systems they compete against.

14. Is TAP Technical Assistance a free service?

As a CHP TAP we offer some services for free and some other co-financed by the DOE and the final customer. Please do not hesitate to contact us for further details.

15. What are the information/reference resources you have for integrated CHP with renewable + battery storage system?

There are many resources on the internet about the integration of CHP and renewables, especially in EPA and IDEA's websites. You can also find many conference papers on modeling renewable energy and CHP hybrid microgrid systems. Some online references are listed below:

- [https://www.epa.gov/sites/production/files/2015-10/documents/meeting\\_063015\\_naik.pdf](https://www.epa.gov/sites/production/files/2015-10/documents/meeting_063015_naik.pdf)

- <https://energy.gov/eere/amo/downloads/barriers-chp-renewable-portfolio-standards-draft-white-paper-september-2007>
- [https://www.hydrogen.energy.gov/pdfs/14003\\_lcoe\\_from\\_chp\\_and\\_pv.pdf](https://www.hydrogen.energy.gov/pdfs/14003_lcoe_from_chp_and_pv.pdf)
- <http://ieeexplore.ieee.org/document/6303122/>

16. Is this PPT to be made available? Also what's the perspective of cooling component under this CHP concept. many thx

Cooling is an interesting application for CHP systems. Single and double-effect absorption chillers can achieve COPs from 0.8 to 1.4. This technology is progressively improving its performance. Absorption chillers have different synergies with has an easy integration and other synergies with technologies such as thermal solar and CHP technologies. We are seen an increasing number of applications for absorption chillers.

17. A thermally sized CHP based on electrical load duration curve is typically 75% of peak electric load. How then do you address the need for 100-120% generation to address peak electric to allow full operation in island mode.

The percentage you cite as a 75% oscillates depending on the on-site electric demand. CHP-based microgrids can coordinate their operation with other generators (such as gas or diesel gen sets), renewable power sources or even the traditional power grid.

18. How long can a microgrid operate independently?

Under a regular operational mode, a CHP-based microgrid will be able to operate 365/24/7. Under a contingency mode, it depends on their components and on the reason why it is under contingency mode (lack of fuel, control system down, etc..)

19. What is the outlook for more States to provide or continue to provide Incentive programs for CHP / Microgrid, especially for the MidWest States?

There are different websites focused on microgrids that can provide you updated information on this and other related topics such as:

- ✓ [microgridnews.com](http://microgridnews.com)
- ✓ [microgridknowledge.com](http://microgridknowledge.com)
- ✓ [microgridmedia.com](http://microgridmedia.com)

✓ <https://www.greentechmedia.com/articles/tag/microgrid>

20. Any suggestion for Utility Companies to streamline Interconnection Application?

I think this question is out of the scope of this webinar.

21. You talked about kWh price point for break-even feasibility. What have you seen for thermal load requirements, or does that just determine the size of the CHP?

You are right, in a regular approach a CHP system is sized to cover thermal demand. In some occasions, we have considered different approaches but they are far from being as efficient as the thermal demand following.

22. Is there a tool available that we can use to perform preliminary financial analysis of a CHP project?

We use a tool, but we are not allowed to distribute it. Anyway, you can contact us to receive free analysis for CHP projects, including preliminary technical and economical assessments.

23. What suggestions do you have for BC market to encourage Microgrid CHP when we have low electricity prices & utility that will only buy renewable power. We are implementing many district energy systems but CHP with microgrids are lost opportunities?

This question is focused on a specific market situation, not easy answer with the provided data. I would recommend you to submit your case to the CHP TAP on your area so we can study it. Preliminary qualification studies for CHP systems are developed for free.

24. As CHP is usually designed for the thermal load, how can we get a better estimate of the thermal demand (other than monthly demand)? Thanks!

Sometimes these facilities have energy meters associated with heating or cooling energy consumption. In case they don't you can always try to define an hourly load profile combining different sources of information such as the energy systems they have on-site, how the facilities are operated, and hourly or daily temperature profiles (HDD or CDD for example). But this is not an easy task and the results must be somehow validated with the final client before continuing with the design process.

25. The CHP seminar was really useful and well organized. I have a question related to the financial aspect of CHP project. Is the facility level (e.g. CHP system in a big hospital) capable of participating in frequency regulation market? If yes, is it fast regulation market or regular traditional market?

Frequency regulation, requires of capacity fully dedicated to the provision of frequency regulation instead of focused on on-site energy needs. One single CHP generator usually can't match both needs at a time.

26. Does CHP have a place in countries with land constraint? Can it be installed in underground spaces?

CHP systems don't have a high rate of footprint per KW, according to EPA's Catalog of CHP technologies, Table 1-3. Comparison of CHP Technology Sizing, Cost, and Performance Parameters. In fact, most of the renewable technologies have a lower rate of KW/m<sup>2</sup>. They can be installed in underground spaces, but they still require to conduct ventilation and combustion air and exhaust gasses, a permanent access and space availability in order to install, maintenance, and overhaul the system when required.

27. Is CHP effective in tropical climate where demand for space cooling is higher than space heating? I understand that cooling can be achieved with the use of absorption chillers and steam driven chillers. However, those two aren't exactly energy efficient. Will it be more energy intensive rather than energy saving if CHP is used for space cooling?

Single effect absorption chillers have a maximum COP around .8. So the efficiency of a CHP applications with cooling purposes is lower than the efficiency of the same CHP system with heating purposes. But absorption technologies are improving their performance. For example, double effect direct-fired absorption chillers have a maximum COP around 1.4.. This technology is still less efficient than electrical chillers, but it has an easy integration and other synergies with technologies such as thermal solar and CHP technologies. We are seen an increasing number of applications for absorption chillers.