UNIVERSITY OF MINNESOTA

Twin Cities Campus

Facilities Management
Energy Management

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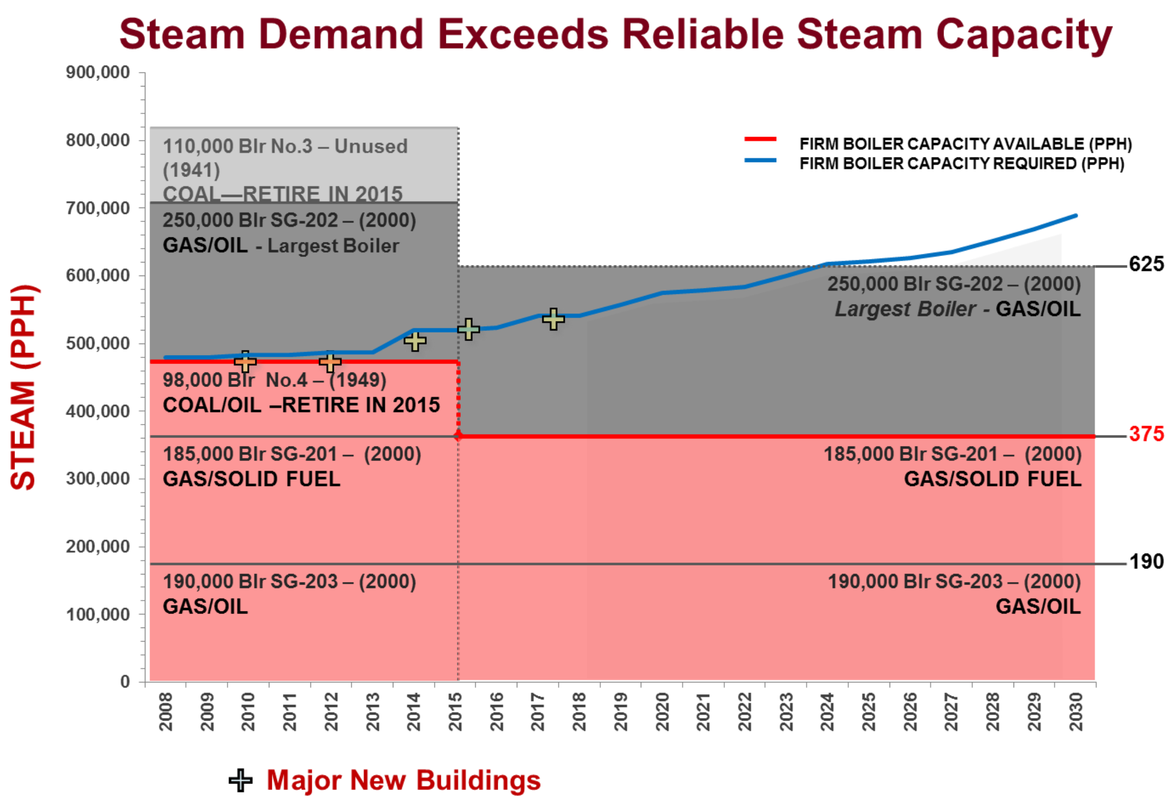
October 31, 2017

CHP and Microgrids on a University Campus – by Jerome Malmquist, Director

In laying out plans and making decisions in Energy Management for the University of Minnesota, three principles are followed: **Reliability, Cost and Sustainability**. This brief will outline how these principles drove us to our decision to install a combustion turbine driven combined heat and power system and the numerous lessons learned along the way.

Reliability:

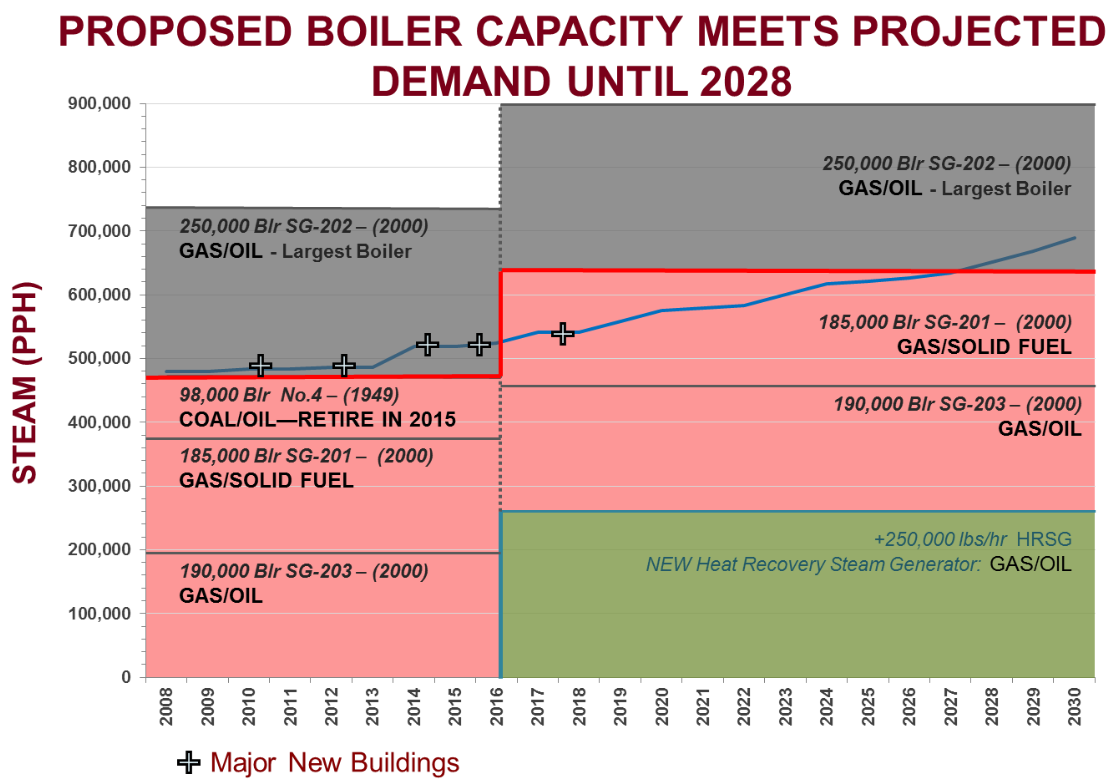
The University of Minnesota is has been around since 1851. Sometimes we feel like some of our assets are as old. Aging requires replacement. Such was the case with the supply of heat for the University. <u>The problem</u>:



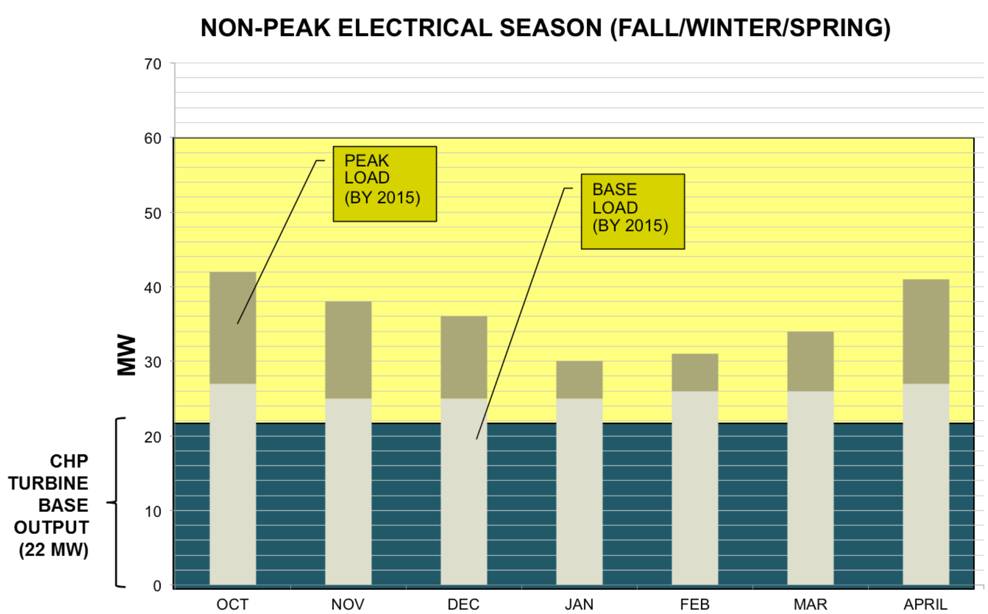
LESSON: Plan ahead. Plan early. Plan often. Build models. Projects of this magnitude take time! Get it as right as possible the first time.

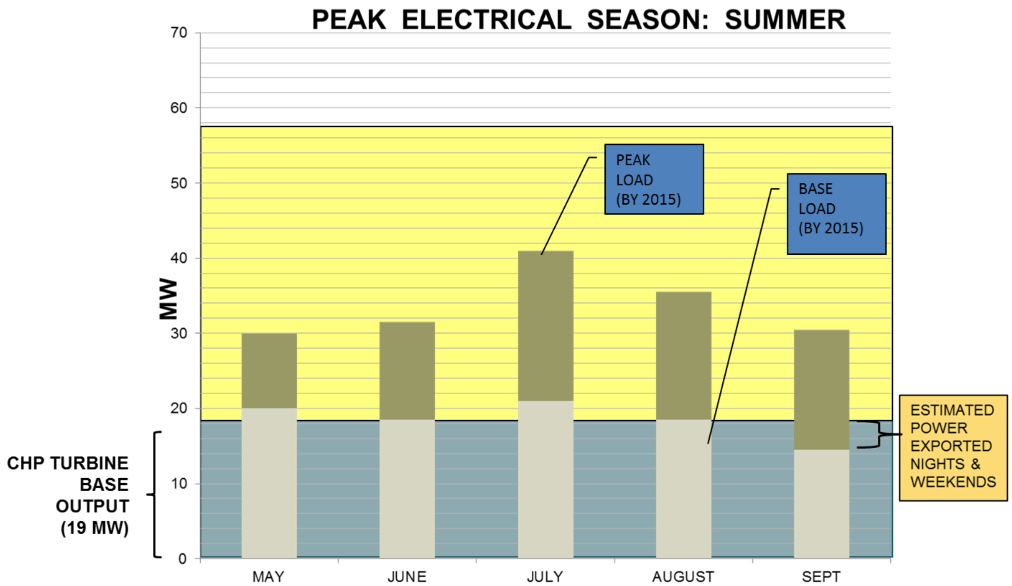
LESSON: If you require the use of a carbon based fuel to provide heat, strongly consider using that fuel to FIRST make electric power, followed by using the waste heat to make the useable heat needed to meet your load demand. Strive for the highest efficiency possible.

The solution:



After numerous studies this university came up with five possible solutions that varied in location, equipment to be used and a “do nothing” option. The following charts demonstrate the ability to use ALL of the power being produced throughout the year. In a closed market, there is no market for excess electrical power.





Cost:

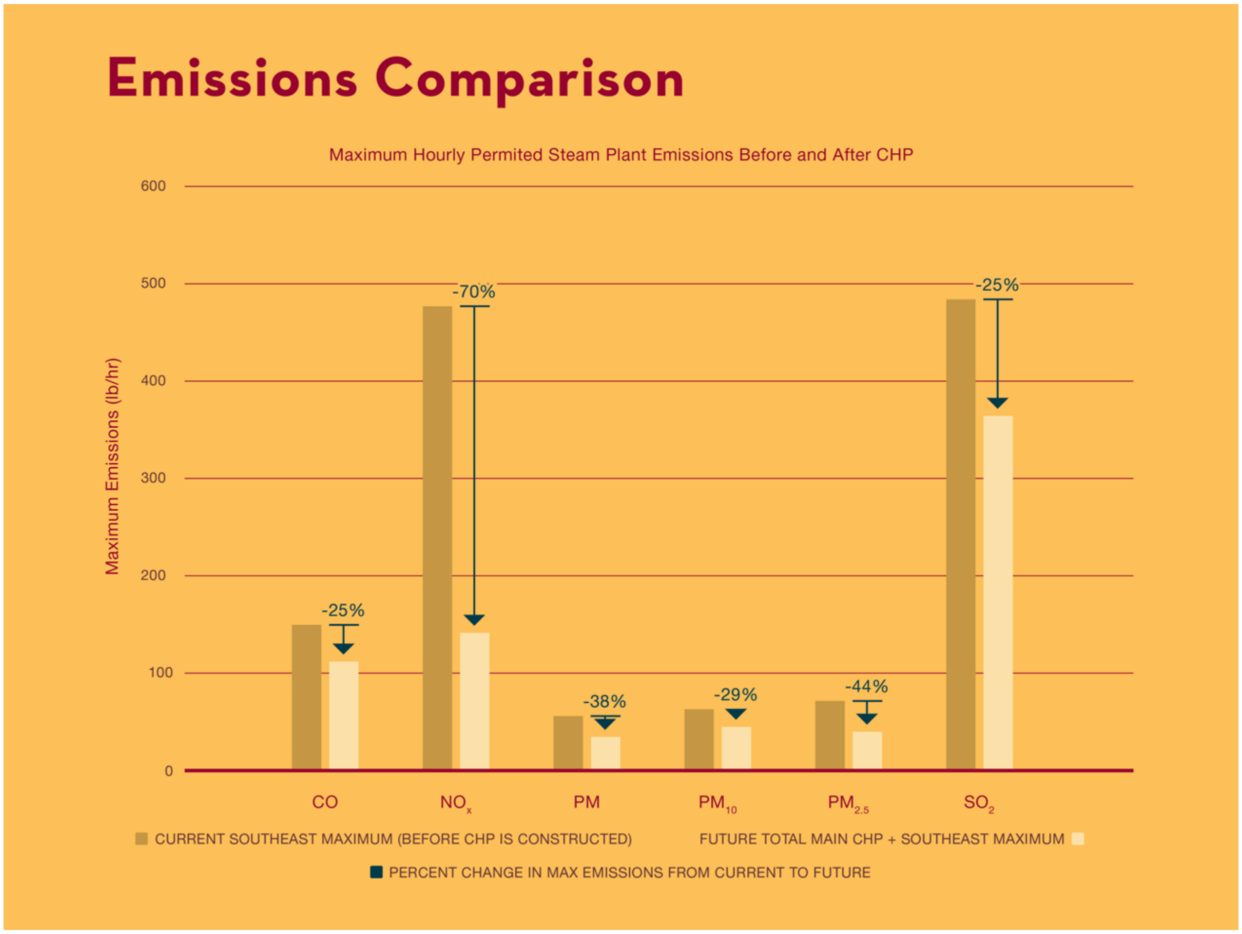
LESSON: One absolutely has to balance the required heat demand with the required power demand. This needs to be done across the entire year. If this is not done, then the project will most likely not work out financially. If modeled correctly it can provide a net gain in operating costs.

Sensitivity Analysis:								
		Natural Gas Cost $/Dthm (University burner tip)						
		$4.00				**$6.00**		
		Xcel Fuel Cost Adjustment (FCA) Multiplier						
		1.000				**1.250**		
Xcel Rate Inc.	**Option**	**Annual Expense**						
7.0%	**Gas Boiler Only**	**$**	**29,037,504**	***Avoided***	**$**	**34,977,641**	***Avoided***	
	GE LM2500 Alt-1	**$**	**20,307,804**	***$8,729,700***	**$**	**26,302,289**	***$8,675,351***	
10.0%	**Gas Boiler Only**	**$**	**29,373,836**	***Avoided***	**$**	**35,313,973**	***Avoided***	
	GE LM2500 Alt-1	**$**	**20,474,736**	***$8,899,100***	**$**	**26,469,221**	***$8,844,752***	

In addition, detailed sensitivity analysis was done to with regards to market power costs and fuel costs to prove to ourselves that regardless of the direction of future markets, this project would be financially sound.

LESSON: Initial performance results from several months have been compiled. Our models were correct. We are meeting and exceeding the financial goals!

Sustainable:



The primary driver for the University was greenhouse gas reduction. Along with the though came a significant reduction in the rest of the air pollutants. Voluntary steps were taken to make the permitting process more acceptable and quicker. The net result is a 10 to 13% reduction in greenhouse gas. As the local utility continues to green, this gets closer to 10%. The financial gains will not change.

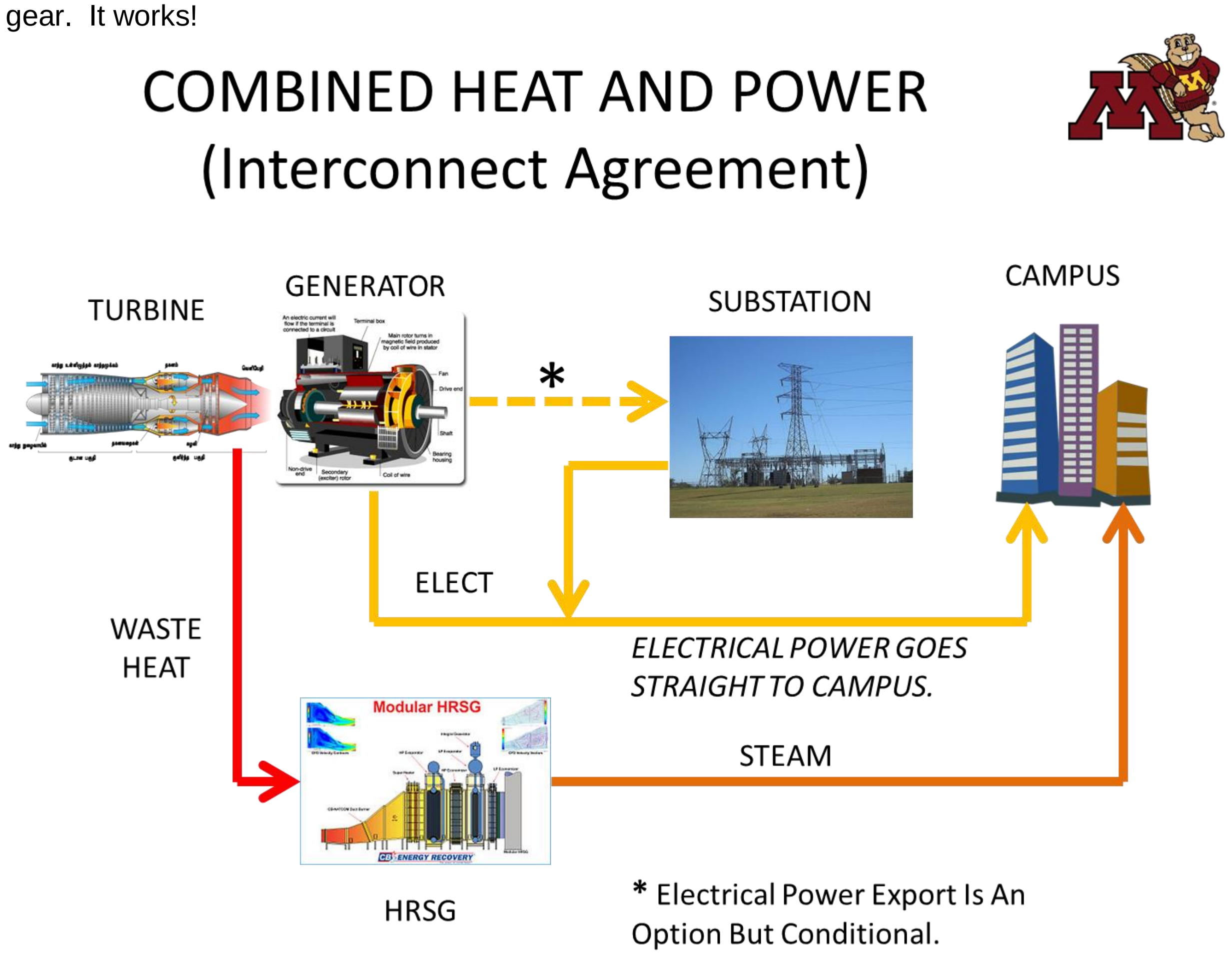
LESSON: The permitting process can take a very long time. In this situation the federal government changed their mind. The required rewriting our permit application. Once we had everything properly in place, we had the permit to construct 15 months later. That actually was very quick and for that we were very thankful! We had been given permission to do brown field cleanup, removing decades of hazardous materials, removing old equipment and preparing the site and the 1912 building for reconstruction and the new equipment.

OTHER LESSONS LEARNED:

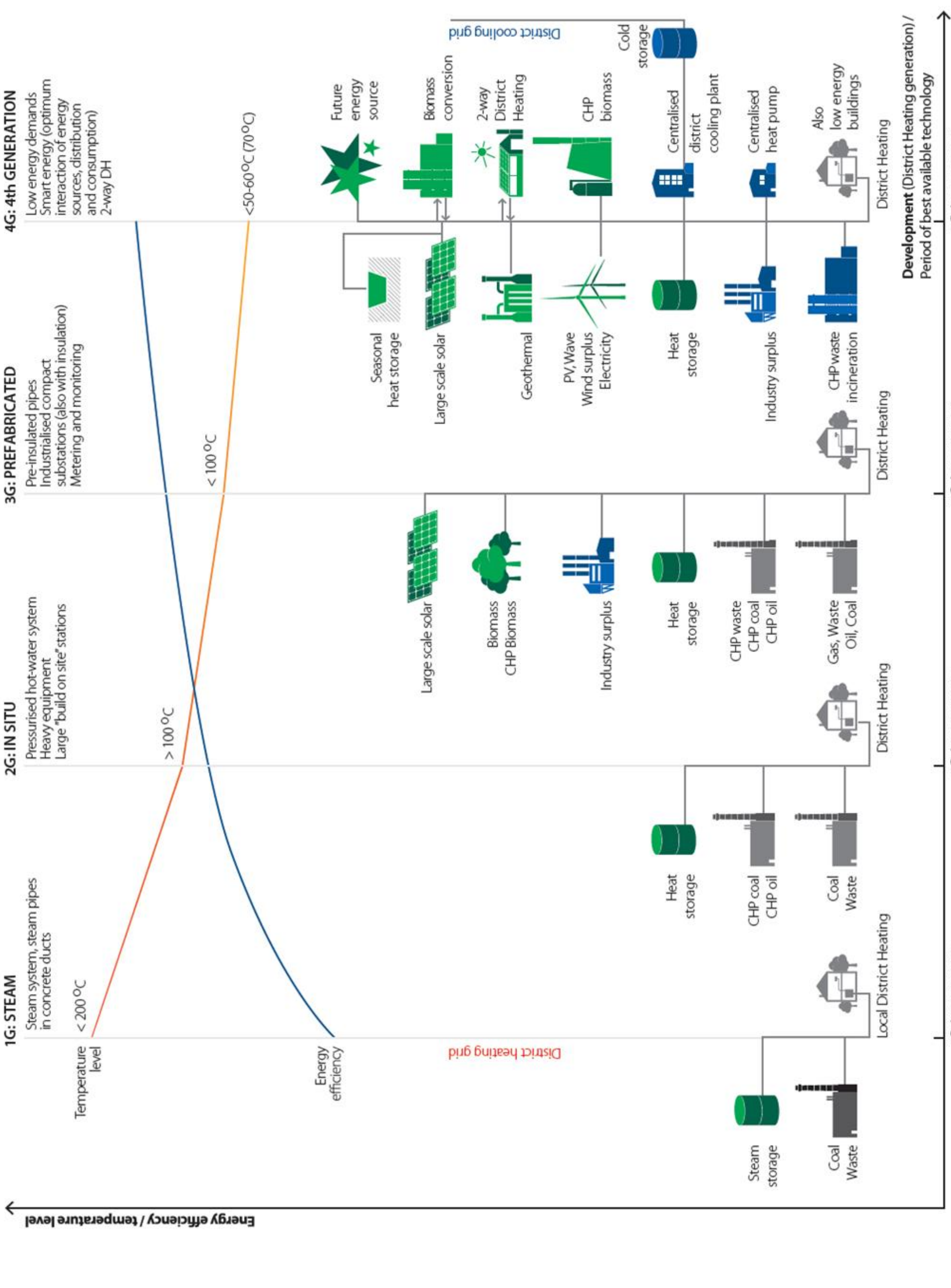
- Interconnect agreements with the local utility are long and tedious to obtain. Plan on at least a year.
- Power Purchase Agreements were required even though the goal was or is to never export power. That is NOT a reasonable expectation. Utilities have a lot of options available so do not expect to get rich selling power from behind your meter.
- Public Utility Regulatory Policies Act of 1978 (PURPA) was helpful, but not that much. Know the laws, in detail!
- In building a power plant, very little product is available within the US. Be very prepared to deal with foreign everything! Deliveries, warrantees, etc. can be a challenge.

- Suppliers can go bankrupt when you least expect it.
- Equipment access can be a challenge depending on your location. The turbine package was 250,000 pounds and the trucking system used to move it was another 250,000 pounds! Getting that from Houston to Minneapolis was the easy part!
- Without any doubt, have highly trained and skilled personnel either on your staff or working directly for you. We were very fortunate to have our own internal folks available to perform or oversee the commissioning of the equipment.
- If it is at all possible, deliver the power to the primary feed for your location. We could not and that created SIGNIFICANT challenges and cost. Good engineers are priceless!
- Yes, we could write a book!

The following is a diagram of the system at the University of Minnesota. Note that our local utility is designed in as a complete backup to our power generation. With multiple electric feeders coming from the utility AND multiple feeders leaving the university's switch stations, the switching procedures become very complicated and very close coordination is needed with the utility's dispatch center. We have completely rebuilt our Supervisory Control and Data Acquisition (SCADA) system and have Automatic Transfer Switches (ATS') installed on most of our switch gear. It works!



For general interest, unrelated to this project, I have enclosed the following diagram that we picked up in Denmark the week of October 10, 2017. Denmark refers to their current district energy status as ***Fourth Generation***. In the US, we are entering Generation 3. We have work to do!



Energy efficiency / temperature level
1G: STEAM
Steam system, steam pipes in concrete ducts
2G: IN SITU
Pressurised hot-water system
Heavy equipment
Large "build on site" stations
3G: PREFABRICATED
Pre-insulated pipes
Industrialised compact substations (also with insulation)
Metering and monitoring
4G: 4th GENERATION
Low energy demands
Smart energy (optimum interaction of energy sources, distribution and consumption)
2-way DH
Temperature level
< 200 °C
> 100 °C
< 100 °C
<50-60 °C (70 °C)
Energy efficiency
District heating grid
District cooling grid
Steam storage
Coal Waste
Local District Heating
Heat storage
CHP coal CHP oil
Coal Waste
District Heating
Large scale solar
Biomass CHP Biomass
Industry surplus
Heat storage
CHP waste CHP coal CHP oil
Gas, Waste Oil, Coal
District Heating
Seasonal heat storage
Large scale solar
Geothermal
PV, Wave Wind surplus Electricity
Heat storage
Industry surplus
CHP waste incineration
Future energy source
Biomass conversion
2-way District Heating
CHP biomass
Centralised district cooling plant
Centralised heat pump
Also low energy buildings
District Heating
Cold storage
1G / 1880-1930
2G / 1930-1980
3G / 1980-2020
4G / 2020-2050
Development (District Heating generation) / Period of best available technology