Current Issues: Centralized vs. Decentralized Energy Systems

By: Devon Savage

Instructors: Dr. Christopher Thoms and Joe Storlien

ENVR 395/Spring 2016

Introduction:

Centralized energy generation is more common around the world than decentralized, but energy is lost over the sometimes vast transmission distance from the point of generation to the consumer. These are large-scale operations that create massive amounts of electricity, can be over 1,100 gigawatts of power, at a central location. Longer power lines to rural areas have a lower voltage which increases line resistance, resulting in high electrical losses. Much of the primary energy produced by centralized systems using fossil fuels is lost during the generation process as well as transmission. Decentralized systems are smaller scale operations defined as producing less than a hundred megawatts per hour. A decentralized power system can contribute to a grid, or as an independent system to meet electricity requirements at a local level and based mostly on renewable methods. These systems have a generating facility closer in proximity to the consumers, thus; decreasing the distance electricity must travel and increasing transmission efficiency.

References:

Environmental Protection Agency, "Centralized Generation," EPA, 2015, https://www.epa.gov/energy/centralized-generation#about (accessed 4/16/16).

Jiguparmar, "Total Losses in Power Distribution and Transmission Lines," Electrical Engineering Portal, 2013, http://electrical-engineering-portal.com/total-losses-in-power-distribution-and-transmission-lines-1 (accessed 4/18/16).

Methods:

I found three towns located in different parts of Minnesota with different populations to estimate a generation method that would best fit each. The method of generation for the decentralized system was depicted based on the cost to build infrastructure and land required. A table was then constructed to reveal which method could be best suited for the given town. The study excluded electrical use of businesses because they receive power from a different transmission source than households. First, the estimated power consumption for the towns was found using the each population over the average family size of four to find the number of households in each town. The product was then multiplied by the average electricity a household uses per day, giving an estimate of consumption. The estimate was then used to determine the system size that would be able to produce enough energy per day for the households, followed by cost, land area for each system.

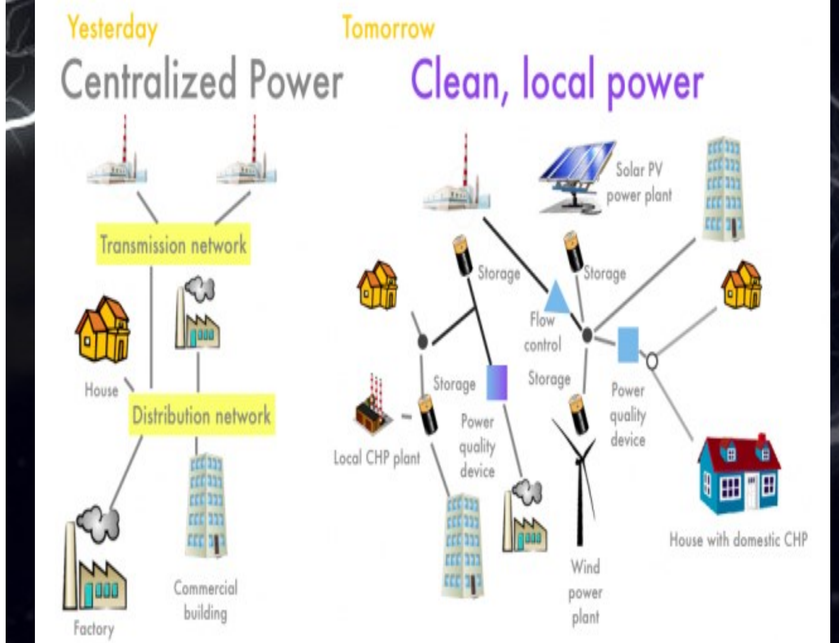

Figure 1. The network of current centralized power and future decentralized clean energy generation and distribution. Local power decreases energy loss over distance.

Generation Method	Pros	Cons
Coal	. Reliable Power . Cheap . Current Infrastructure	. Harmful Emissions . Water Pollution if used for Cooling . Mineral Extraction Damages Land . Transportation Pollution and Cost . Limited Resource
Natural Gas	. Reliable Power . Cheap . Increased Infrastructure . Cleaner than Coal	. Extraction (Fracking) can Harm Land, Humans, and Wildlife . Transportation Damages Land . Limited Resource . Higher Long Term Cost
Wind	. No Emissions . No Fuel Transportation . Low Long Term Cost . Renewable Power Source	. Expensive Initial Cost . Land Required Depending on Size of Farm . Can Kill Birds . Expensive Maintenance . Dependent on Weather Conditions
Solar	. No Emissions . No Fuel Transportation . Low Long Term Cost . Renewable Power Source . Easy to Maintain	. Expensive Initial Cost . Land Required (Large Scale) . Building Materials are Problematic to Dispose . Dependent on Weather Conditions

Case Study:

	Solar		Wind		Coal		Natural Gas	
Towns	**Cost ($/MW)**	**Area (sq. km)**	**Cost ($/MW)**	**Area (sq. km)**	**Cost ($/MW)**	**Area (sq. km)**	**Cost ($/MW)**	**Area (sq. km)**
Littlefork	5817.6	1.4	3384	.144	4310.4	.047	3465.6	.047
Slayton	19028.4	4.6	11068.5	.471	14098.6	.120	11335.4	.120
Nimrod	727.2	.17	423	.018	538.8	.005	433.2	.005

Table 1. Shows estimated cost and land area needed of each method of energy production to meet the needs of each town in Minnesota.

Conclusion:

Distributed systems are more efficient than centralized systems because transmission distance is shorter, providing less resistance. The farther away consumers are from the original point of generation, the more electricity is lost according to Ohm's Law. Certain systems are more efficient according to the landscape and environmental factors in Minnesota. For example, one area could maintain high wind speeds, prime for wind generation, where another area does not receive the same wind speed due to wind breaks. This suggests that renewable sources of generation are optimal depending on these factors, meaning they are limited by the environment. Conventional generation does not rely on the environment and promotes energy security by being a constant source. However, the burning of fossil fuels uses a limited resource while contributing to environmental degradation through methods by which they are extracted, transported, and emissions.