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THE CALIFORNIA ENERGY SHORTAGE

DISTRIBUTED, ON-SITE, COGENERATION, VS. UTILITY GAS TURBINES AND NON-UTILIZED WASTE HEAT

ALI HUSNAIN
BS, ELECTRICAL ENGINEERING
MBS Engineering, San Ramon, CA, USA

Table of Contents

1. California Energy Crisis 2000-2001:

In 1996, the deregulation of energy, bill AB 1890, was passed with a unanimous vote. This bill stated that IOUs[1] would sell their power production facilities and focus only on power delivery. This would result in power generation companies to compete in order to sell power and so, they would lower costs of electric power. Additionally, the government threw in a requirement to discount electricity by 10% and therefore freezing the price of electricity below the market value. The market functioned this way for about 2 years and then failed. The cost of electricity skyrocketed during these 2 years. The main reason was that the power providers began to manipulate markets with artificial scarcity: shutting down power plants to increase the demand of electricity and increasing the prices with it. The increase in prices is as shown in figure 1.1. Skilling, Lay, et al. (Enron) were at the center of this scheme, and were eventually legally dealt with. Ken Lay's concept of 'cap and trade' would later become the UN-vaunted model for the contested 'Global Carbon Exchange'.

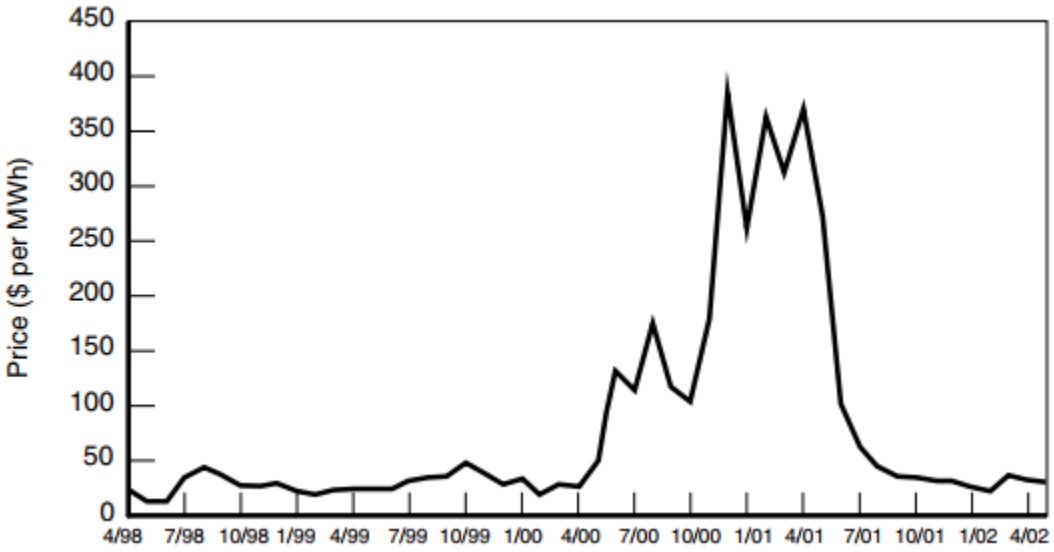

Figure1: Average wholesale Prices in California, 1998-2002

Source: Joskow and Kahn (2001b)

These rising prices of the electricity wholesale market wreaked havoc on the consumers living in California. Many companies like PG&E and SCE eventually declared bankruptcy and the state spent billions of dollars to survive this crisis and to recover from it.

[1] Independently Owned Utilities (IOUs) are private electricity and natural gas providers, like Pacific Gas & Electricity.

2. Modern Day Energy Shortage in California

With an electricity market as deregulated as California, the state is yet on another brink of another energy crisis. The state of California is once again failing to meet the growing demands of electricity for the people.

2.1. Decrease in Generation

There are a number of reasons behind California's inability to meet it's growing energy demand, the most important one is that there has been a huge decrease in generation capacity, generation from different sources has been cut down due to a number of reasons, a few are discussed below;

a) **Coal.** Coal-run power plants have historically been a huge source of electrical power, but in the recent years a huge number of coal power plants have been shut down. The main reason being their effect on environment and the controversy of carbon emissions. At this point only 0.2 % of the total demand in the state of California is met by those coal power plants (which are slated to be shut down imminently). The amount of electricity generated by coal power plants fell from a huge 2,286 GWh to just 302 GWh in last eight years.[2]

b) **Nuclear.** California shut down it's two nuclear power plants in 2013 and is about to shut the remaining two of its nuclear plants as soon as their license expires – also imminently. The amount of energy generated by nuclear power plants has been cut to half in the last 8 years. This is mainly due to public perception about nuclear safety after some major accidents like Chernobyl, Three Mile Island, and the Fukushima, Japan incident.

c) **Renewable.** The next biggest source of electricity is renewable energy. Currently about 30% of the energy produced in California comes from renewable sources such as solar and wind. The stated objective of the state government and energy commissions is to produce about 50% of the electricity by renewable resources soon. Several problems arise with these resources; chief among them are unreliability and inconsistency of wind and sun energy. Renewable resources cannot generate electricity round the clock i.e. Solar panels cannot be operated at night and wind turbines need to have a specific range of wind speed to operate. In order to make this energy available 24/7, electricity needs to be stored during peak generation hours in order to be utilized later. For this storage of electricity, massive arrays of largely lithium batteries are required. The devastation to the environment notwithstanding, this is a problematic solution, because the batteries require almost continuous maintenance and have a short lifespan (needing to be replaced or refurbished every few year). These combind factors make the energy generated from renewable resources cost-prohibitive, and the prospect impractical.

d) **Natural Gas.** The most important energy source in California today, contributing about 49% of the total energy production, is natural gas. However, the conventional methods of producing electricity from the gas – internal combustion or natural gas turbines – is inefficient, and the delivery means to the end consumer bleed a substantial percentage of the power produced. In the end, grid electric is about 40% efficient. And Internal Combustion, Steam, and Gas Turbine engines that transport power and which do not use Combined Heat And Power (CHP), or 'cogeneration' (capturing the clean 'waste heat' from these methods), are themselves on the order of 45% efficient. The modality of energy production is implied by each of these technologies; in the case of steam: gas is combusted to heat water into steam, which powers a generator. The

[2] Source : www.energy.ca.gov

steam is again cooled, wasting more than half of heat energy that the steam had left in it. At the end of it all, there is tremendous waste that comes from aggregate power generation and delivery methods for grid electric, and from the specific means and methods used. All suffer from power lost due to bleed during distribution of electric power, and the non-use of waste heat. By comparison, an on-site gas turbine that is using cogeneration or CHP (the recuperation of waste heat) is about 90% efficient.

The figure given below shows the percentage of electricity produced by different sources in California.

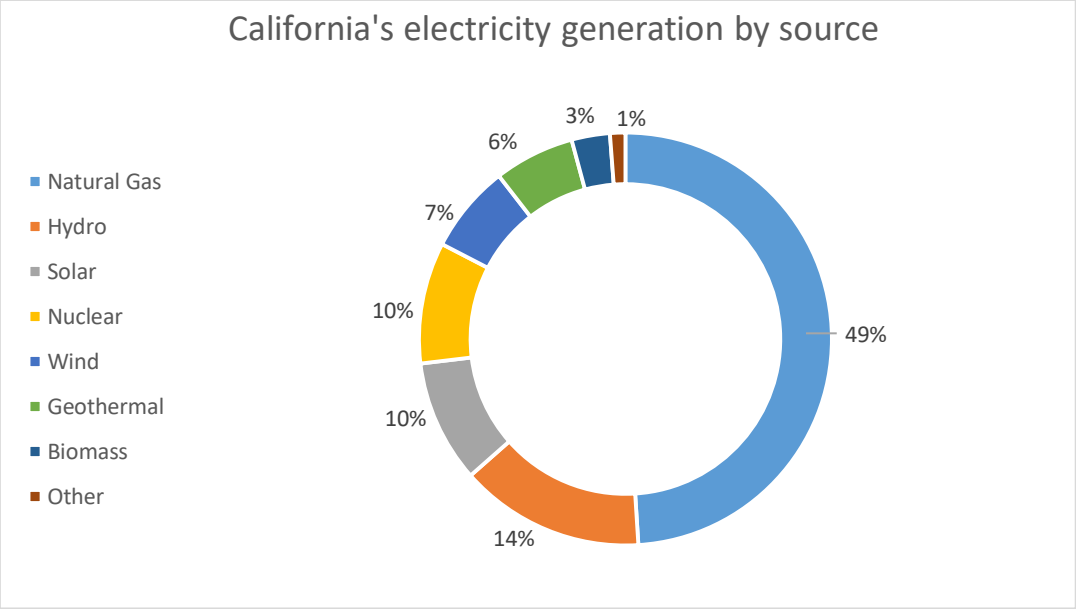

Figure 2: Pie chart showing the generation of electricity with different sources in California

Source: https://www.eia.gov

2.2. Power Outages Due To Severe Weather And Technical Failures

The reliability and resilience of a grid system is extremely important in modern day industry, commercial and domestic market sectors. Yet much of the nation's grids and power systems are no more robust than they were a century ago. These systems are highly vulnerable to large-scale power outages due to several reasons including technical power failures, system overload, cyber-attacks and severe weather.

Conversely, natural gas is far more disaster-resistant. The American Gas Association and SoCal gas have both performed in-depth studies into the disaster resilience of natural gas. Lines are buried and not exposed to falling trees. Supply lines are maintained and viable in earthquakes (FEMA advises gas as a redundant power source up to seismic events above 7.2). There are bypass lines and redundant delivery systems with gas. And the advances with excess and seismic shut-off valves mean, even in a disaster, natural gas fires like we saw during the 19th century are largely preventable by private parties, if not the gas utility itself.

2.3. Increase in Population

California is the most populated state of U.S at 39.9 million people: 1.5 times more than the second most populated state of Texas. The population of California has been growing at a steady 0.9 % annually and by 2030 California is estimated to have a population of 44 million. California's economy has been growing rapidly and is now fifth largest in the world, just behind US, China, Japan and Germany. From 2012 to 2017, there has been a 16% increase in the job growth in California, which is more than any other state in US. New businesses in all major fields and several new fields have been emerging during the recent years,

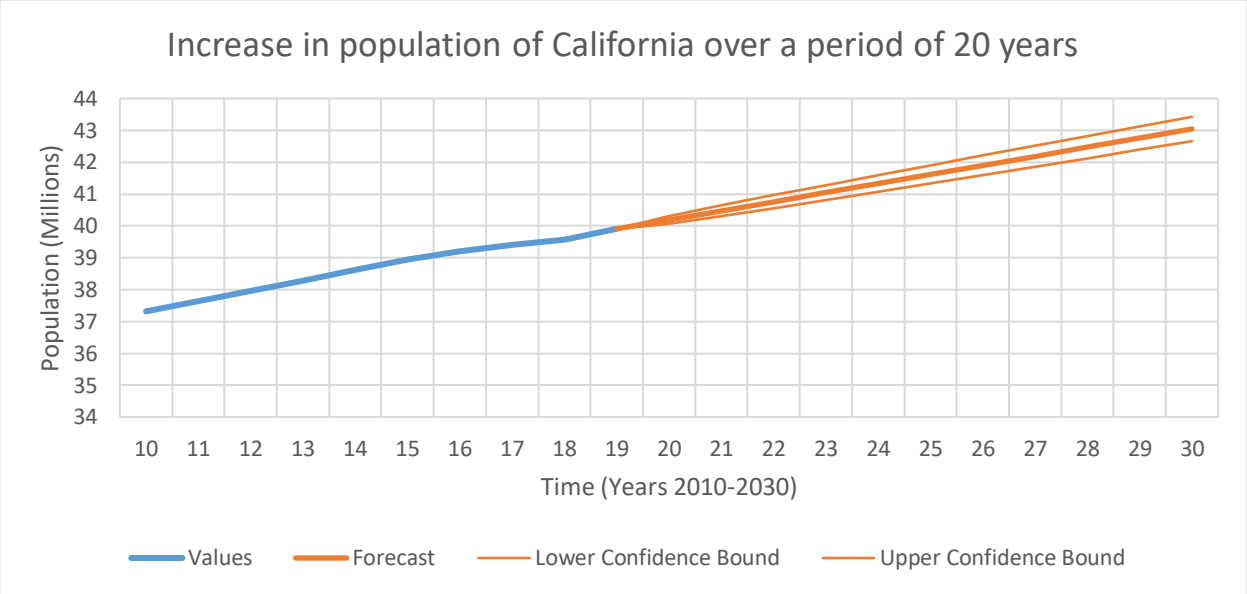

Figure 3: Graph showing the increase in population

including in the so-called 'green' sector, comprised of cannabis and hemp (the power demands for which are considerable, comprising lighting, HVAC, humidifiers, dryers, processing and packaging). Beyond a fixed kWh per person, this industrial and economic growth means a power demand that will grow, per person, in addition to the population growth. The demand of electricity is expected to increase by 50,000 GWh in the next 10 years. This growing demand increases the marginal cost that results in an increase in the overall prices of electricity. Figure 3[3] shows the increase in population projected over a period of 20 years. The expected impact on the cost of power is startling, as marginal demand drives up costs exponentially. The math is clear: California's population and kWh demand has been steadily increasing, as the power production capability has been stagnant, even if they modes of power production have shifted to greener solutions (renewables and natural gas, and fewer nuclear and coal production plants).

[3] This data has been collected from the website of Public Policy Institute of California and then the population numbers have been extrapolated as per the rate shown on the website www.ppic.org

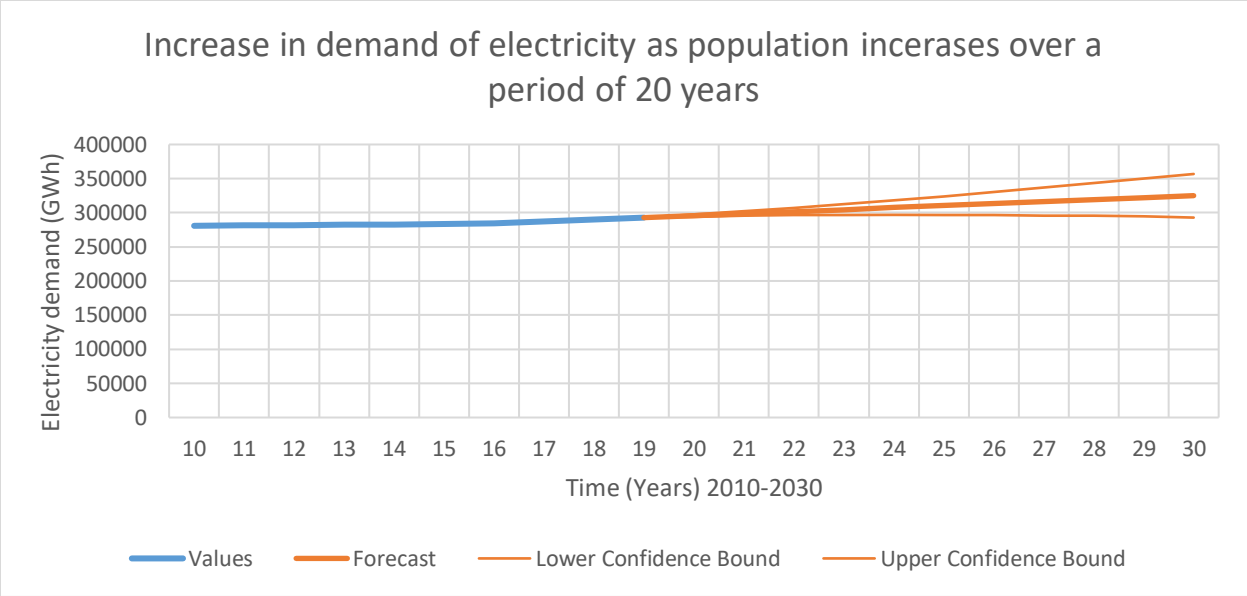

Figure 4: Graph showing an increase in the demand for electricity.

Increased number of people in the state means there is going to be an increase in the demand of electricity, which is clearly shown by figure 4.[4]

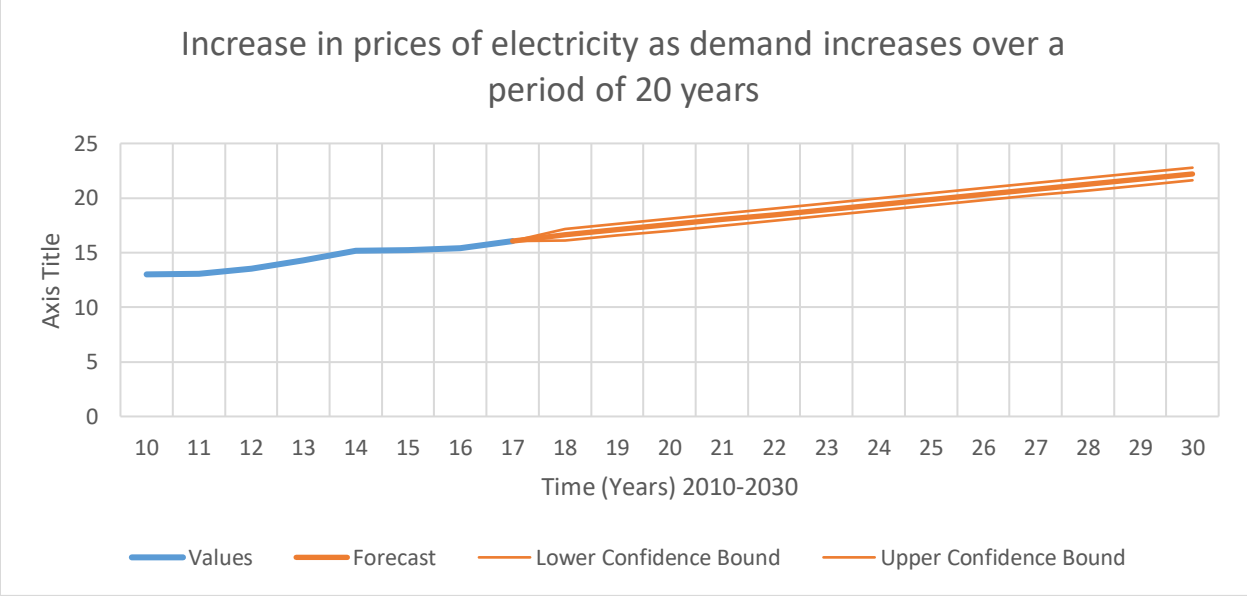

Figure 5: Graph showing increase in the prices of electricity

Although several new generation plants have been installed, including renewable or hydro-electric power; but the increase in population has out-paced kWh production. This means an increase in the marginal cost

[4] Source: www.energy.ca.gov – State wide energy demand data.

because the demand is larger than the supply and that results into an overall increase in the prices. Figure 5[5] shows this rate of increase over a projection of 20 years.

3. Problems due to Energy shortage

An energy shortage that arose from an actual limited ability to provide power for those businesses and residences that need it would manifest differently than the energy crisis that was engineered in the 2000s.

3.1. Increase In Electricity Prices

To wit: electric prices will roughly double inside the next 10 years or so, *optimistically*.

3.2. Business and Industry

Power comprises the biggest operational expense to manufacturing, as well as being indispensable to multiple other verticals (shipping, import/export, aviation). With competition stiff, it should be expected that high energy costs will drive some businesses out of existence, or cause them to flee the region, as high corporate taxes have been repeatedly shown to do. This would obviously impact employment. Because California has a large growing capacity, it should be expected that many verticals reliant upon power (pumps, irrigation, filtration, temperature control) will be impacted.

3.3. Residential Regions

High power prices have an austerity effect on consumption societies, and in this case high power prices – these would have a regressive impact on lower-income populations – which have been steadily growing, in an exaggeration of the trend seen throughout the entire nation.

4. Impact of Gas Turbines and Cogeneration[6]

In the face of ever-increasing energy crisis, micro grids, localized gas generation units and combined heat and power systems comprise a solution.

Currently, internal combustion, steam, and gas turbines are used. But, as stated above, CHP – which makes use of so-called waste heat – could produce more power as a function of the same natural gas used.

4.1. Gas Is Abundant, Disaster-Resilient, And Price-Stable

During an energy shortage such as the one, we are expecting in coming years electricity prices can hike up rapidly. Natural gas prices have been stable for a long time and would continue to do so for a long time due to a huge supply of natural gas if used efficiently. That is one of the reasons why the state of California is generating electricity from natural gas. However, these plants and companies are using conventional gas generation plants that can at best give an efficiency of 33%. By using combined heat and power technology, we can boost this efficiency to close to 90%.

[5] Source: www.eia.gov

[6] Cogeneration is the generation of electricity in such a way that the residual heat from the plants is used for other useful purposes such as heating or cooling.

4.5. The Catch – CHP Must Be Generated On-Site To Capture Waste Heat, For A Distributed Or End-Node Power Generation Model

As stated above, waste heat cannot be captured and used when natural gas is burned by gas turbines on power utility land, because the thermal energy – like electric – will bleed over distances. There aren't systems in existence to capture the waste heat, using a high-mass liquid or other, and transfer the energy to an off-site destination to be used.

Gas distributed to on-site gas turbines, where electricity and waste heat produce energy will beat natural gas combusted by the power utility, to be transported as electricity. It is cheaper and has a smaller CO2 footprint, being roughly 90% efficient vs. 30% efficient.

4.6. Avoided Transmission and Distribution losses

In U.S the average transmission and distribution losses range from 4.23 % to 5.35 % of the total energy[7]. By using a combined heat and power system, we are generating electricity on the site. Hence, there is no need for the distribution and transmission system, that means we can save the electricity lost during transmission and distribution.

4.7. The Cleanest Fuel; Natural Gas

In addition to all these economic benefits natural gas turbine units are the cleanest of all the fossil fuels that can be used to produce energy. When burned natural gas releases up to 50 % less carbon dioxide emission than coal and 30 % less than that of oil. In our system, natural gas is used for power generation where it emits only 50 % less carbon dioxide than coal. The other emissions such as sulfur dioxide SO2, nitrogen oxides NOx, mercury Hg, and other particles are in negligible amounts. [8] One other reason why natural gas is a cleaner alternative than oil and coal is because it offers a significant contribution to improving the air quality and public health.

New technologies are being developed which will store the CO2 released from the gas turbine generators that will result in even further reduction of emissions.

Natural gas generation when compared to nuclear energy is safer as nuclear power plants produce radioactive waste, which is extremely harmful for any living organism and our environment, and it has to be kept safely for hundreds of years..

4.8. Is There Enough Gas To Power Industry?

Due to the high reliability and resilience of the power systems, that have localized generation many universities and cities have considered this option. Localized generation systems currently produce 5 GW of energy for these universities and from time to time, and they have proved to be better than grid electricity. During the hurricane Sandy, most of the places on the east coast did not have access to power for up to 7 days. During this time, places with localized generation systems were running constantly and smoothly without any connection with the local grids. Some of these university buildings were even used as locations for American Red Cross foundations to set up camps to help the people affected by the hurricane. Businesses that were using localized generation systems were also running smoothly, were able to survive the hurricane period, and did not suffer afterwards either. If localized generation systems

[7] Source: Emissions & Generation Resource Integrated Database [eGRID]
[8] Source: International Gas Union

can help cities and businesses survive such extreme weather conditions they can surely help them get through any modern day energy crisis.

5. On-Site Turbines Will Keep Prices Down On Average, For All, And Hugely Benefit The Few

While we make an effort to predict prices using a marginal cost calculator, and the variables of increasing population, electrical power demand, and stagnant power provision, CHP and nodal or distributive power generation from natural gas (vs. central power genernation which cannot utilize waste heat), can only have a positive impact.

Since on-site gas turbine and grid electric gas turbine power provenance will be competing, while average prices may stay lower, or be prevented from dramatically rising, you can expect a divergence between natural gas prices kWh and grid electric; meaning, the price projections will not apply for people using CHP on-site – they'll be paying far less. Such a power price advantage would become a competitive in the several competitive industrial verticals.