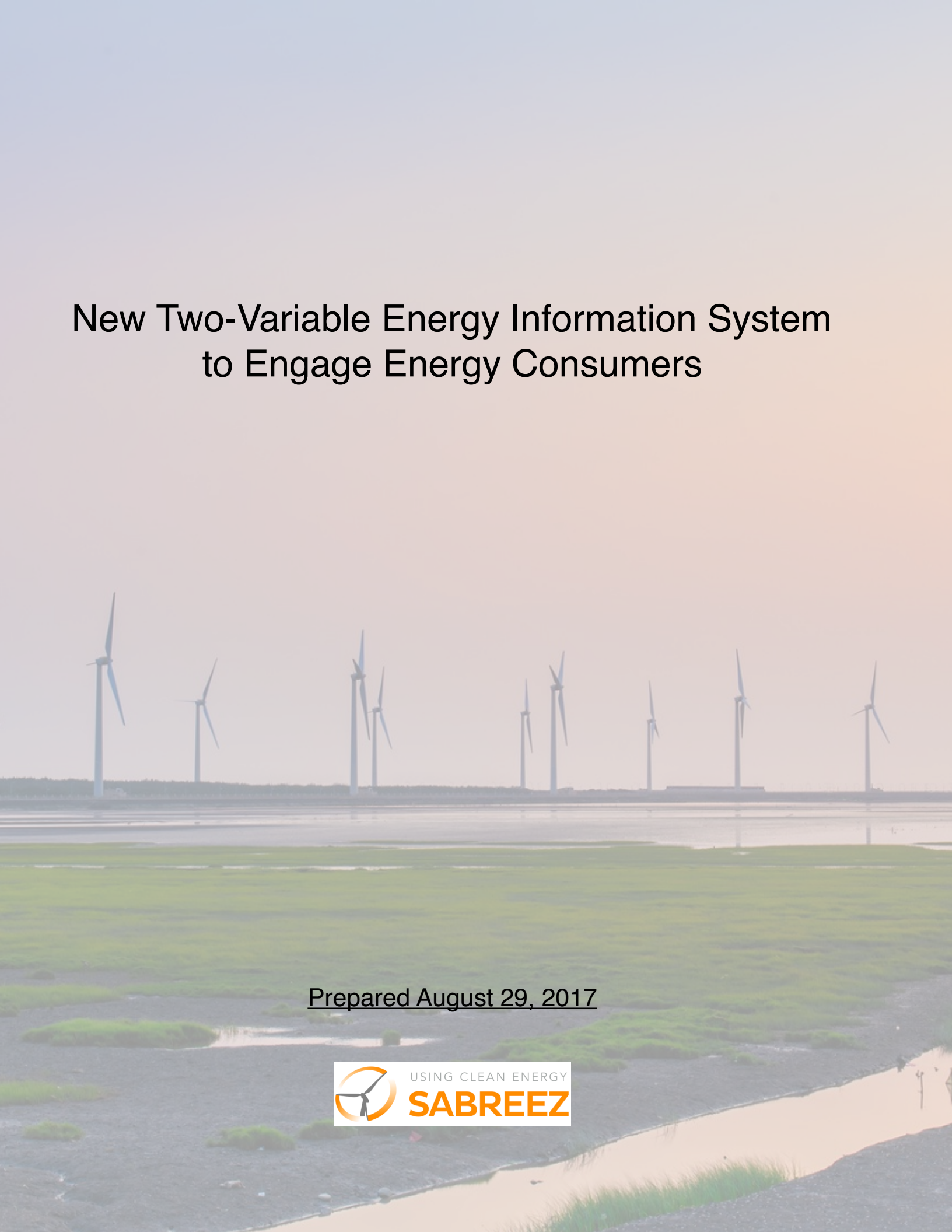
New Two-Variable Energy Information System to Engage Energy Consumers



Prepared August 29, 2017

USING CLEAN ENERGY
SABREEZ

Introduction

Californians value the environment and want to use cleaner energy, but there is now enough solar power in California that it has begun to be curtailed; other technologies need to be deployed. Electric power is usually cleanest between 8:00 am and 4:00 pm, but carbon emissions remain high throughout the remaining hours. Moreover, carbon pollution varies with the weather on a day to day basis in the overall context of weekday vs weekend demand, which in turn varies seasonally.

On the generation side, wind power and energy storage can be further developed, but there is growing interest in engaging consumer energy demand. Consumers are buying electric vehicles, energy storage, connected appliances, and rooftop solar. As always, consumers can manually control when they use electricity, but most don't have a reason to shift energy usage. Consumers need a consumer-facing energy-information system that shows them when electric power is cleaner. They also need to know how to use the existing technology in their home to use cleaner energy.

Our market studies first initiated in 2011 indicate California energy consumers value clean energy as much as saving money with time of use rates. If 100,000 households shift one kilowatt hour (kWh) on any given day to avoid the last peak hour, it avoids the need for 100 megawatts of power plant to turn on each day, and provides additional benefits that warrant utilities, smart home Apps, and media outlets providing the information to the consumer in real time, and through a daily and weekly forecast, much like a weather report for energy.

Seasonal Variation in California Electric Power Production

California is a leading market for the adoption of solar and wind power, and has a diverse energy mix of hydroelectric, natural gas, nuclear, geothermal, and other renewable resources. Even with this diverse mix and almost 10 gigawatts of solar power and more than 4 GW of wind power, the State relies heavily on thermal resources like combined cycle natural gas plants, and more importantly, natural gas combustion turbine (CT) plants that are used to balance supply with demand. In this system, marginal energy costs are lower when it's sunny and windy, and/or when demand is low. Costs spike when CT plants crank up to meet increased demand. In essence, clean energy costs less for energy consumers on a time of use rate.

To save consumers money while efficiently integrating supply with demand, Sabreez shows energy consumers when their energy supply is cheaper and cleaner; and when it's not. The Wind Number[1] is defined as the hourly ratio of wind power divided by electric power coming from thermal resources (fossil fuels), multiplied by 100. The Solar Boost is calculated in a similar fashion as the ratio of solar power divided by electric power coming from fossil fuels, multiplied by a constant which varies seasonally. Together, they illustrate when California's statewide electric power supply is cleaner.

$$\text{Wind Number} = \frac{\text{Wind Power}}{\text{Power from Fossil Fuels}} \text{x100} \qquad \text{Solar Boost} = \frac{\text{Solar Power}}{\text{Power from Fossil Fuels}} \text{xConstant}$$

The Wind Number and Solar Boost were calculated on an hourly basis for the months of October 2016, and January, April, and July of 2017. The spreadsheets are attached in Appendix A.

1. The Wind Number is the subject of U.S. Provisional Patent Application Serial No. 61/904,573, filed November 15, 2013, for METHODS FOR ANALYZING ENERGY CONSUMPTION TO REDUCE COST AND DEVICES THEREOF and U.S. Patent Application Serial No. 14/540,589, filed November 13, 2014 for METHODS FOR OPTIMIZING AN ANALYSIS OF ENERGY CONSUMPTION TO REDUCE COST AND DEVICES THEREOF. Wind Number and Solar Boost are Trademarks of Sabreez, llc.

October 2016

October of 2016 was characterized by low seasonal demand and low wind power. Statewide electric power consumption is lowest at 4:00 am when the average electric power demand was just over 20 GigaWatts (GW), and highest at 8:00 pm when the average was just under 30 GW.

The combined Wind Number and Solar Boost increase at 8:00 am each day as the sun rises and demand levels off it's morning peak. The cleanest electric power occurs from 9:00 am until 3:00 pm, then after 4:00 pm the Solar Boost drops off rapidly as energy becomes dirtier with the increase in power supply from CT Plants.

The best days for clean energy production are presented below. Power plant emissions when the Wind Number and Solar Boost are high correspond to statewide carbon emissions of less than a half-pound per kWh. Average hourly carbon emissions for the period were calculated to be 0.755 pound/kWh[2], so using electricity at these times reduces household emissions significantly.

Figure 1-1 Avg. Hourly Wind Number- October 2016

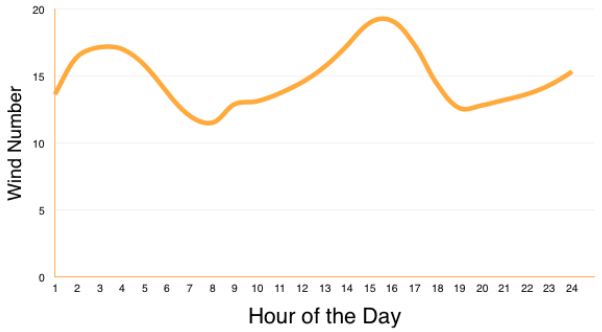


Figure 1-2 Avg. Solar Boost - October 2016

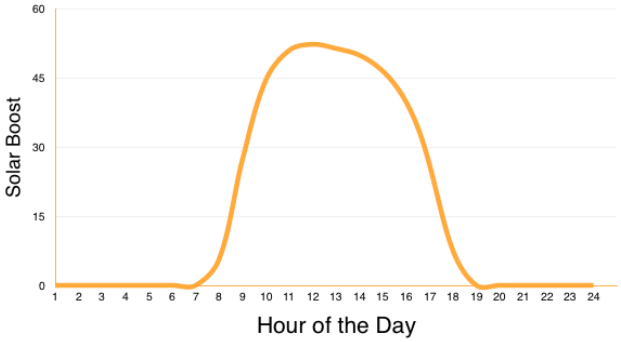
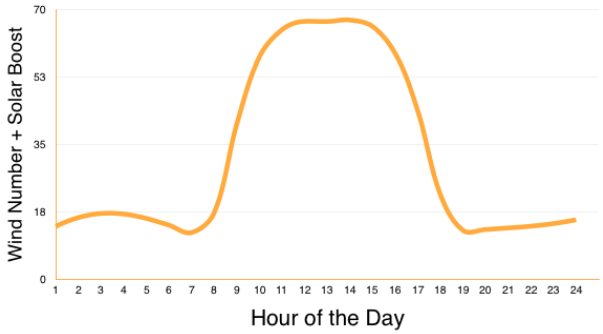


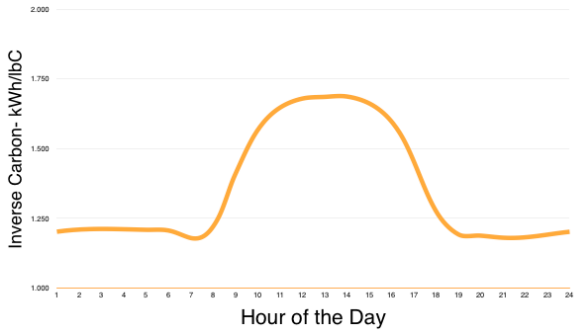
Figure 1-3 Wind Number+Solar Boost - October 2016



Cleanest Energy Days in October

Date	Wind Number + Solar Boost	Best Hour	Carbon lb/kWh
10/2/2016	165	14	0.31
10/15/2016	144	14	0.36
10/16/2016	131	14	0.40
10/5/2016	111	15	0.40
10/3/2016	108	11	0.43
10/17/2016	90	14	0.46
10/18/2016	86	12	0.44
10/1/2016	85	12	0.45
10/14/2016	84	12 & 13	0.43
10/12/2016	82	16	0.42

Figure 1-5 Inverse Carbon Output- October 2016



2. Carbon emissions based on a value of 900 pounds of carbon per MegaWatt hour (MWh) for in-state thermal resources and 1,100 pounds of carbon per MWh for imported electric power.

January 2017

January of 2017 was similar to the October 2016 period in terms of demand and wind power generation, but with increased hydroelectric power generation due to increased rainfall. Statewide electric power consumption is lowest at 4:00 am when the average electric power demand was just over 21 GW, and highest at 7:00 pm when the average demand was just over 29 GW.

The combined Wind Number and Solar Boost increase at 9:00 am each day as the sun rises and demand begins to drop off it's morning peak. The cleanest electric power occurs from 9:00 am to 3:00 pm, then after 4:00 pm the Solar Boost drops off rapidly as energy becomes dirtier with the increased power supply from CT Plants.

The best days for clean energy production are presented below. Average hourly carbon emissions for the period were calculated to be 0.596 pound/ kWh[2], cleaner than the average for October due to lower average hourly demand.

Cleanest Energy Days in January

Date	Wind Number + Solar Boost	Best Hour	Carbon lb/kWh
1/1/2017	176	14	0.35
1/21/2017	131	10	0.32
1/28/2017	110	11	0.33
1/29/2017	109	14	0.31
1/27/2017	94	13	0.36
1/15/2017	89	13	0.41
1/8/2017	83	12	0.42
1/30/2017	76	12	0.40
1/19/2017	75	14	0.43
1/31/2017	72	14	0.39

Figure 2-1 Avg. Hourly Wind Number- January 2017

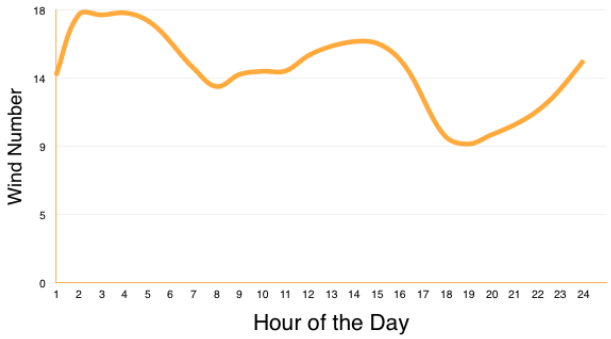


Figure 2-2 Avg. Hourly Solar Boost- January 2017

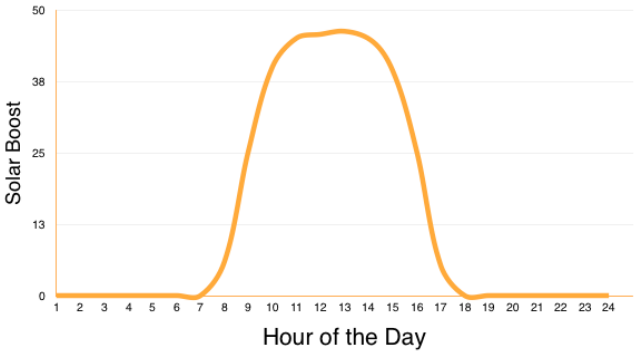


Figure 2-3 Wind Number + Solar Boost- January 2017

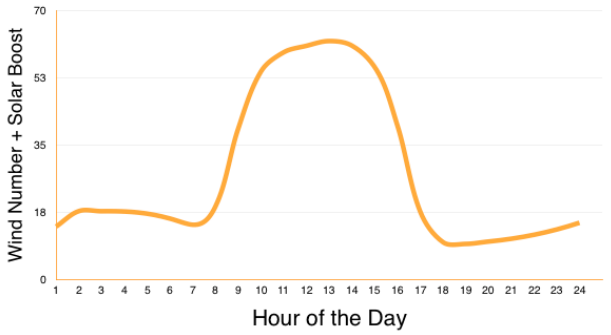
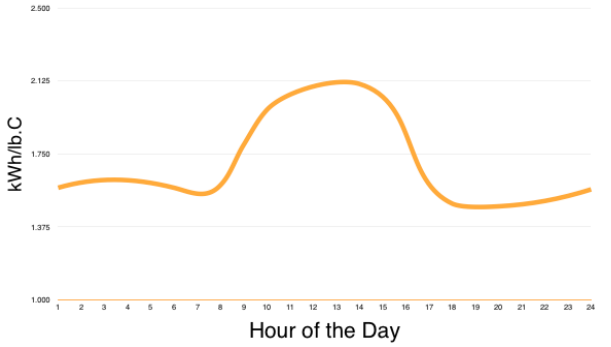


Figure 2-5 Inverse Hourly Carbon Output- January 2017



2. Carbon emissions based on a value of 900 pounds of carbon per MegaWatt hour (MWh) for in-state thermal resources and 1,100 pounds of carbon per MWh for imported electric power.

April 2017

April is the start of wind power season in California, and when combined with increased hydroelectric power generation from historically high precipitation, California enjoyed an abundance of clean energy resources. Statewide electric power consumption ranged from less than 20 GW to just over 27 GW.

Wind Numbers are much higher this time of year, with wind power strong from the afternoon through early morning hours, sometimes exceeding 4 GW. As wind wains, the Solar Boost increases at 8:00 am each day when the sun rises. The cleanest electric power occurs from 9:00 am to 6:00 pm, then the Solar Boost drops off rapidly as approximately 8 GW of CT plants turn on. Wind power can become available concurrent with solar production depending on the weather. Low demand leads to solar curtailments often. More than 80,000 MegaWatt hours of wind and solar were curtailed in April.

The best days for clean energy production are presented below. Average hourly carbon emissions for the period were calculated to be 0.454 pound/kWh[2], but as low as 0.2 pound/kWh, the cleanest period of this report.

Figure 3-1 Avg. Hourly Wind Number- April 2017

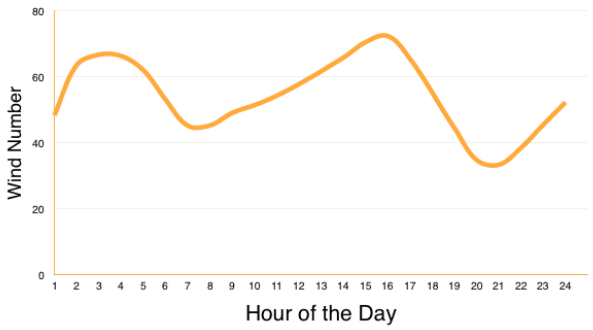


Figure 3-2 Avg. Hourly Solar Boost- April 2017

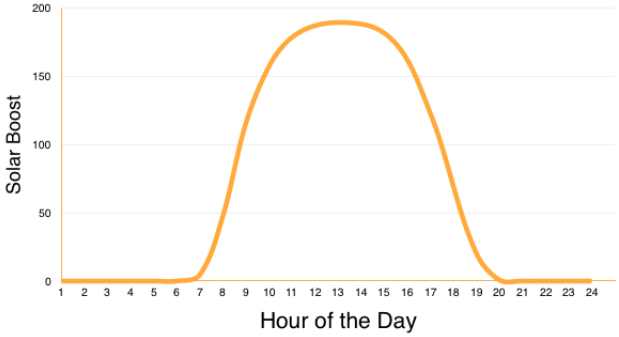


Figure 3-3 Wind Number + Solar Boost- April 2017

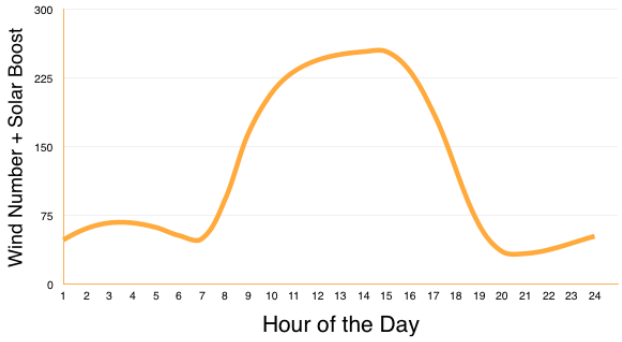
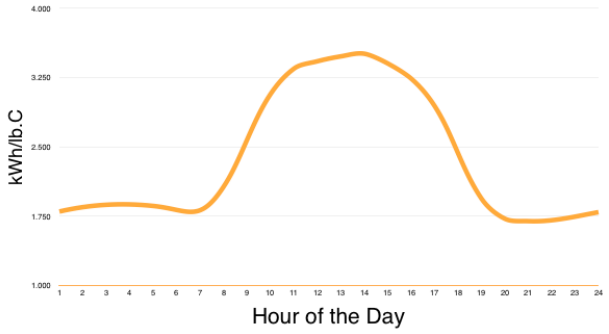


Figure 3-5 Inverse Hourly Carbon Output- April 2017



Cleanest Energy Days in April

Date	Wind Number + Solar Boost	Best Hour	Carbon lb/kWh
4/23/2017	577	15	0.19
4/29/2017	412	12	0.21
4/2/2017	409	16	0.19
4/30/2017	382	15	0.30
4/8/2017	354	13	0.21
4/3/2017	334	12	0.18
4/24/2017	325	12	0.31
4/14/2017	323	14	0.21
4/1/2017	318	14	0.25
4/16/2017	306	15	0.26

2. Carbon emissions based on a value of 900 pounds of carbon per MegaWatt hour (MWh) for in-state thermal resources and 1,100 pounds of carbon per MWh for imported electric power.

July 2017

July was the hottest month of the reporting period, with air conditioning use driving demand over 40 GW on some days. Statewide electric power consumption ranged from an average of 24 GW during the early morning hours up to 39 GW on average at 7:00 pm.

Wind Numbers are lowest mid-day when the Solar Boost is highest. Since both variables are defined as the ratio of clean energy over power from fossil fuels, the Solar Boost is highest before Noon then drops off as demand increases. The State's abundant solar and wind energy resources effectively reduce the evening peak, and push it later to around 9:00 pm, when the combined Solar Boost and Wind Number are lowest.

The best days for clean energy production are presented below. The best time of day to use electric power is 9:00 am to 4:00 pm, though better hours for clean energy consumption are available on some days. Average hourly carbon emissions for the period were calculated to be 0.54 pound/kWh[2], cleaner than October and January, but not quite as clean as April.

Cleanest Energy Days in July

Date	Wind Number + Solar Boost	Best Hour	Carbon lb/kWh
7/2/2017	373	10	0.25
7/1/2017	341	11	0.28
7/4/2017	225	10	0.28
7/3/2017	181	12	0.34
7/30/2017	126	11	0.34
7/16/2017	103	10	0.42
7/18/2017	101	12	0.41
7/20/2017	96	11	0.44
7/29/2017	95	10	0.40
7/12/2017	93	10	0.43

Figure 4-1 Avg. Hourly Wind Number- July 2017

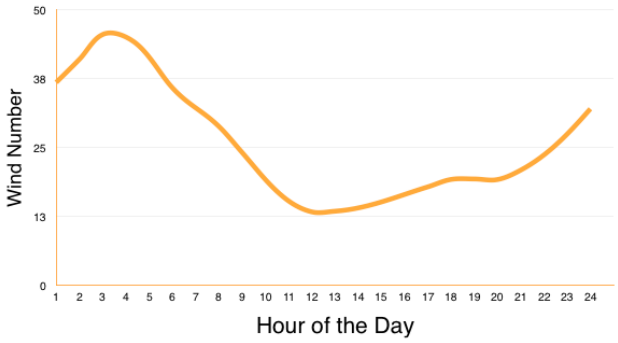


Figure 4-2 Avg. Hourly Solar Boost- July 2017

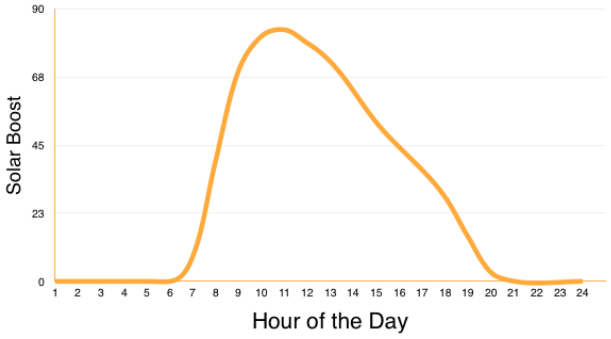


Figure 4-3 Wind Number + Solar Boost- July 2017

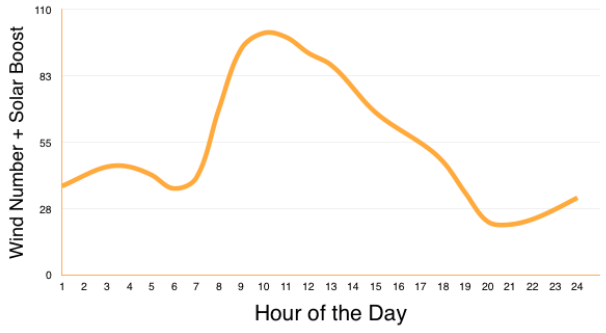
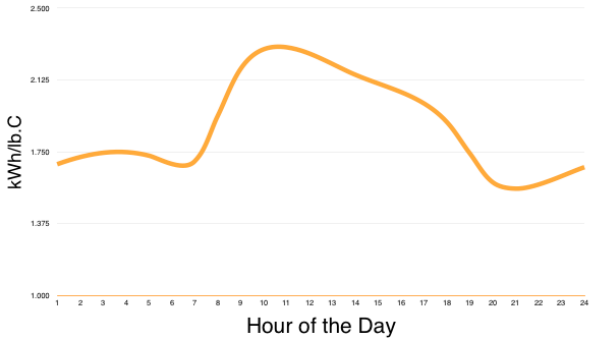


Figure 4-5 Inverse Hourly Carbon Output- July 2017



2. Carbon emissions based on a value of 900 pounds of carbon per MegaWatt hour (MWh) for in-state thermal resources and 1,100 pounds of carbon per MWh for imported electric power.

Summary

The Wind Number and Solar Boost effectively describe California's electric power supply in terms of clean energy production relative to systemwide demand and produce an actionable forecast that the typical energy consumer can understand and will want to see on a daily basis. There is a strong inverse correlation between carbon pollution and the Wind Number and Solar Boost. Although not explicitly discussed previously, there is a similar correlation observed in wholesale pricing with the Wind Number and Solar Boost. When it's sunny and windy, the power supply is on, and wholesale pricing drops. This can lead to negative wholesale prices for electric power. When demand spikes through an absence of solar and wind power or through consumer-driven demand, power prices spike. Clean energy costs less.

Two primary needs of California energy consumers are saving money and protecting the environment. Most consumers don't understand that their energy costs are lower when their energy supply is cleaner on an hourly basis; but it's the most powerful message for engaging the largest percentage of energy consumers. Much of the consumer-facing messaging from utilities has focused on using less energy and critical peak pricing events, rather than on the opportunity to use cleaner energy and save money. Energy consumers will find this message to be a compelling value proposition that motivates load shifting and the adoption of enabling technologies.

An effective Customer Engagement Plan should consist of the following;

- Utility Sponsorship
  - Utilities add Wind Number and Solar Boost APIs to their website
  - Present household clean energy consumption to the consumer relative to the population
  - Offer social media game and rewards each month to engaged population
- Expand app value to smart-home and rooftop solar Apps
  - The Wind Number and Solar Boost will be available through an API allowing companies to add the value of offering cleaner energy to their customers
  - Promote the ability to hit "auto" directly to consumers as an additional service
  - Provide information on California's smart grid to rooftop solar users to enhance understanding of their position in California's clean energy system
- Propagation of the Wind Number and Solar Boost as a daily clean energy forecast
  - Report the best and worst hours of each day to use electric power
  - Report a pick of the week and critical peak pricing events
  - The prototype of this system can be viewed by visiting www.facebook.com/windnumber
- Consumers can opt-in to enter a contest based on their clean energy consumption. This was the basis for Sabreez' entry into the U.S. Department of Energy's "Apps for Energy Contest" in 2014.

Sabreez will be conducting our first utility-sponsored study of our messaging system this year. The study will consist of offering the messaging to a population of energy consumers and evaluating the results through hourly smart meter data. The results of the study will be presented as a roadmap for other markets, like Texas and the Plains States. California often leads on environmental awareness, but concern for the environment isn't limited to California. The majority of Americans want to use cleaner energy. Now that cleaner energy costs less, a consumer-facing energy information system should find wide-spread acceptance in an ever increasing number of markets.

Appendix A

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