Exemplary Advances

2021 March ***"Exemplary Advances"*** is the newsletter for Exemplary Energy Partners, Canberra. Feel free to forward it to friends and colleagues. Click here to subscribe or unsubscribe. Feedback is most welcome.

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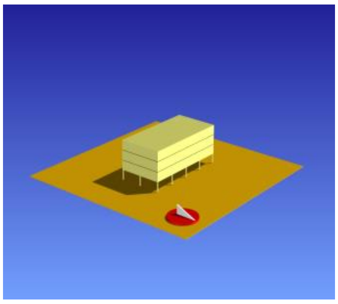
Exemplary Weather and Energy (EWE) Index[i] - February 2021

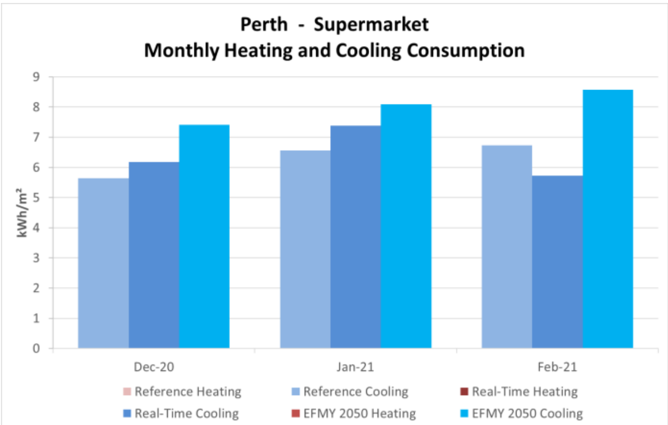
Monthly tabulation and commentary relative to the climatic norm – the Reference Meteorological Years

2021 February	Canberra		Perth		Sydney	
	Heat	Cool	Heat	Cool	Heat	Cool
10-Storey	N.A.	N.A.	-	-2%	-	-24%
3-Storey	N.A.	N.A.	-	-1%	-	-27%
Supermarket	N.A.	N.A.	-	-15%	-	-20%
Solar PV	N.A.		-1.7%		15.0%	
PV Farm	N.A.		-		-	

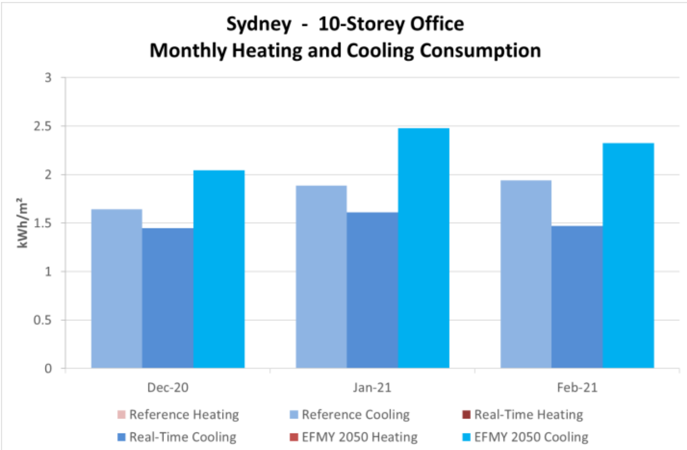


The Exemplary Real Time Year weather files (RTYs) the current Reference Meteorological Year files (RMYs) and the Ersatz Future Meteorological Years (EFMYs) used for these monthly simulations are available for purchase to allow clients to simulate their own designs for energy budgeting and monitoring rather than rely on analogy with the performance of these archetypical buildings and systems.

Canberra had no data for February. The problem with CSIRO's weather station is being worked on but this much appreciated source of data over more than five years will not continue for long anyway. CSIRO has advised that the project that was funding the ongoing maintenance of the solar monitoring sites is being wound up, so there's now no official support to keep things running. See below (Weather and Solar Radiation Data) for our report on progress with alternative data sources.



Perth had a cooler but more humid February than average. The mean average, mean maximum, and mean minimum temperatures were lower than the long-term averages by 1.9°C, 2.6°C and 0.9°C respectively. The mean average and mean minimum relative humidity (RH) was higher than long term average respectively by 5.8% and 1% while the mean maximum was lower by 2% (2021 Feb RH minus long term average Feb RH). Perth generally received higher than average solar irradiation in the mornings and early afternoons. However, the solar PV simulation showed an output 1.7% less than the average. This may be because wind speeds were generally lower than average leading to slower heat transfer from the solar panels thereby increasing their temperature and decreasing their efficiency. All three commercial building models had lower than average cooling consumption with the office building model lower in the range of 1-2% while for the supermarket it was 15% less. All of the 10-storey office building zones showed a lower than average energy usage for cooling. The east and north facing zones had the least negative deviation in cooling energy as the solar irradiation was higher than average from the morning hours until around 2 pm. Overall, the cooling energy consumption of the 10-storey office building was 2% lower than average. When comparing the simulation results using our EFMY 2050 climate data with the current climate, it is projected that the two office building models would have around 20% higher cooling consumption and the supermarket would have 33% higher cooling consumption than this February.

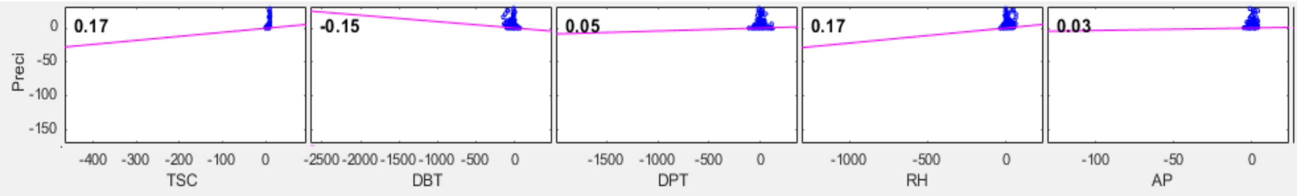


Sydney also experienced a cooler but more humid February than the average. The mean average, mean maximum, and mean minimum temperatures were lower than the averages by 2.3°C, 3.4°C and 1.6°C, and with regards to the relative humidity (RH) experienced in February, these values were higher than average by 2%, 3% and 9% respectively (2021 Feb RH minus long term average Feb RH). It was generally sunnier than average from around 9 am in a normal day in February and the wind speeds were generally higher than average. These three factors resulted in the solar PV array output being higher than average by 15%. The cooling consumptions of all the commercial building models were lower than the average and ranged between 20-27%. Despite that, the east facing zone of the 10 storey office was higher than average cooling consumption by 11.1% due to the lower than average solar irradiation in the mornings but these hours encountered higher than average humidity leading to higher latent cooling loads. All other zones had lower than average cooling consumptions. When comparing our EFMY 2050 simulation results with the results for February, it is projected that the two office models would have around 37-38% higher cooling consumption, and the supermarket would have about 35% higher cooling consumption than for the February just gone.

Precipitation Data – Progress Report on Developing Hourly Data

Readers may recall updates given about the task taken up by Exemplary to seek ways to distribute daily precipitation values into hourly values for 200 locations across Australia whenever the hourly data is not available. This work was taken up primarily to offer a complete weather data package for 30 years from 1990 and this could find application in studying condensation problems in buildings and building components in all Australian climate zones. This exercise has now been taken up by Exemplary Energy's **Nihal Abdul Hameed** under the guidance of Masoume Mahmoodi, a Ph.D student at ANU pursuing research in the area of Power systems and renewable integration.

The approach followed was to find a correlation between precipitation (mostly rainfall) and various weather elements like Total Sky Cover and hourly change in dry bulb temperature, dew point temperature, relative humidity, and atmospheric pressure. This is done with hourly precipitation data in the locations and time duration where the latter was available from the Bureau of Meteorology. This correlation will be used to estimate the hourly precipitation values from the daily values in the 1990s and early 2000s when only daily data (to 9 AM) has been recorded. The initial step taken was to find linear correlation between these data sets and the result was obtained as seen here.



This led to the understanding that the above datasets do not have a strong linear correlation. Now the next step is to check for non-linear correlation between these datasets and modelling software like Matlab will be employed for this. Our working hypothesis is that informing such software the type of correlation that could be expected between the datasets would result in finding accurate and reliable correlations. Therefore a literature survey was undertaken to understand if any such correlation between these data has been established. Several interesting findings were observed in academic works endeavoured in different locations of the world. For instance, it was recorded that the temperature was found have an exponential relationship with precipitation and it followed a positive correlation in low temperature or winter conditions while a negative scaling was observed in conditions of high temperature or summer. This phenomenon was understood to be due to the effect of relative humidity in the respective summer and winter conditions. With these kinds of interdependences existing between the weather elements, it was decided to implement the approach of Multilayer Perceptron (MLP), which is a data analysis tool that would also take into account not only the relation between precipitation and various weather elements individually but also the interdependence existing between the weather elements themselves.

Further updates and results obtained for the above mentioned approach would be posted in coming editions of Exemplary Advances.

Australian Standards Update: Weather Statistics over three decades

Exemplary Director (Buildings), **Trevor Lee**, serves on Committee CS-028 (Solar Water Heating) of Standards Australia. SA has a policy of cyclic updating of its published standards and its solar energy standards are no exception. Having recently provided climate data for the update of AS/NZS 4234 *Heated water systems - Calculation of energy consumption*, Exemplary is now to provide weather data and statistics for the updating of AS 3634 *Solar heating systems for swimming pools*. The revision of those standards is now at an advanced stage and "Exemplary Advances" will keep you up to date with their public review and eventual publication.

Weather and Solar Radiation Data for 2019 and 2020 now Imminent

Production of weather files for the years 2019 and 2020 and climate files incorporating that data is now imminent, potentially with enhanced solar data from the Bureau of Meteorology (BoM). As well as the higher resolution (geographically and temporally) made possible by the Himawari satellite, there is also a clear potential for the cloud cover data from which the BoM infers its solar data to be published as well. Currently, weather and climate data processors, like Exemplary, need to "reverse engineer" (infer) the cloud cover data from the BoM-derived solar data. This is dubious science during daylight hours and complete non-science for the half of all hours with no solar data - leaving processors no better solution than linear interpolation through the hours of dusk, night and dawn.

In addition, the proposed rapid release of the data, approaching real time, will allow the expansion of the number of locations included in our Exemplary Weather and Energy Index to include all Australian capital cities. Those Real Time Years (RTYs) will also be available for purchase to allow building and energy system simulation to be used on an ongoing basis for operational efficiency reviews and responses. For more information on the use of RTYs, see our paper to the ICEM 2015 in Boulder CO USA.

We will continue to keep you informed of developments in this field, although nothing has been announced in the past four months. The hiatus since July 2019 has meant an embarrassing delay to the production of up to date weather files for over two years now. The full one-page statement from the BoM released in November last year is still available here for reference in the interim.

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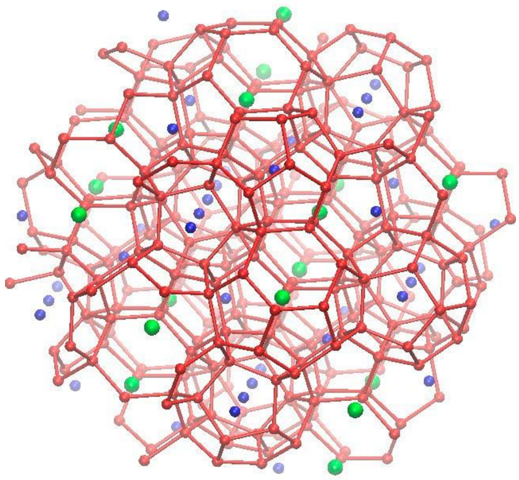
New Team Member – Masoume Mahmoodi

Our team has grown with the joining of Masoume as a Software Analyst with us. She is currently a PhD candidate at the Australian National University (ANU) specializing in Renewable Energy Integration in Distribution Power Systems under the supervision of Prof Lachlan Blackhall. She has attained her bachelors and masters in Electrical Engineering from Amirkabir University of Technology (AUT), Tehran, Iran. She has also worked as a power market expert in Iran Grid Management Company (IGMC) and now has a role in tutoring undergraduate and masters student engineers at ANU. Her insights in Systems Modelling and her skills in computer programming, especially in MATLAB and PYTHON, will be valued greatly here at Exemplary, especially as a complement to our intern **Nihal Abdul Hameed** (introduced to you in our 2020 January edition) in our project to statistically analyse precipitation data in particular.

Petroleum industry to avoid carbon emissions?

Nihal Abdul Hameed, Exemplary Energy

Reversing the technology used in the petroleum industry to avoid carbon emissions is a part of my master's degree in Renewable Energy at the Australian National University (ANU). I had taken up a research project in the area of carbon capture in the ANU's solar thermal group. The project involves studying the formation of gas hydrates of carbon dioxide. Gas hydrates are formed when carbon dioxide molecules get entrapped within a group of water molecules and become stable at low temperatures and high pressures. Another gas hydrate found in nature is that of methane in the arctic beds which is facing threats of getting released into the environment due to global warming.



Gas hydrates are formed when molecules (shown in green and blue) get entrapped in the interstices of water in the solid form (shown in red)

The study at ANU is about finding the best ways to increase the production of these gas hydrates so that the carbon dioxide from the flue gases coming out of the industries could be captured and a carbon free mixture of gas could be released into the environment. To achieve this thermodynamic and kinetic promoters like sodium dodecyl sulphate (SDS) and tetrahydrofuran (THF) are utilized which increase the rate of hydrate formation and improve the conditions at which the gas hydrates become stable. These promoters help in bringing the gas hydrate formation conditions closer to Standard Temperature and Pressure (STP) to minimize the energy that needs to be expended to reach the formation condition and in the laboratory, conditions in the range of 3-12°C and 1-5 MPa (10-40 atmospheres) is required with current knowledge of promoters to achieve the hydrate formation. Interestingly, in recent decades, intensive research was done to achieve ways to inhibit the formation of these gas hydrates as their production could lead to blockages of under-the-sea natural gas pipelines. Now the focus has changed: promotors are under scrutiny to separate the carbon dioxide from flue gas mixtures which could be later utilized industrially or stored underground. This process could then be used to ameliorate the greenhouse gas potential of flue gases from any fossil-fueled plant.

Read more about gas hydrates at Physics World here.

Mount Isa looks to 50 MW solar thermal storage

Concentrated Solar Power (CSP), including forms of generation that rely on storing the sun’s heat focused by a field of heliostat mirrors, have been slow to prove themselves commercially.

The biggest disappointment was the failure of SolarReserve to attract backing for its 165 MW Aurora facility in South Australia. The biggest success, meanwhile, has been the system installed at Sundrop Farms in South Australia, which can generate up to 39 MW and helps its owner turn out “endless shiny truss tomatoes”.

The technology suits dry, hot locations, which is part of the reason why Australian concentrated solar thermal power company Vast Solar has attracted financial backing from the Queensland government-owned Stanwell Energy to look into the feasibility of a 50 MW solar thermal plant in the remote silver-lead-zinc mining city, Mount Isa, in north-west Queensland.

“Once you get the technology right, it will be the cheapest form of dispatchable renewable energy in hot dry places”, says Vast Solar CEO Craig Wood. *“We’re quite confident in that.”*

Read more at Ecogeneration.

[i] Exemplary publishes the EWE for three archetypical buildings and a residential solar PV system each month; applying the RTYs to EnergyPlus models developed using DesignBuilder for a 10-storey office, a 3-storey office and a single level supermarket as well as an SAM model of a typical 3 kW_{peak} solar PV system designed by GSES. All values are % increase/decrease of energy demand/output relative to climatically typical weather. Especially during the mild seasons, large % changes can occur from small absolute differences. RTYs are available for purchase for your own simulations.