Solar Eclipse 21 June: Effects on the Taiwanese Power System

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- On 21 June 2020, an annular solar eclipse could be observed from Africa to Asia.

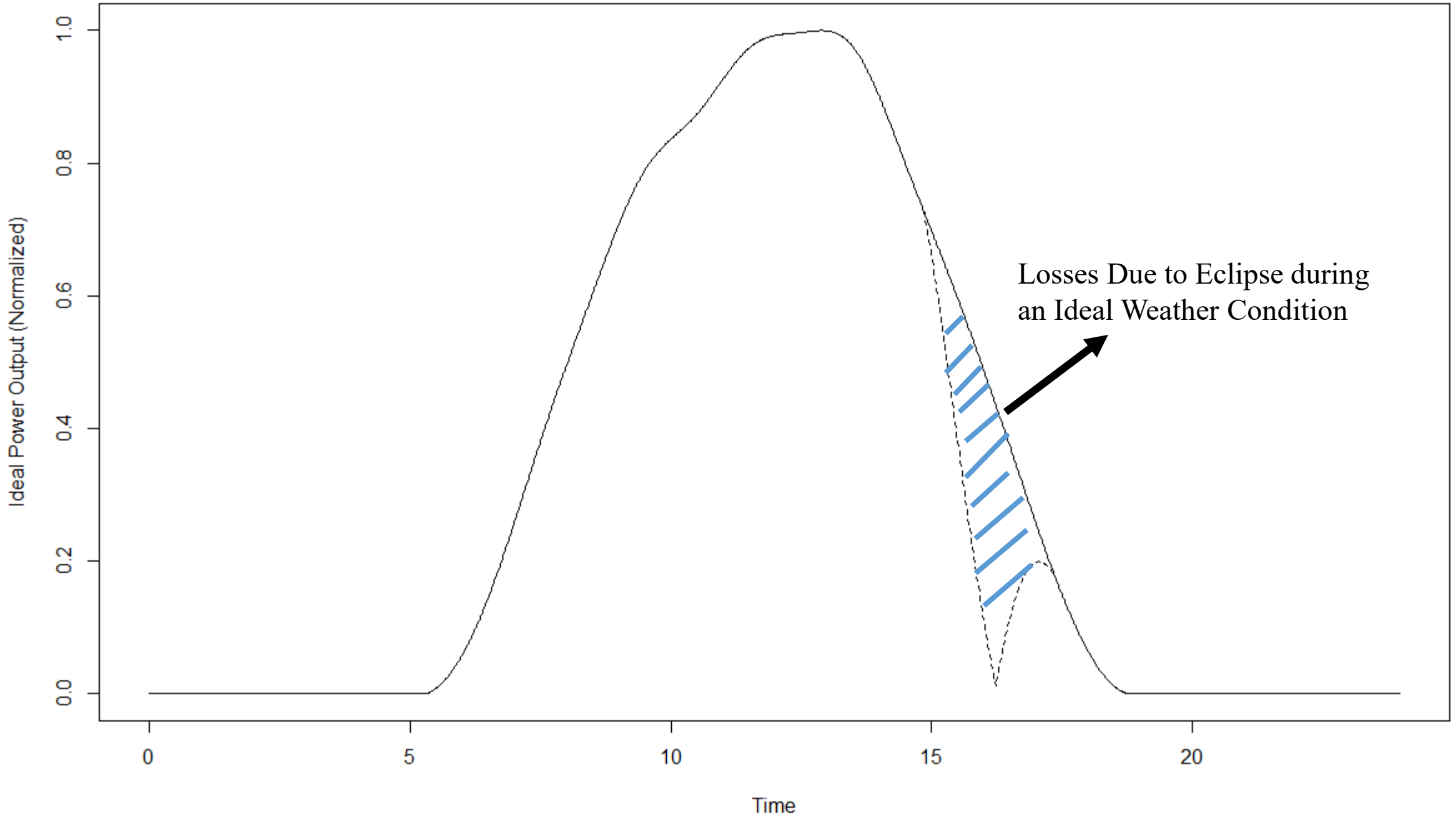
- For Taiwan, the event took place from 14:49 to 17:25, a duration for more than two and half hours.

Modeling Based on Previous Data

- Based on the solar power output data in the previous week, it was possible to estimate the effects of the event.

- Under an ideal weather condition, the eclipse would reduce daily electricity yield from solar power plants by around 6,30%.

- During the eclipse, the electricity yield would be reduced by 40,39% under an ideal weather condition.

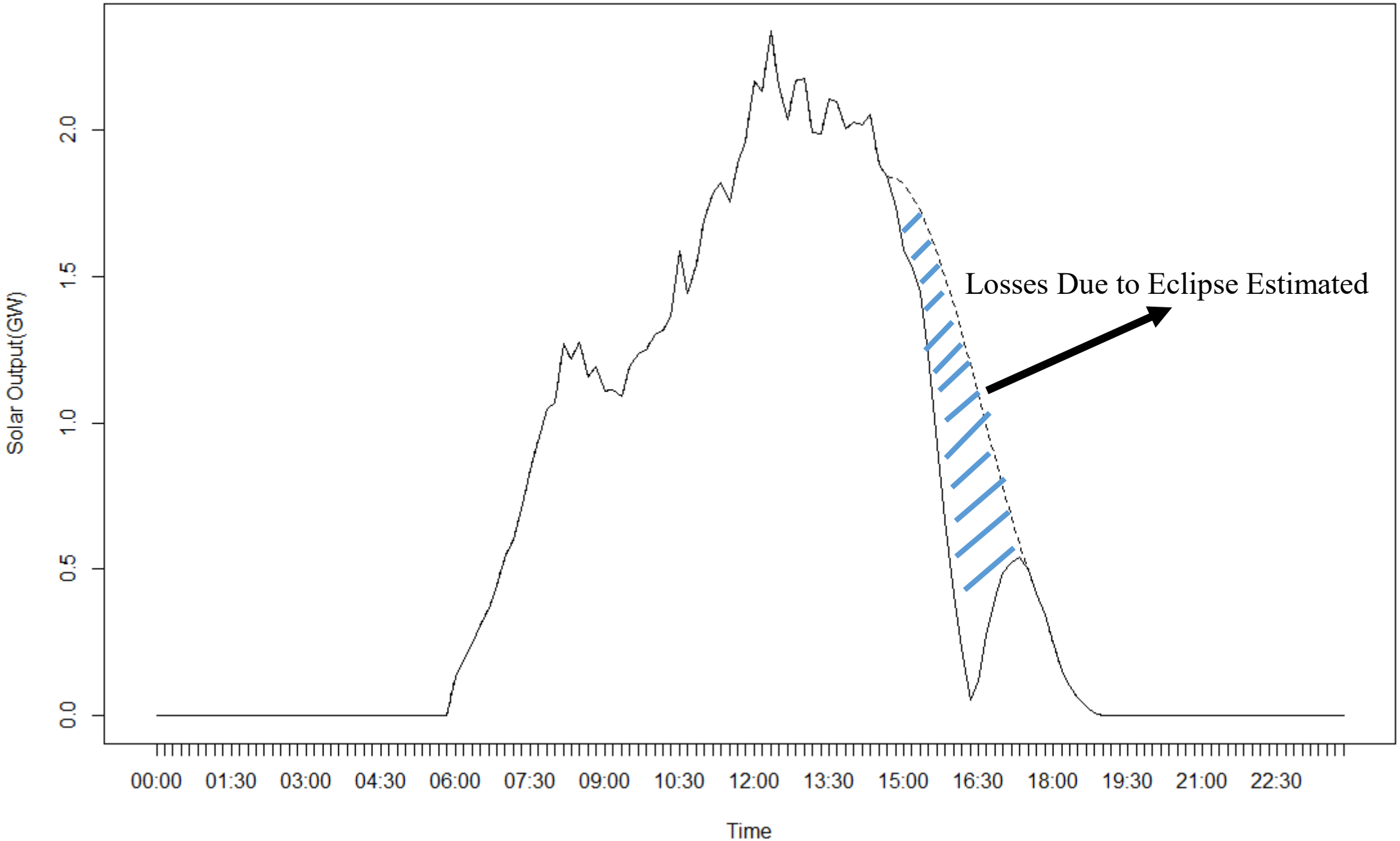

Losses Due to Eclipse during
an Ideal Weather Condition
Ideal Power Output (Normalized)
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
20
Time

Empirical Results

- In reality, on the morning of 21 June, many places in Taiwan were cloudy and rainfall occurred occasionally.

- Luckily during the eclipse, the rain and cloud faded away in most places.

- By interpolating the data, we estimate the event reduced the electricity yield from solar power plants by 9,68% that day; however, if we focus only on the time interval where the eclipse took place, the figure would be 38,11% - very similar to our estimation based on previous data.


Losses Due to Eclipse Estimated
Solar Output(GW)
0.0
0.5
1.0
1.5
2.0
00:00
01:30
03:00
04:30
06:00
07:30
09:00
10:30
12:00
13:30
15:00
16:30
18:00
19:30
21:00
22:30
Time

Overall Impact on the Power System

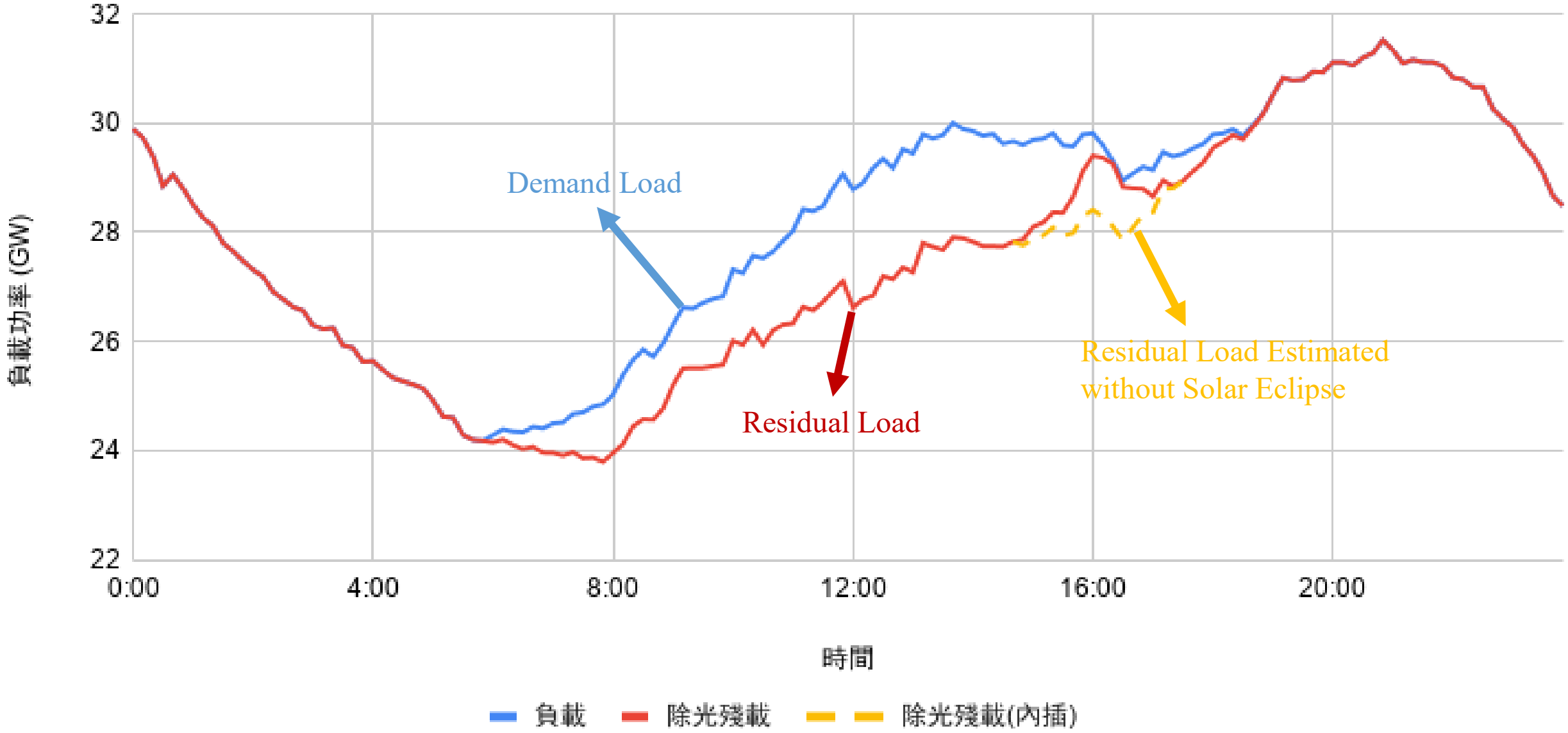
- The effect solar eclipse had on the residual load was minor; a local peak occurred around 16:00, with around 1 GW of additional flexibility requirement compared with a no eclipse case.

- Compare this with the flexibility requirement of the normal diurnal pattern of the residual load that day, such additional requirement was negligible.

Overall Impact on the Power System

- As with the normal diurnal pattern, the additional flexibility requirement was fulfilled by hydroelectricity and conventional gas power plants.

- Also worth noting: correlation among solar output, temperature, and demand load could still be observed even under such extreme event; maximum obscuration occurred between 16:13 and 16:14, but the residual load started to drop 10 minutes before that extrema was reached since the temperature (and thus demand from AC load) was also dropping.

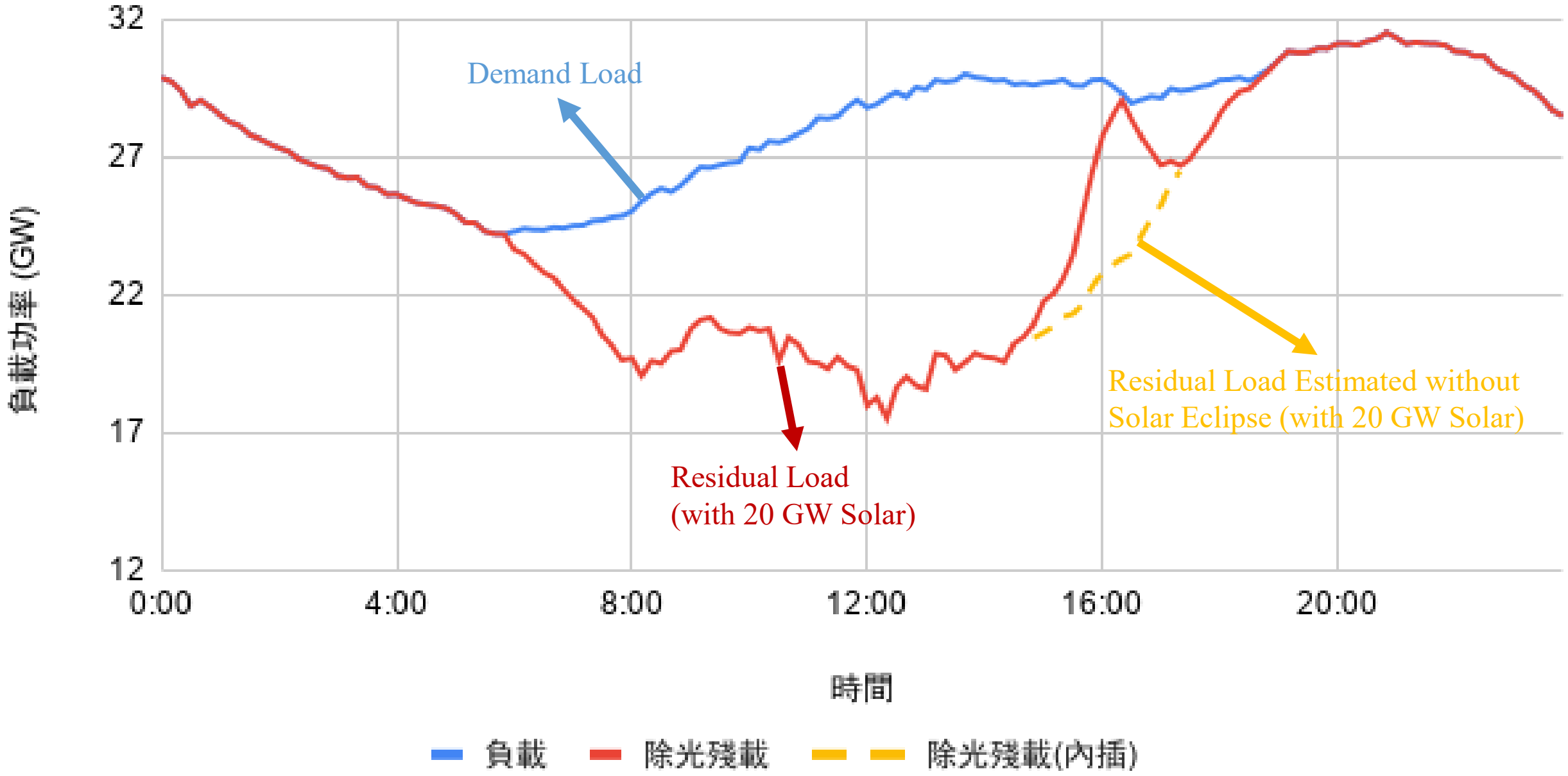


Note: The residual load here only considers demand minus solar; wind is omitted

Insights to the Future

- Should a similar solar eclipse event occur in 2025 (when Taiwan's solar fleet is 5 times of its current size), the impact would be more significant.

- The flexible resources requirement would still be less than what the normal diurnal residual load pattern required, albeit the ramp rate needed would be faster than that under normal operation conditions.


32
27
22
17
12
負載功率 (GW)
0:00
4:00
8:00
12:00
16:00
20:00
時間
Demand Load
Residual Load
(with 20 GW Solar)
Residual Load Estimated without
Solar Eclipse (with 20 GW Solar)
負載
除光殘載
除光殘載(內插)

Insights to the Future

- The next time Taiwan experiences such dramatic solar eclipse event will be in 2070.

- By that time, our energy system should already be run with nearly 100% renewables, with at least 200 GW of solar and 100 GW of wind (Jacobson et al., 2019).

- Flexible VRE, demand side management, and different storage options will probably provide more than enough flexibility for such astronomical ramping event by then.