Grid Value Propositions for Tidal based Generation Resources – a Temporal Analysis

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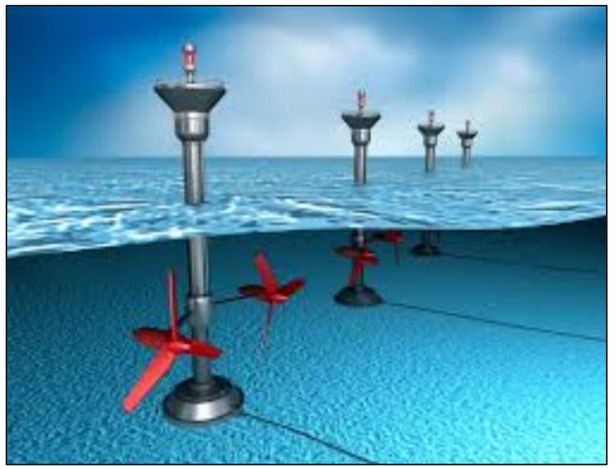
Outline of the presentation

- Why Marine Renewable Energy (MRE) as a grid resource?
- Objective of this paper
- Data and Model Descriptions
- Temporal Metrics for Analysis
- Analytical Results
- Conclusions and future work

MREs as a grid resource

- MREs are (still) not cost-competitive as solar/wind
- Unique aspects of MREs might still provide unique grid benefits
- These unique benefits still remain uncompensated, unquantified and unvalued to a large extent



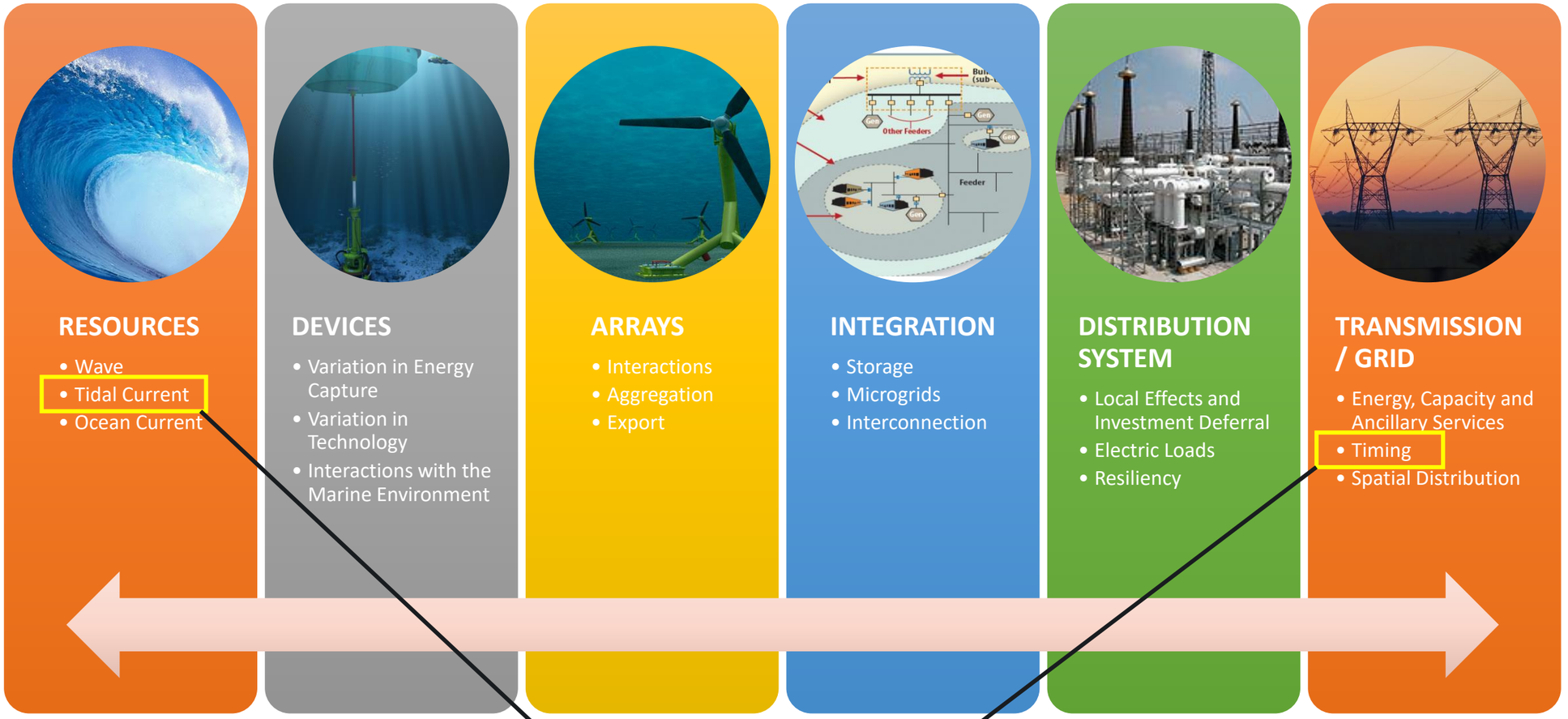
Wave energy resources

Tidal energy resources

Ocean current energy resources

Image courtesy: DPTI – South Australia, Wood Harbinger (web-based resources)

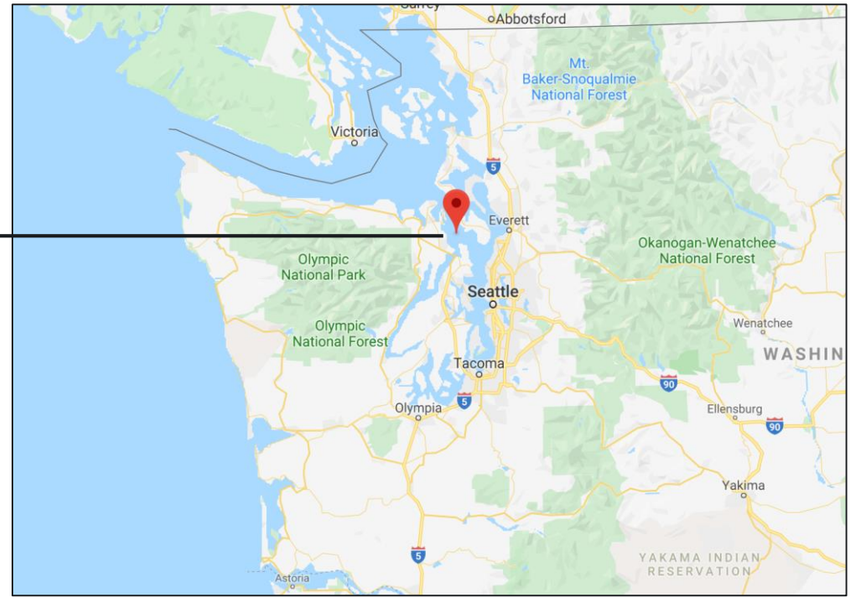
MREs as a grid resource (contd…)



Objective of this paper

- To understand the temporal characteristics of tidal generation
- Discuss potential challenges in data needs and curation
- Develop some metrics to quantify characteristics (and compare with other REs)
- Relate to possible applications in the grid domain
- Discuss potential challenges and opportunities for aforementioned applications
- Location chosen: Admiralty Inlet, WA

Admiralty Inlet, WA



Data and model descriptions

- Admiralty Inlet, WA – tidal velocity profiles (http://mhkdr.openei.org)

Max power output from generator

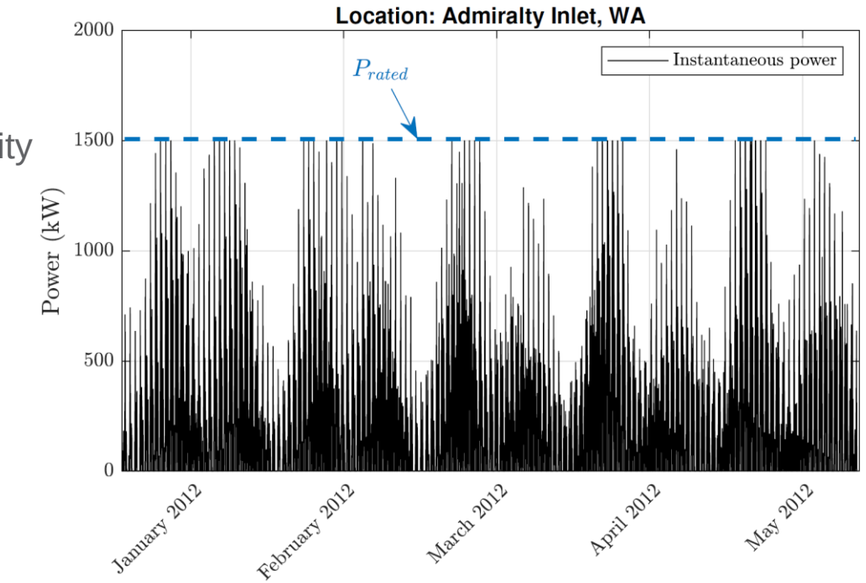
Density

Rotor diameter

Mechanical efficiency/ coefficient of performance

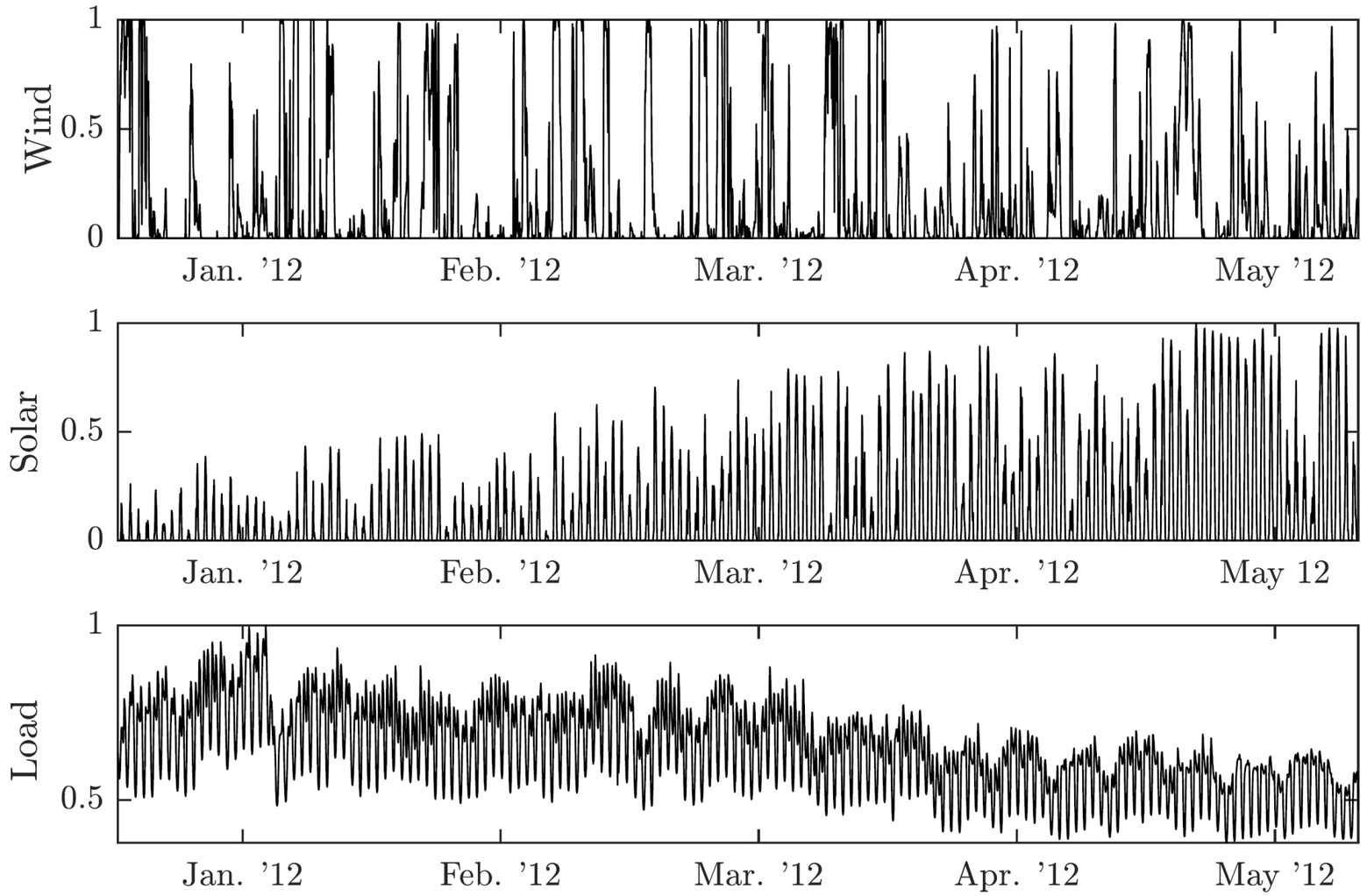
Tidal velocity

$$P_{max} = \frac{1}{2}\rho_{turb}\left(\frac{\pi d^2}{4}\right)C_{p,max}v^3$$



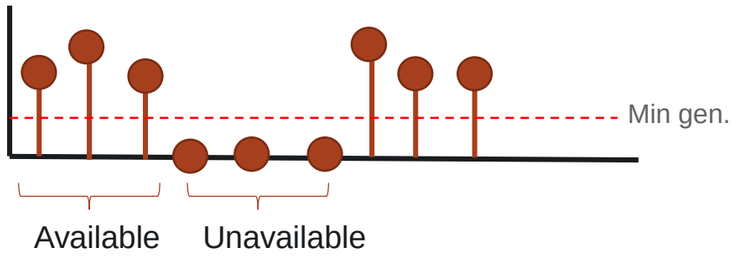
Region 1	Region 2	Region 3	Region 4
v < cut-in	cut-in < v < cut-out P_max < P_rated	cut-in < v < cut-out P_max > P_rated	v > cut-out
$P = 0$	$P = P_{max}$	$P = P_{rated}$	$P = 0$

Data and model descriptions (contd…)

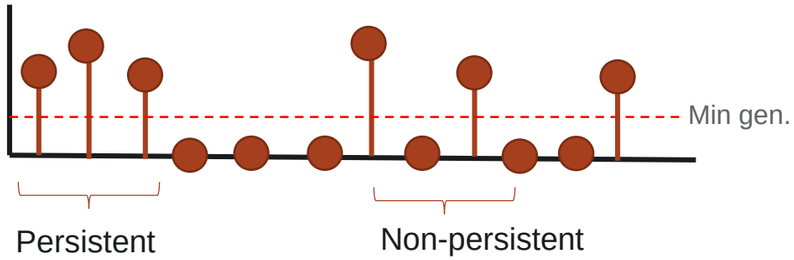


Temporal metrics for analysis

- **Resource Availability**



- **Resource Persistence**



- **Resource Approximate Entropy (higher implies more randomness)**

$$\Phi^m(r) = (N-m+1)^{-1} \sum_{i=1}^{N-m+1} \log(C_i^m(r))$$

$$\mathrm{ApEn} = \Phi^m(r) - \Phi^{m+1}(r)$$

m is length of compared un of data, *r* is filtering level

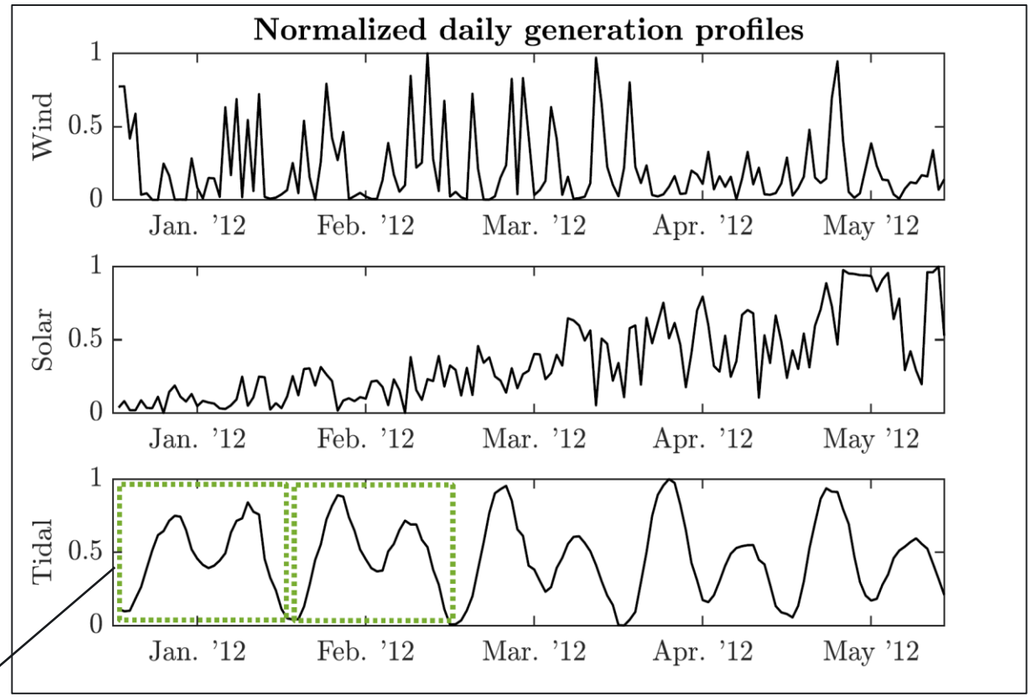
Analytical results

TABLE I
TEMPORAL METRICS FOR SOLAR, WIND AND TIDAL GENERATION RESOURCES AT HOURLY TIME SCALE FOR ADMIRALTY INLET, WA

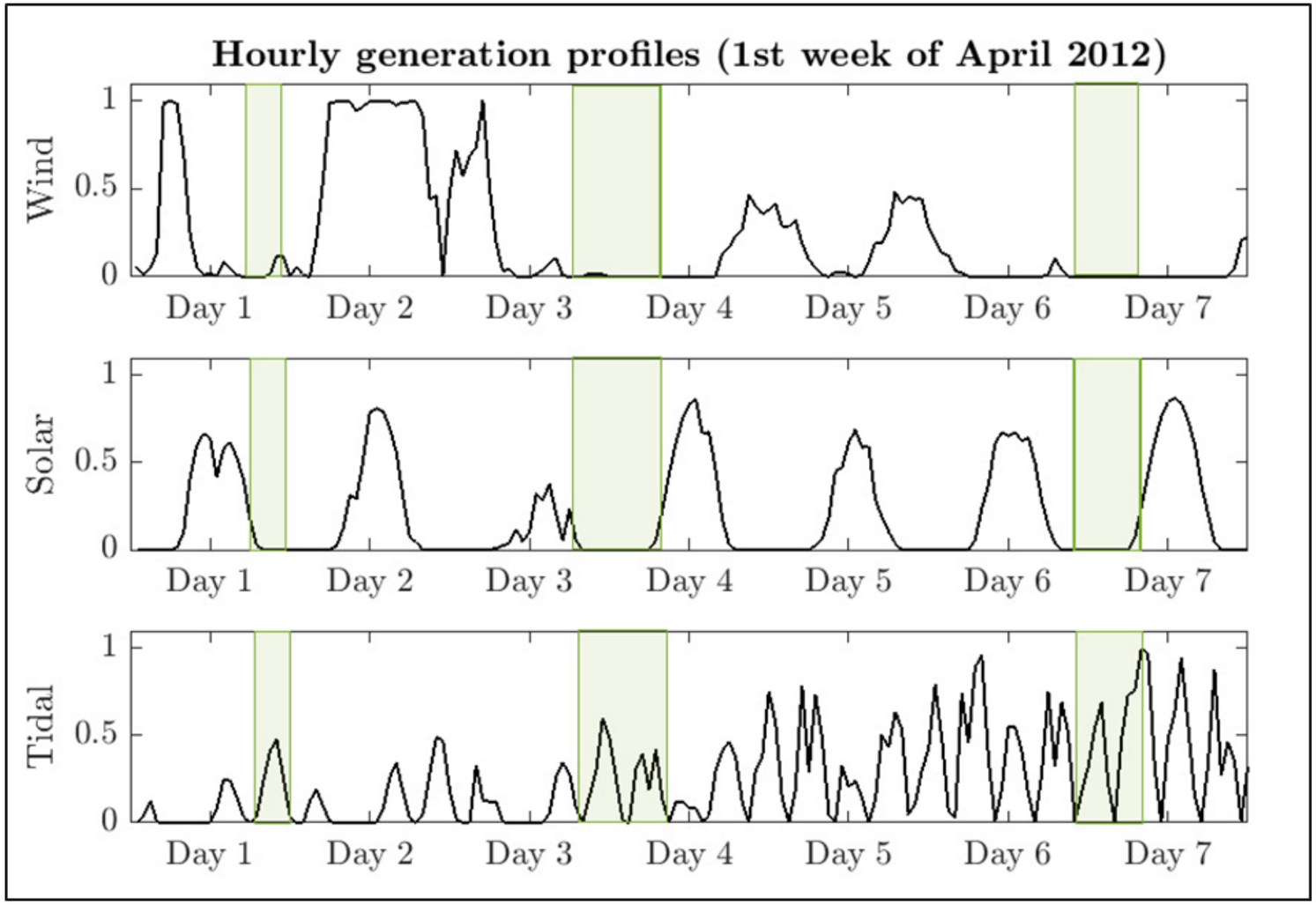
Metric type	Solar	Wind	Tidal
RA	0.3853	0.4150	0.6756
RP	0.2955	0.3190	0.3984
R-ApEn	0.6765	0.6293	1.3407

TABLE II
TEMPORAL METRICS FOR SOLAR, WIND AND TIDAL GENERATION RESOURCES AT DAILY TIME SCALE FOR ADMIRALTY INLET, WA

Metric type	Solar	Wind	Tidal
RA	0.9527	0.6689	1.0000
RP	0.8699	0.3493	1.0000
R-ApEn	0.8110	0.9562	0.6656



Tidal generation is much more predictable at a daily granularity than solar and wind – how does that bode for power systems? Can be helpful for capacity planning, scheduling, reduction of reserve requirements etc.



Tidal resources are observed to be available in scenarios where solar and wind are not available – more versatile resource!

Conclusions and future directions

- Temporal analysis of tidal energy resource
- Observed to be more predictable at daily granularity when compared to solar and wind
- Can be vital for several grid applications (at scale)
- Analysis being extended for wave and ocean currents
- Analysis can be extended to non-US sites as well to understand similar narratives at a global scale
- Enable (re)shaping and (re)tuning of energy policies

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Thank you