



Small cell energy optimization to enable ubiquitous connectivity

November 20, 2024



SAUDI ARABIA
SMALLCELLS
WORLD SUMMIT



Circadian Background

Digitalization to Decarbonize and Decentralize Energy

Energy optimization, analytics, and virtual power platform enabled by edge computing & wireless sensors

End to end solution for Macro & Micro base stations

Our Customers



Pre-Commissioning

Commissioning

Post-Commissioning

Strategic planning to reduce CapEx

> Right-sized solar and storage designs for new sites based on load analysis

Reduce Time to Market

> Enable Interoperability on site

Reduce OpEx, Monetize

- > Reduce consumption
- > Enable TOU, Peak Shaving
- > VPP, Aggregate to monetize
- > Carbon reporting, RECs



Backed by industry champions



Circadian's lead investor is BayWa r.e Ventures Team, the climate impact investment team of Europe's largest renewable energy company.



At a glance

Countries
Operating in

MW Capacity
Installed Globally

MW Managed
Globally

2022 Revenue
(€, millions)

31

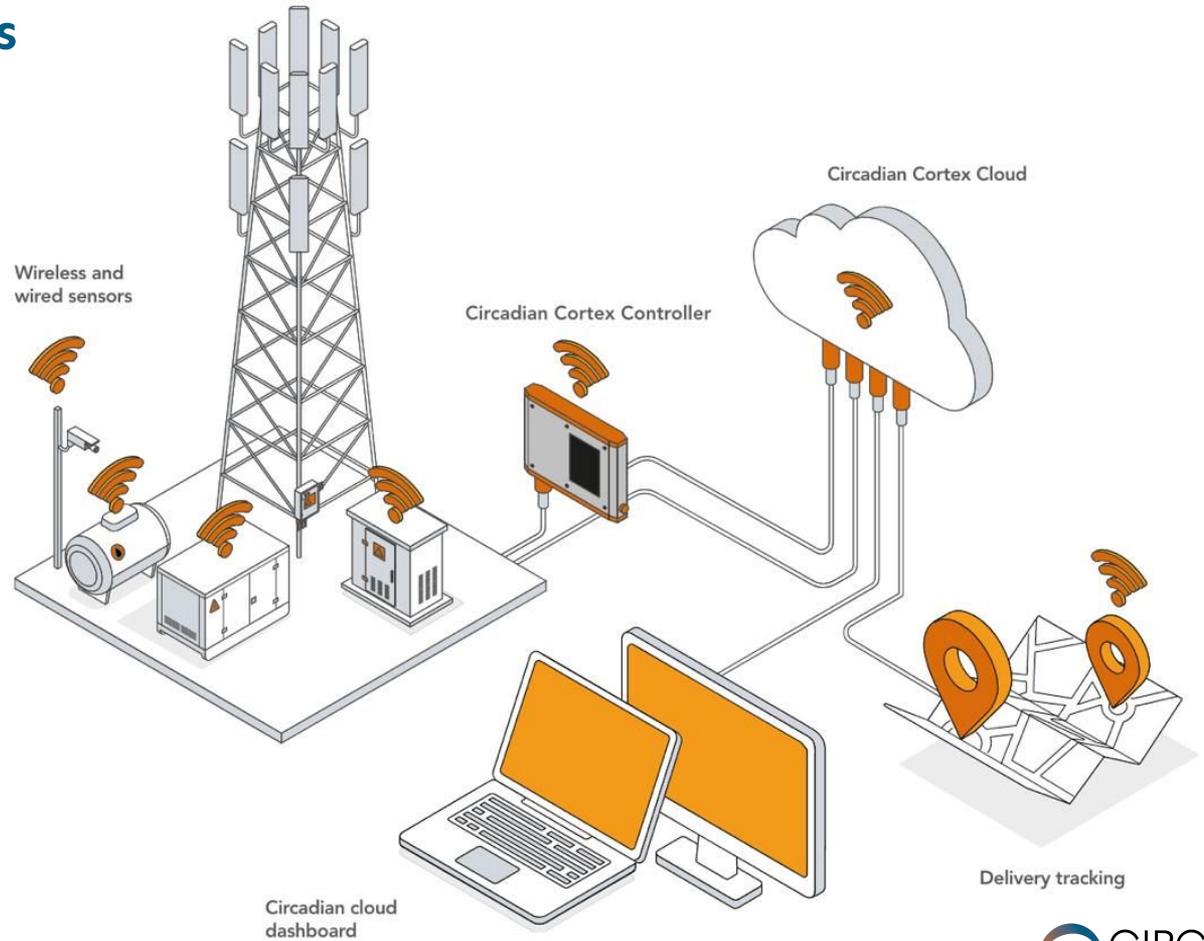
5,500

10,500

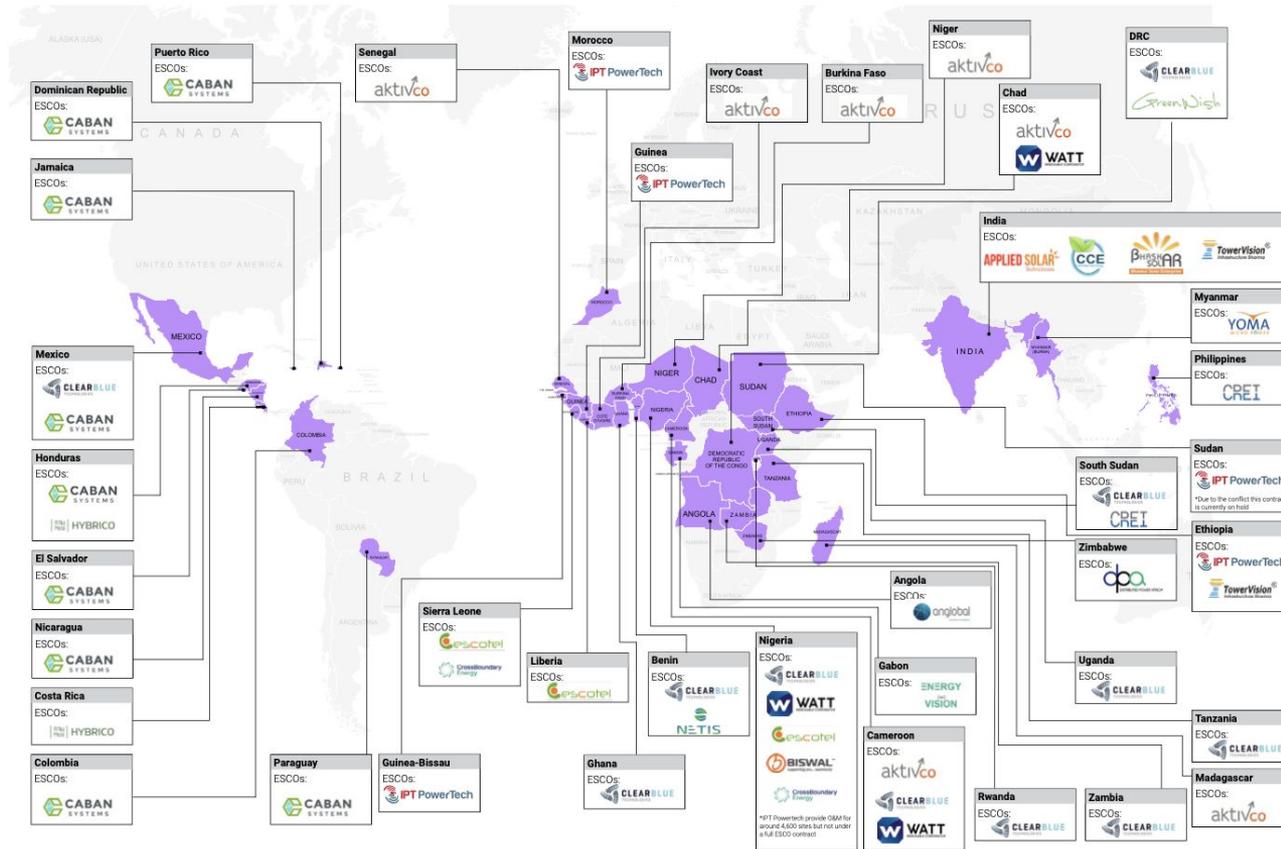
6,500

BayWa r.e. hybrid power plant
at Fekola mine, Mali

Digitalization across the value chain



ESCOs are driving renewable energy in emerging markets

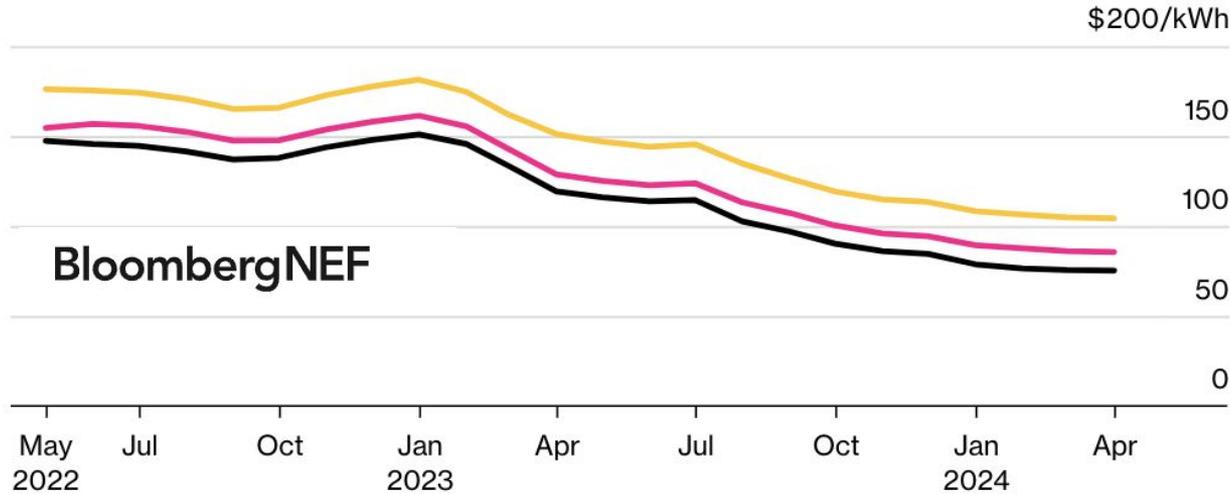


Lithium battery modules now <\$70

Lithium-ion Battery Prices Are Dropping Fast

Battery pack prices in China

- Black line: Lithium iron phosphate (LFP) packs
- Pink line: Nickel manganese cobalt (NMC) packs
- Yellow line: High nickel NMC packs

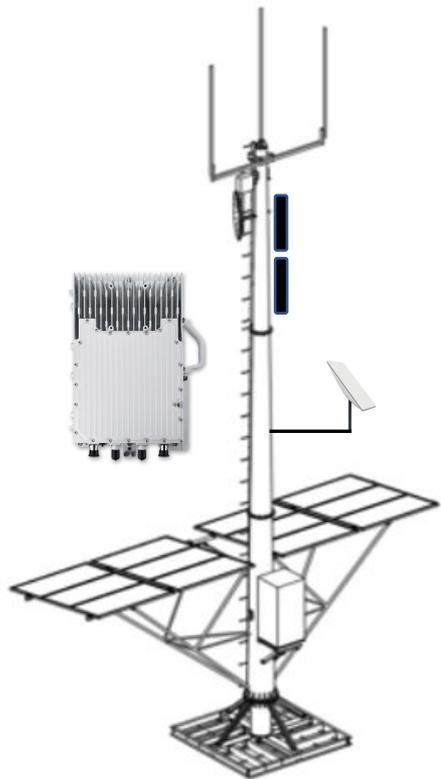


Source: BloombergNEF, ICC Battery

Note: NMC = Nickel manganese cobalt and includes prices for NMC111, NMC532 and NMC 622 batteries. High-nickel NMC includes NMC811, NMC955 and NCA

Enabling connectivity in rural Africa

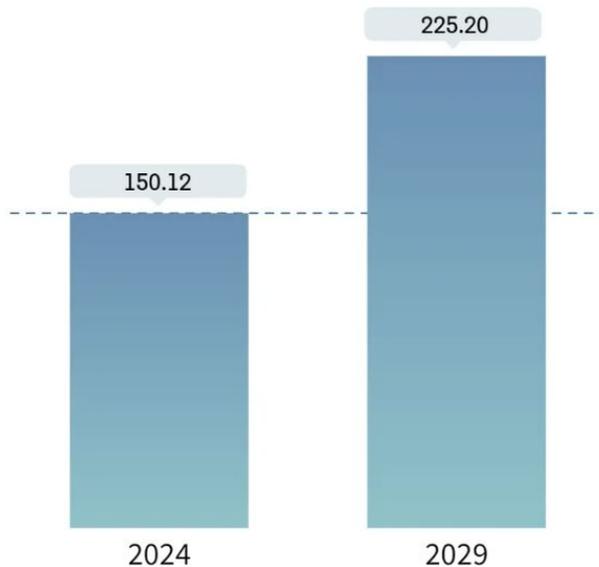
Energy storage for resilience in emerging markets



Africa Small Cell Market

Installed Base in Thousand RUs

CAGR 8.45%



Network-as-a-Service (NaaS) in rural Africa

An export opportunity for KSA's Small Cell Innovators?



>\$300m raised in VC financing
> 70% revenue share with MNO



4209 Small Cells
\$100m financing



<2000 Small Cells
\$86m financing



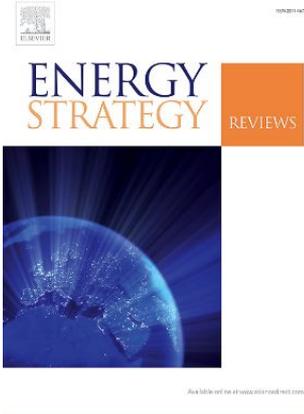
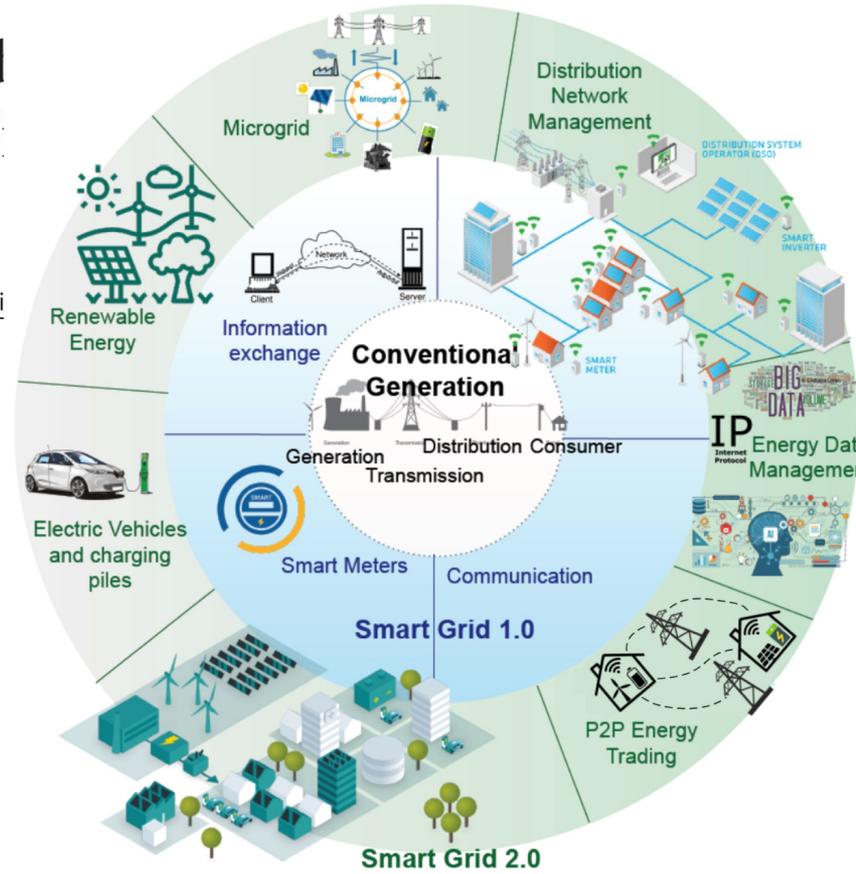
1000s Small Cells
\$88m financing

Vision 2030 energy transition drives Smart Grid, VPP

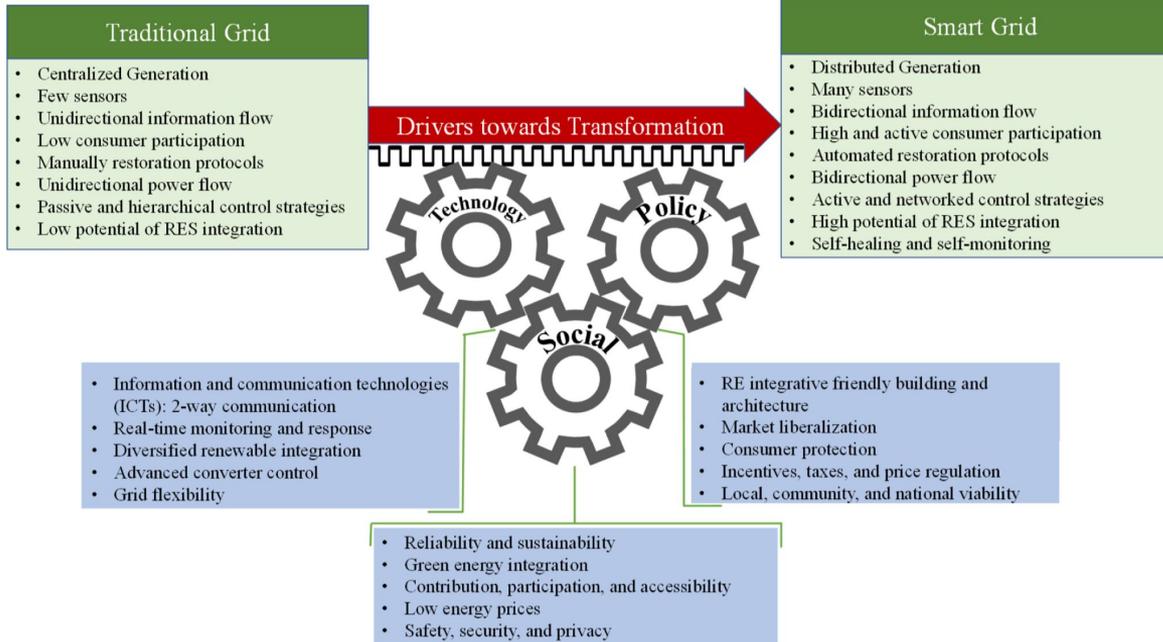
Review

Smart grid infrastructure and renewal energy deployment: A conceptual review Saudi Arabia

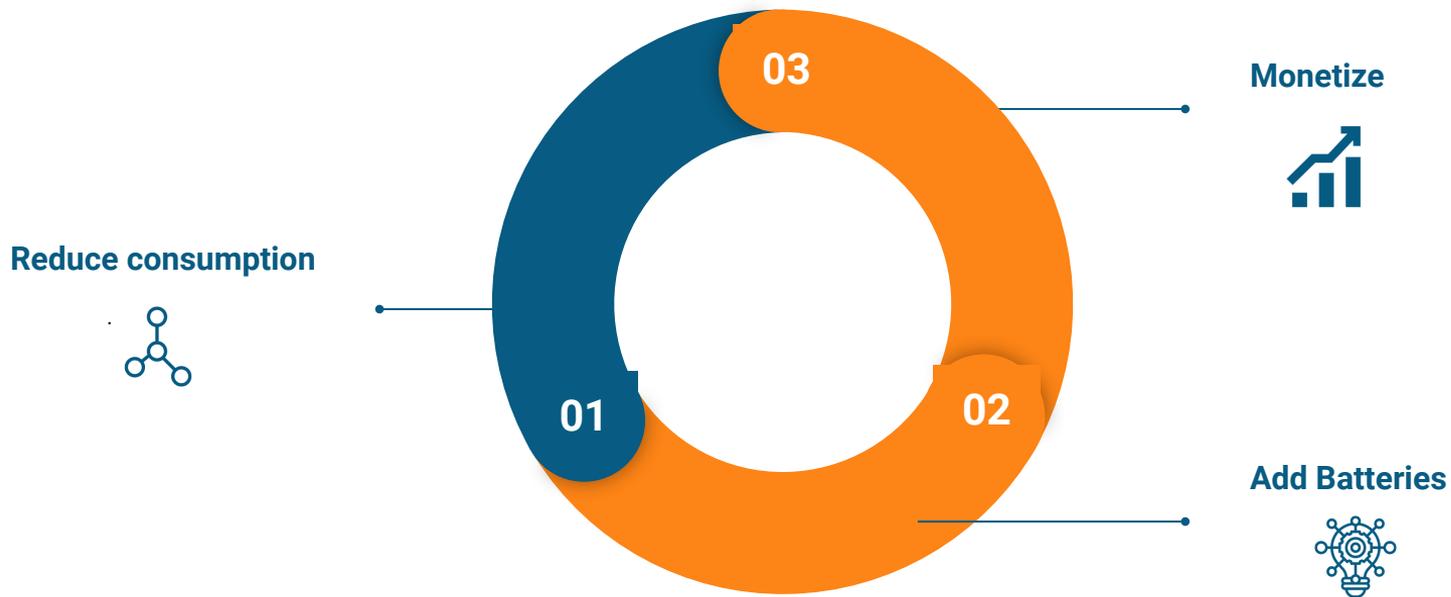
Khalid A. Khan ^{a f g}, Md Muzakkir Quamar ^b, Faleh H. Al-Qahtani ^c, Muhammad Asi Mohammed Alqahtani ^e, Muhammad Khalid ^{a f g}   



Vision 2030 - Smarter Grid through Telecoms



Everything stems from
DES: Distributed Energy Storage



Insights from Europe: VPP Platform & energy trading Europe's 585k towers



Aggregate for market participation:

Remotely control rectifiers at each site, aggregating hundreds of telecom towers to create at least 1 MW of controllable load.



Time of Use arbitrage:

Utilize your tariff structure to charge batteries when prices are low and discharge them during peak prices.



Peak shaving:

Integrate real-time pricing data with alerts to shift loads to batteries, effectively avoiding peak power prices.



Grid balancing:

Provide power to the grid or reduce grid consumption by shifting load to batteries, helping to balance grid stability.



Automated bidding:

Monitor reserve energy market requests on a day-ahead and intraday basis, automating bidding to Transmission System Operators (TSOs).



Reserve market payments:

Validate balancing power provision to secure revenue from TSOs.

THE BENEFITS



REDUCE ENERGY COSTS

10% Reduction through Time of Use Arbitrage



REVENUE GENERATION

Potential earnings of \$1200 per tower per year



ENHANCED BATTERY PERFORMANCE

Monitor degradation analytics vs Li-ion warranty

Digitalization drives energy efficiency



1. Traffic Load Monitoring:

- Continuously monitor the traffic load and user demand within the small cell.
- Calculate the average traffic load $L(t)$ over a specific time interval.

2. Determine Power Adjustment Factor:

- Define a threshold T that represents the minimum traffic load below which power savings measures are activated.
- Calculate power adjustment factor $P_{adj}(t)$ based on the traffic load:

$$P_{adj}(t) = \begin{cases} 0.5 & \text{if } L(t) < T \\ 1 & \text{otherwise} \end{cases}$$

- Here, $P_{adj}(t)$ reduces the transmit power by 50% during low traffic periods.

3. Adjust Transmit Power:

- Adjust the transmit power of the small cell based on $P_{adj}(t)$:

$$P_{transmit}(t) = P_{normal} \times P_{adj}(t)$$

- Where P_{normal} is the normal operating transmit power of the small cell.

4. Energy Consumption Calculation:

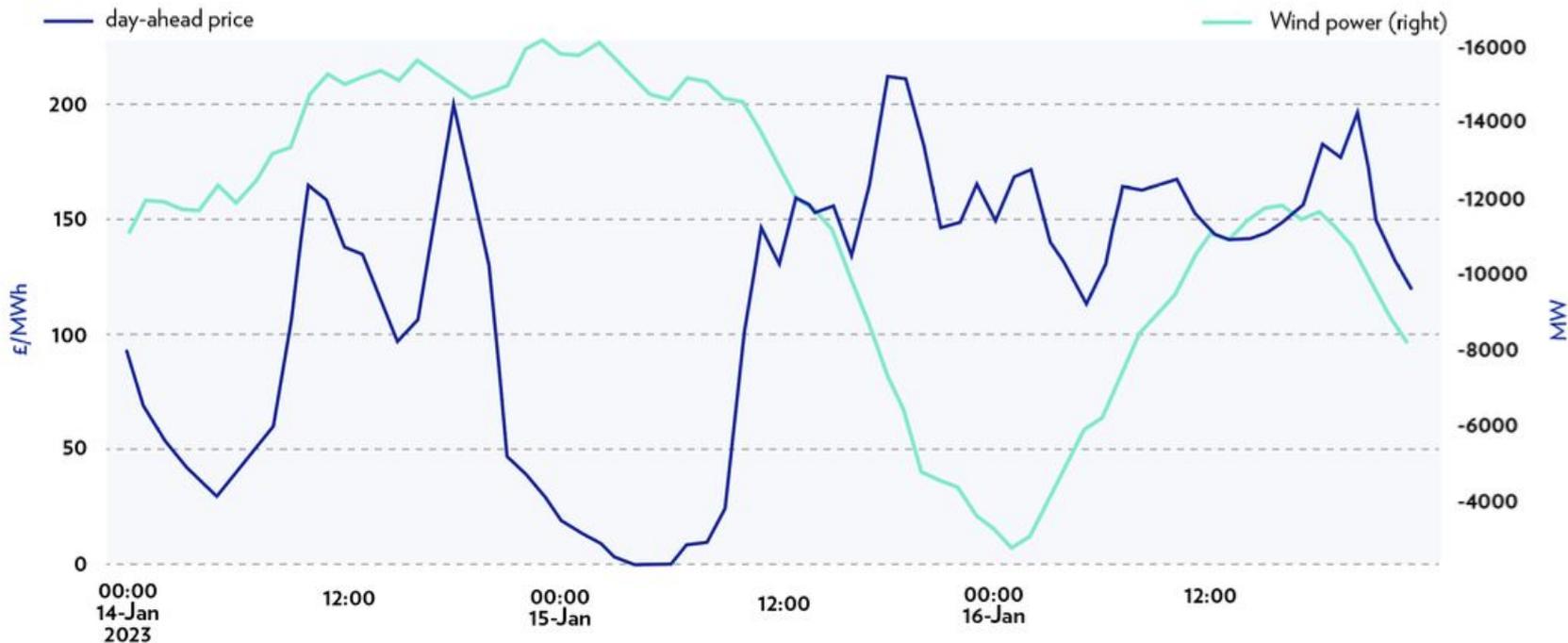
- Calculate the energy consumption during both peak and off-peak hours:

$$E(t) = P_{transmit}(t) \times \text{Operating Hours}$$

Energy arbitrage in Europe

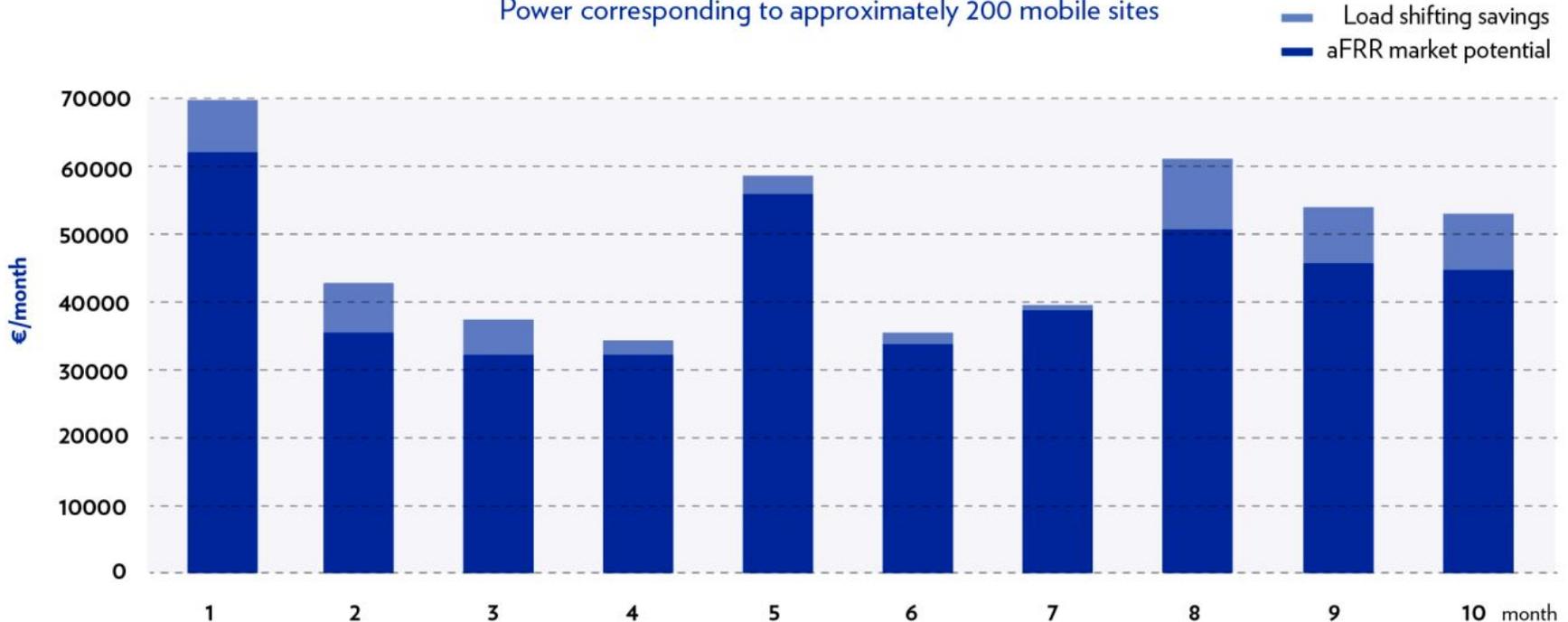
TOU: Time of Use

UK wholesale (day-ahead) prices (£/MWh) and wind power production (MW) in January 2023



Monthly revenue potential with 1MW, Finland, 2023

Power corresponding to approximately 200 mobile sites





Example figures

6kWh, 12hr backup

Small Base Station: 500W Consumption

\$430 CapEx

\$70/kWh x 6kWh

\$329/yr Arbitrage

\$0.15 kWh peak shaving & TOU

76% IRR

Annualized over 10 yrs

Carbon Credits, RECs

No longer the wild west





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