

SMART OFF-GRID SOLAR APPLIANCES

A SUMMARY FOR NEWCOMERS AND ESTABLISHED INNOVATORS

OCTOBER 2025

INTRODUCTION

Off-grid appliances are vital for expanding energy access, strengthening food security and reducing vulnerability to climate change. Yet current sales meet less than 2% of total need¹, leaving millions without reliable solutions. Remote monitoring can help bridge this gap. By enabling real-time tracking of appliance performance, usage, and faults, this technology gives companies the tools to help improve service quality, strengthen customer trust, and unlock new financing models.

For companies, the benefits can be threefold. Remote monitoring can enhance **affordability** through models such as PAYGo and Energy as a Service. It can improve **reliability**, reducing downtime through preventive maintenance and ensuring appliances deliver the promised impact. It enables **innovation**, from precision irrigation and cold chain tracking to accessing carbon finance.

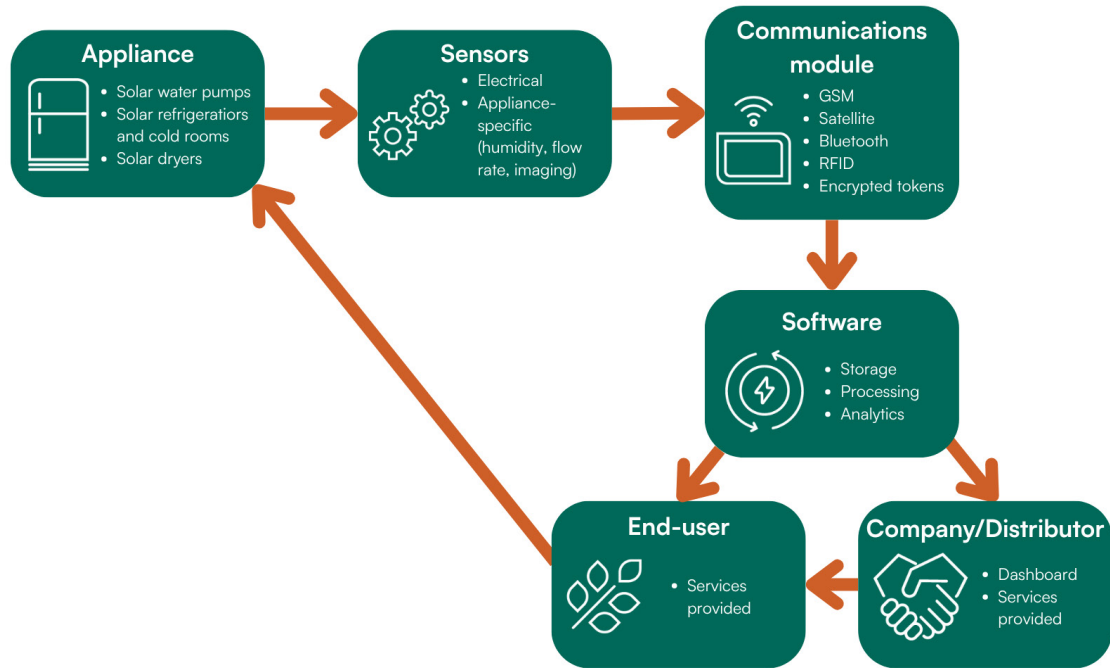
This report is designed for two groups of companies:

- Newcomers exploring remote monitoring for the first time. This report highlights the practical steps to get started, from low cost, modular options to key questions about data use, costs, and connectivity.
- Established innovators looking to expand or refine their systems. We showcase emerging opportunities — from predictive maintenance and digital monitoring, reporting and verification to cross-sector interoperability — that can create new business models and revenue streams.

Remote monitoring is no longer a niche technology. With falling costs, expanding connectivity, and growing demand for transparent, reliable services, it is becoming an essential enabler of scale and impact in the off-grid appliance sector.



How remote monitoring works



KEY TAKEAWAYS



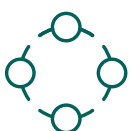
Remote monitoring is a strategic enabler, not just a technical tool.



Adoption is growing but uneven. The technology is accessible, but challenges remain around cost, connectivity, interoperability, and user engagement.



Tailored solutions are critical - companies should match remote monitoring approaches to their business models, customers, and operational contexts.



Cross-sector collaboration is key. Standardisation, shared tools, and policy alignment can accelerate innovation and reduce barriers for all.

INSIGHTS FOR NEWCOMERS



Remote monitoring is more than a technical add-on. It enables new business models (e.g. PAYGo, Energy-as-a-Service), improves reliability, and supports financing.



Affordability and simplicity are key. Solutions must work in low-connectivity areas, be modular, and not add prohibitive costs.



Data builds customer trust and supports better services. Monitoring provides insights for product design, maintenance, and tailored customer support.



Implement multiple integration pathways. Options range from open-source tools (low cost, adaptable) to proprietary platforms (fast deployment but more expensive).



INSIGHTS FOR ESTABLISHED INNOVATORS



Smart services boost efficiency and productivity.

Remote monitoring enables precision farming, cooling-as-a-service, and cold chain assurance.



Predictive maintenance reduces downtime and cost. AI-enhanced monitoring can detect faults before failure.



Carbon finance is an emerging opportunity.

Monitoring can provide the data on carbon finance needed to unlock revenue streams.



Interoperability drives innovation and lowers costs.

Shared standards prevent lock-in and enable cross-sector growth.



Processing mangoes inside a remotely monitored solar dryer

Photo credit: Synnefa

GETTING STARTED: WHAT DO YOU NEED TO KNOW?

Remote monitoring technology consists of sensors, communication systems and data management and processing systems. Our full report goes into options for systems, as well as models for integration (such as open-source tools, in-house development or subscribing or purchasing proprietary tools). The table below summarises the key questions companies should consider, and signposts to relevant sections of the full report.

QUESTIONS	DETAILS & OPTIONS	PAGE REFERENCE IN REPORT
What's your business case for integrating remote monitoring?	<ul style="list-style-type: none"> • Improve after-sales service and maintenance • Enable PAYGo models • Monitor product performance and usage • Generate data for impact reporting • Access carbon credits 	P19 — 29
What model to use for integration?	<ul style="list-style-type: none"> • Open-source • In-house development • Proprietary platforms 	P13 — 16
What technical specifications are important?	<ul style="list-style-type: none"> • Communications: remoteness and data capacity needs, end-users • Live or delayed data transmission • Robustness: weatherproofing, durability, tamper resistance • Applications: the sensors, software and analytics needed to enable these • Data resolution & sampling rates for different monitoring needs • Power type: compatibility with AC/DC, single/three-phase systems • Security: digital and physical • Is the remote monitoring device integrated into the device, or added on 	P10 — 13
How to cover the costs of remote monitoring?	<ul style="list-style-type: none"> • Through added value for company • Carbon credits by proving usage/ emissions reduction • Customer or distributor payment models • Integrated pricing via upfront fees or subscriptions 	P16 — 17

INNOVATIVE APPLICATIONS AND OPPORTUNITIES

Remote monitoring is unlocking new opportunities across the off-grid appliance sector, moving beyond a technical add-on to a driver of innovative business models and reliable services.

Enabling business models

The most widespread application is in financing models. PAYGo uses remote monitoring to track usage, manage payments, and lock or unlock devices, lowering barriers to entry for low-income households and small businesses.

Koolboks, for example, integrates PAYGo into solar refrigerators, allowing entrepreneurs to start earning income without high upfront costs². Some providers, such as RAD and Ennos³, are exploring Energy-as-a-Service, where customers pay for a service like cooling or irrigation rather than owning equipment outright.

Predictive maintenance

Monitoring data allows companies to act before breakdowns occur. Innovex's REMOT platform⁴ has identified eight common faults in solar water pumps and refrigerators, sending SMS alerts to users. Pilots reported a 10% reduction in technician visits and savings from avoided repairs — improving reliability while reducing service costs.

Smart agriculture

Remote monitoring is improving smallholder productivity. Synnefa's Farm Shield⁵ combines solar sensors with a cloud platform, giving farmers real-time data on soil moisture, temperature, and water flow. This has helped reduced water use by up to 50%, cut fertiliser needs by 40%, and increased crop yields by 30%. Access is via smartphone or SMS, helping overcome connectivity and literacy barriers.

Cold chain and healthcare

In cold storage and health, monitoring protects livelihoods and lives. Ecozen⁶ uses real-time data in solar cold rooms to reduce spoilage and optimise technician deployment. RAD is piloting fish transport boxes equipped with GPS and temperature sensors to rebuild trust in cold chain value chains. In healthcare, monitoring of oxygen concentrators and incubators has revealed gaps in power reliability, helping providers design more resilient systems.

Carbon finance and results-based financing

Remote monitoring can unlock new revenue streams. SunCulture⁷ uses irrigation pump data to verify carbon savings, while Koolboks and other cooling providers are piloting carbon credit models to cut costs for customers. Usage data from monitoring also provides the evidence funders need for results-based financing, reducing the expense of manual verification.

WHAT NEXT?

For companies, remote monitoring should move from being a technical add-on to a core part of business strategy. Start with clear goals - whether to enable PAYGo, improve reliability with predictive maintenance, or unlock new financing streams. Focus on affordability, interoperability, and usability to ensure solutions scale with customers' needs.

Looking ahead, two priorities stand out.

- First, responsible data use is essential. Companies must safeguard customer privacy, take steps to make products and services inclusive, and ensure transparent consent processes. Addressing these issues early can reduce reputational risk and regulatory barriers, while building long-term trust with users and financiers.
- Second, next-generation technologies are reshaping what remote monitoring can deliver. Artificial intelligence will extend beyond predictive maintenance to enable automated fault diagnostics, adaptive energy management, and deeper customer insights. At the same time, digital MRV systems will make verification for carbon credits and results-based financing faster and more affordable. Companies that invest now in these innovations - and engage with initiatives like GOGLA's Connect⁸ initiative to shape data standards and interoperability - will be best placed to capture emerging opportunities and scale sustainably.

REFERENCES

- 1 Efficiency for Access. (2024). Leave No-One Behind: Bridging the energy access gap with innovative off-grid solar solutions. <https://efficiencyforaccess.org/publications/leave-no-one-behind>
- 2 Koolboks. (2021). Using Geospatial Technology and Solar Power to Provide Sustainable Refrigeration in Africa. <https://kenya.koolboks.com/blog/2021/10/19/using-geospatial-technology-and-solar-power-to-provide-sustainable-refrigeration-in-africa/>
- 3 Ennos. (2022). Sunlight Pump Datasheet. https://ennos.ch/wp-content/uploads/2022/06/Datasheet_english.pdf
- 4 Innovex. (2025). <https://innovex.org/>
- 5 Synnefa. (2025). GSMA Digital Grantees Portfolio: Synnefa. <https://www.gsma.com/solutions-and-impact/connectivity-for-good/mobile-for-development/digital-grantees-portfolio/synnefa/>
- 6 Ecozen. (2025). AI Solutions. <https://www.ecozensolutions.com/ai-solutions>
- 7 Shell Foundation. (2025). BII, Shell Foundation, and SunCulture pilot innovative carbon financing to accelerate access to solar irrigation systems for Kenyan farmers. <https://shellfoundation.org/news/bii-shell-foundation-and-sunculture-pilot-innovative-carbon-financing-to-accelerate-access-to-solar-irrigation-systems-for-kenyan-farmers/>
- 8 GOGLA. (2021). The Connect White Paper. <https://gogla.org/consumer-protection-standards/consumer-protection-code/the-connect-initiative/>

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REPORT HERE**



DISCLAIMER

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Innovex engineers conduct rigorous testing on parts for use in remote monitoring

Photo credit: Innovex