The Connect White Paper

**Defining a universal connector and firmware
for 12V SHS Kit and Appliance interoperability**

Acknowledgements

Executive Summary

The Connect White Paper proposes a universal connector and device-to-device firmware guidelines for 12V SHS Kits and appliances and explores the opportunities and challenges this will create for the Off Grid Solar (OGS) market. We believe that greater standardisation and enhanced interoperability of OGS products can bring benefits to companies, consumers, and the environment. OGS is a highly competitive market which is evolving fast. The adoption of universal guidelines could create a new dynamic, enabling specialisation, better AI & IoT integration, the development of new partnerships and business models, and fresh investment.

The OGS market is relatively young, but the value chain is already large and complex. The sector is dominated by vertically-integrated manufacturers whose PAYGo model has proved highly effective at enabling African consumers to afford SHS Kits and appliances. But there are also numerous hardware and software developers, B2B manufacturers and B2C distributors, as well as a cash sale segment for low- and high-power SHS Kits and a grey market for non-Quality Verified (non-QV) appliances.

As a result, the OGS sector is highly fragmented and there are no universal connector, electrical or firmware standards, which limits interoperability and hinders deeper cooperation and partnerships. This situation restricts consumers' freedom to switch supplier or purchase appliances from a rival manufacturer which will not work on their competitor's SHS Kit, effectively locking them in with their existing supplier.

In order to create a more interoperable OGS market, the Connect Initiative proposes the adoption of four Technical Guidelines to ensure that SHS Kits and appliances from different manufacturers work together safely and reliably. These Guidelines have been developed by GOGLA's Technology Working Group and its partners and are combined in the 'interoperability stack', which includes the following layers:

1. Universal Family of Connectors for 12V SHS Kits that will support power delivery and communications for lights, phone charging and many appliances;
2. Electrical characteristics (such as voltage and current);
3. Communications protocol (OpenPAYGO Link) developed by Solaris; and
4. PAYGo Activation and Device Control (Nexus Channel) developed by Angaza.

We believe that the Connect Initiative could bring substantial benefits, not just to the manufacturers and distributors of SHS Kits and appliances, but more importantly to the consumers of SHS Kits and appliances. However, we do not advocate or expect all companies in the OGS ecosystem to specialise and become interoperable; vertically-integrated companies may wish to adopt elements of the technology and enjoy the benefits without radically changing their business model. We envisage a market in which both interoperable and proprietary ecosystems, and vertically integrated and specialist supply chains, can co-exist and compete as part of the commercial landscape.

The decision to adopt the Connect Technical Guidelines and transition to a more interoperable market will come from companies that see value in cooperation. We propose to convene a Roundtable with Executives of companies interested in aligning their strategy with the Connect Technical Guidelines later this year. We request your feedback to inform this journey.

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The Connect Initiative is really about protecting consumers' interests and growing the market.
Koen Peters, CEO, GOGLA

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Introduction

The predominant model in the off-grid solar (OGS) sector is that of non-interoperable systems – brand-specific connectors combined with proprietary digital protocols. For pay-as-you-go (PAYGo) consumers, this means they must purchase their solar home system kits (SHS Kits) and appliances from the same company. They are unable to use an appliance with another company's SHS, or vice versa. For cash sale customers, this means limited flexibility and choice of appliances, and a high risk of buying an appliance that is not compatible with their SHS Kits.

The *Off-Grid Solar Market Trends Report 2020* identified interoperability as a game-changer. Interoperability entails products, services and information systems being able to work well together, reduced product development and manufacturing costs, and enabling greater competition and supply chain efficiency. Although it is categorised as a 'small win', interoperability underpins many of the other game-changers, including specialisation and partnerships. Experience from other electronics and consumer goods industries shows that greater standardisation and interoperability can drive market growth (see Case Study on smart home systems below).

Figure 1 – Relative Ranking of Game Changers (2020 Off-Grid Solar Market Trends Report | GOGLA)

Low Hanging Fruit (Lower impact & higher likelihood)

Key Drivers (Higher impact & higher likelihood)

Higher likelihood

- Household appliance availability
- Targeting unreliable grid
- Commoditization
- Standardized KPIs
- PAYGo availability
- Strategic investor engagement
- Off-balance sheet financing
- Specialization & partnerships
- 'Beyond energy' model
- Chinese manufacturer involvement
- AI and IOT integration
- Pulse appliance availability
- Company profitability

Lower impact

Higher impact

- Hardware and software interoperability
- Consolidation (M&A)
- Engagement of large appliance manufacturers
- Targeted concessional investments
- Availability of subsidies
- Local currency debt
- Market enabling policies and regulations
- Climate and social finance

Small Wins (Lower impact & lower likelihood)

Lower likelihood

Tipping Points (Higher impact & lower likelihood)

● Market player ● Technology ● Finance ● Policy ● Technology / consumer

> Greater product interoperability could be a game-changer for the OGS market. It would enable business model innovation and specialisation, and enhance consumer flexibility and choice.
>
> Russell Sturm, IFC

Introduction

Project Connected Home - a model for creating an interoperable OGS ecosystem?

Amazon, Apple, Google, and the Zigbee Alliance have created a working group to develop and promote the adoption of a new, open and royalty-free connectivity standard for smart home appliances.[1] As more consumers buy smart home devices, the lack of compatibility across platforms is resulting in purchase delays and user frustration over having to use multiple apps to connect devices to their smart home hubs.

The aim of this project is to simplify development for manufacturers and make it easier for them to build devices that are compatible with smart home and voice services such as Amazon's Alexa, Apple's Siri and Google's Assistant. Building on Internet Protocol (IP), the project will enable communication across smart home devices, mobile apps, and cloud services, as well as define a set of

IP-based networking technologies for device certification.

This project could bring huge benefits for consumers. First, it will guarantee that new appliances will always work with smart assistants; second, it will encourage more competition and drive down prices; and third, it could help address security concerns by creating minimum security requirements for device vendors to join the project.

The working group has pledged to take an open-source approach to developing and implementing a unified connectivity protocol. This is a powerful demonstration of these companies' shared belief in the importance of interoperability, even though they have been highly competitive in the past. Their approach offers useful lessons for the Connect Initiative.

However, the off-grid solar sector is a unique beast – the energy and power limits of the technology, combined with the PAYGo business model and the early stage of the market, mean that an interoperable ecosystem also presents challenges and risks to consumers, and to the companies providing OGS goods and services to them. The opportunities and risks depend to some extent on whether you are a vertically-integrated company or a supply-chain specialist (e.g. a 'PAYGo 2.0' company).

Most PAYGo players sell VeraSol quality-verified (QV) products that meet IEC standards, but a large market also exists for non-quality-verified (non-QV) and non-branded SHS Kits and a wide range of appliances (including TVs, fans, radios, hair razors, etc).[2] Some manufacturers sell non-QV appliances such as hair razors or radios on the open market. Finding compatible non-QV products and ensuring they work well can be a challenge, given the range of connectors on the market, the unknown electrical characteristics, and uncertain quality and safety. Non-QV SHS Kits and appliances can have a negative impact on the

market, undercutting QV products on price, while poor quality and sometimes dangerous goods fail to deliver customer value and damage trust in the technology.

This White Paper explores the opportunities and challenges provided by universal connector and PAYGo standards for 12V SHS Kits and appliances. It draws together work on the Connect Initiative (formerly the Interoperability Initiative) by the GOGLA Technology Working Group[3] and its members, supplemented by research and interviews with stakeholders in the OGS industry.

The aims of this White Paper are to:
- Raise awareness and spark debate in the OGS industry about the Connect Initiative;
- Articulate in detail the benefits and risks of interoperability for consumers, companies, and the industry;
- Prompt wider discussion on what the Connect Initiative will mean for companies' strategies, operations, and customer relationships; and
- Get your feedback on the Connect Initiative and how we can work together to achieve its aims.

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1   Sources: https://iot.eetimes.com/amazon-apple-and-google-unveil-smart-home-collaboration/ and
    https://www.apple.com/uk/newsroom/2019/12/amazon-apple-google-and-the-zigbee-alliance-to-develop-connectivity-standard/
2   This non-quality-verified market is predominantly 'basic' technology, i.e. is sold in cash (without PAYGo Activation) and has no digital com-
    munications for device control (also known as 'dumb').
3   The Compatibility and Interoperability Technology Roadmap (efficiencyforaccess.org), published in September 2019, identified the universal
    connector and firmware standards; this formed the basis for the Connect Initiative.   5

Vision & Objectives

We believe that greater standardization and enhanced interoperability of OGS products can bring benefits to companies, consumers, and the environment. We envisage a market in which both interoperable and proprietary ecosystems can co-exist and compete as part of the commercial landscape. Moreover, we believe that both vertically-integrated and supply chain specialist models can benefit from a more interoperable market without radical changes to their business models.

The 'Apple' model	The 'Microsoft' Model	
Proprietary Brands Market leaders offer brandspecific products and services that only work with their own brand.	**'Connect' Affiliates** An ecosystem that guarantees one manufacturers' products can work with another's (provided both products meet defined technical requirements). It includes PAYGo Activation and Smart controls.	**Open Ecosystem** An ecosystem that embraces the open market, including the wide range of non-quality-verified and non-branded SHS Kits and Appliances. Products bought seperately have an improved chance of working together.

A comparable model would be the Apple versus the Microsoft ecosystems. Proprietary brands will continue to offer end-to-end services, selling a family of devices powered by their own SHS Kits. Alongside this, an ecosystem of Connect Affiliates can develop that guarantees one manufacturer's products work with another's, provided they both adhere to technical guidelines. There will also be space for growth of a fully Open Ecosystem, which would enable non-QV products to plug in with a better chance of working together.

A critical mass of industry players is necessary to establish an interoperable ecosystem and realise its benefits, and we believe this should be entirely voluntary, driven by companies that see value in alignment with the Connect strategy. The OGS market is young and dynamic, comprising diverse business models, and this is a complex initiative that is likely to bring structural shifts with some outcomes difficult to predict.

> **"**
> We believe that the interoperability standards should be the building blocks for innovation, not the basis for commoditisation.
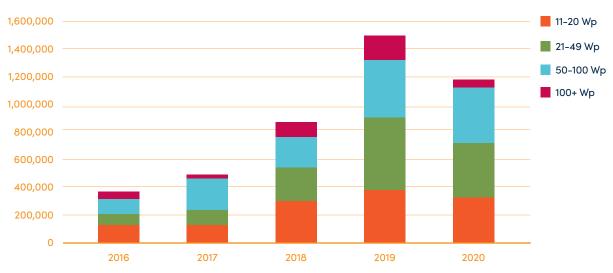> Lesley Marincola, CEO Angaza
> **"**

The aims of the Connect Initiative are to:

- Catalyse market growth and business model innovation;
- Create an OGS ecosystem in which SHS Kits and appliances are interoperable (i.e. that guarantees one manufacturer's product can work with another's);
- Improve the alignment of the QV segment with the non-QV products (i.e. to increase the likelihood that QV and non-QV products will work well together);
- Enhance the value for consumers by offering more flexibility and choice of products and providers, and potentially lower prices;
- Define Technical Guidelines that promote standardisation and simplification along the supply chain, resulting in a quicker route to market for new products, and enhanced profitability for companies;
- Build an alliance of companies that see value in cooperating on common technology guidelines; and
- Define and follow an industry roadmap to increased interoperability; this will be a stepwise transition that establishes the supporting functions (such as quality assurance and labels) to mitigate risks.
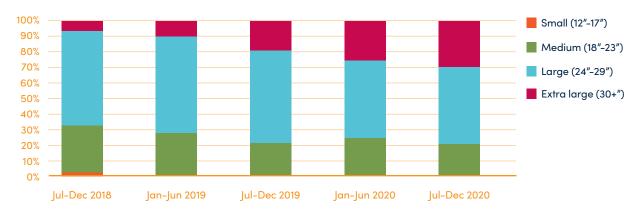
Overview of SHS Kit & Appliance Market

The trend is towards larger SHS Kits, more appliances, and PAYGo

More than 3.5 million SHS Kits and nearly 5 million appliances have been sold by GOGLA members and affiliates over the past three years. The sales trend shows strong growth for SHS Kits (defined as with 10-350W PV module), with the highest growth in the 21-49W power tier - the entry-level SHS Kit that can power a TV.[4] The PAYGo business model has done much to enhance the affordability of larger, more expensive systems, and now represents 87% of SHS Kit sales (up from 77% in 2018). The notable drop in sales in 2020 is due to the supply and demand challenges caused by the COVID-19 crisis.[5]

We recorded 237,000 TVs sold in the second half of 2020, and 90% of these were sold on PAYGo in Africa. Crucially for the Connect Initiative, 18% of all TVs have been sold as additional products to existing SHS customers, often when they have completed payment for their original SHS in full. There is also a clear trend towards larger screen size, with 30% of the market in the 30"+ category in H2 2020, compared to just 6% in the H2 2018.

Figure 2 - Global sales of SHS Kits by PV module size. GOGLA (2021), 'Global Off-Grid Solar Market Report Database', in partnership with Lighting Global and the Efficiency for Access Coalition (here)

Figure 3 - Global sales of TVs by screen size. GOGLA (2021), 'Global Off-Grid Solar Market Report Database', in partnership with Lighting Global and the Efficiency for Access Coalition (here)
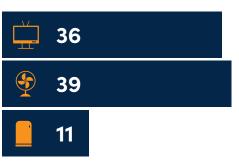

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4 VeraSol Product Database.
5 Global Off-Grid Solar Market Report | GOGLA.

Overview of SHS Kit & Appliance Market

The dramatic growth in sales demonstrates the strong demand that exists for solar-powered appliances. But we believe that the potential is much higher. Consumer expectations are also rising – people want more than simply to light their homes or power a fan: they want to keep precious food from spoiling in their fridge and watch the Premier League on a widescreen TV. The Connect Initiative could help unlock this demand and bring the market closer to a bigger customer base.

We estimate that there is an obtainable market of 36 million households for televisions, 39 million for fans and 11 million for fridges. This represents the customer base that can be reached within the physical geography of existing distribution networks, and with the affordability based on the PAYGo model.[6] This obtainable market is forecast to rise from an estimated USD 12.6bn in 2018 to USD 18.2bn by 2025 and over USD 25bn by 2030. This is a huge commercial opportunity for manufacturers, distributors and service providers, and all commercial models will have a role to play in meeting this demand.
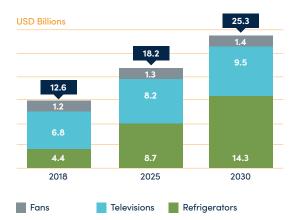
Figure 4 - The obtainable market could be worth over USD 25 billion by 2030

Millions of Households

36

39

11

Obtainable Market, 2018

'Obtainable market' is the customer base that can be reached, defined by affordability and physical accessibility.

Market potential
The State of the Off-Grid Appliance Market, 2019

USD Billions

	2018	2025	2030
Total	12.6	18.2	25.3
Fans	1.2	1.3	1.4
Televisions	6.8	8.2	9.5
Refrigerators	4.4	8.7	14.3

Fans   Televisions   Refrigerators

Figure 5 - The OGS ecosystem is relatively young but is already complex

| Hardware manufacturing | Hardware design | Software Development | Marketing & distribution | Consumer financing | After-sales support |

The off-grid solar value chain (2020 Off-Grid Solar Market Trends Report | GOGLA)

Overview of SHS Kit & Appliance Market

The OGS market is relatively young, but the value chain has already become large and complex. The sector is dominated by vertically-integrated manufacturers whose PAYGo model has proved highly effective at enabling African consumers to afford SHS Kits and appliances. There are also numerous hardware and software developers, B2B manufacturers and B2C distributors, as well as a cash sale segment for low- and high-power SHS Kits. The sector is highly fragmented, with limited interoperability hindering deeper cooperation and partnerships.

There is no off-grid connector standard
Unlike national electricity grid standards (see box), there are no universal electrical or connector standards for OGS at a national, regional or industry level. This is the result of the organic growth of the sector over the past ten years and is natural for this stage of the market. As a result, each manufacturer has its own brand-specific connector and electrical characteristics. Many of these companies are not proprietary by choice but owing to the lack of industry standards. This is a major barrier to interoperability and a constraint on the growth of the sector.

Global grid electricity standards
The International Electrotechnical Commission (IEC) was established in 1906 and has coordinated discussions on electrical standards ever since. In the world today there are 14 main plug/socket types, 8 voltages and 2 frequencies, all of them governed at national levels. There are also 11 pairs of appliance inlets and connectors for globally traded devices. In comparison, there are no widely agreed connector standards for OGS kits and appliances.

The PAYGo model dominates in Africa
Africa is the home of PAYGo, which has dominated recent growth in the OGS market. The PAYGo model, under which customers pay off their SHS Kits and appliances through digital payments, has proved highly effective at connecting Africa's off-grid households. The PAYGo model has evolved into end-to-end service delivery, backed by strong customer service, providing power, Internet, and TV, as well as credit, insurance and other digital services to millions of Africans.

However, the current PAYGo offering has a notable disadvantage for consumers. Once they have paid off their units – which typically takes 12-18 months for a small unit and up to 36 months for a large one – they are locked in by their service provider. Even once their units have been unlocked, they cannot plug in an appliance from another manufacturer and have complete confidence that it will work on their SHS Kit. Some customers may check that the appliance connector matches the SHS Kit port, but they are unlikely to understand the technical specifications (a visual check is hard even for experts). Others may attempt a rough home-fix by changing the connector type (which is, of course, prone to reliability and safety issues). If they want to avoid the risk of buying a useless appliance or damaging the SHS Kit, the only solution is to upgrade with their existing company or invest in a brand new SHS Kit and appliances with a competitor.

As a result, energy stacking is common, with African households owning two, or even three, different SHS Kits operating in the home, each powering different appliances in different areas of the home, but none of them interoperable with each other.[7] This has altered the evolution of the market, replacing the concept of a linear 'energy ladder' with a more gradual 'energy staircase', which involves stacking of SHS Kits and appliances whilst maintaining the upward energy access trajectory.[8] This can be inefficient and expensive for low-income households.

There is a thriving grey market for non-QV 12V appliances
Many countries have a thriving grey market (non-QV) for 12V appliances, especially lights and fans. The grey market is made up a wide variety of manufacturers, including repurposed second-hand SHS Kits and appliances from Europe and North America, and a plethora of unbranded Chinese devices which are sold in large batches in local markets. The lack of common standards

7   See these publications for examples of energy stacking:
    1 https://core.ac.uk/download/pdf/195316485.pdf
    2 https://www.researchgate.net/publication/222915847_Solar_Home_System_Electrification_as_a_Viable_Technology_Option_for_Africa's_Development
8   *Powering Opportunity in West Africa: Improving Lives, Powering Livelihoods with Off-Grid Solar*, GOGLA, December 2019, p.9.

Overview of SHS Kit & Appliance Market

results in improvised solutions – for example, a rudimentary connection of an SHS Kit and battery to an unbranded TV – which may work for a while but ultimately damage both the SHS Kit and the appliance. As a result, the typical lifetime of an electrical product in Africa is very short.

There is very little data about the second-hand and repair markets for SHS Kits and appliances, though informal repair shops are ubiquitous and the thrift economy is strong. In theory, a lack of interoperability may constrain consumers from gifting or selling their used SHS Kits and appliances separately; for example, if they want to give a relative an old TV that works on an SHS Kit that is different from the one they own. Third party product repair is known to be constrained by a lack of spare parts, tools, and product specifications, and limited skills.

The growing problem of solar e-waste

Currently SHS Kits and appliances account for only a small percentage of e-waste generated in emerging markets, but the volume of waste – and the industry's obligations to provide waste management solutions – is growing.[9] The waste hierarchy dictates that the first step is reduction of waste by extending product life, enhancing ease of maintenance and repair, and creating second-life options.

The lack of interoperability between SHS Kits and appliances may drive premature obsolescence; a whole system (or parts thereof) may have to be replaced if a component fails and a replacement cannot be found or repair completed. Third-party repair and refurbishment are also hindered by the non-standard components and variety of firmware, which challenges both formal service providers and the informal market.[10] There are some companies that aggregate and repurpose old SHS Kits and resell them as branded kits, but this market remains small.[11]

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9   A recent study estimated that 26.2 million solar lanterns and SHS Kits have reached their end-of-life in Sub-Saharan Africa and South Asia (GOGLA 2018). In Kenya, 3-4% of the 55,000 tons of total e-waste produced in 2017 was from solar kits.
10   https://storage.googleapis.com/e4a-website-assets/Pathways-to-Repair-in-the-Global-Off-Grid-Solar-Sector_final.pdf
11   https://www.rafode.co.ke & https://www.cleancookingalliance.org/partners/item/999/2628.

The Connect Technical Guidelines

Ensuring that SHS Kits and Appliances from different manufacturers will work together safely and reliably requires products to meet a set of Technical Guidelines.[12] GOGLA's Technology Working Group has been working with partners – notably Solaris and Angaza - to define a set of Technical Guidelines for the following product categories and uses:

- SHS Kits up to 350Wp (PV module) in-line with VeraSol and IEC industry standards[13]
- SHS Kits with 12V outputs;[14]
- Primarily for household use cases, for appliances up to 100W (and therefore excluding high power applications such as solar water-pumps or agri-processing; and
- For both 'Basic' and 'Smart' loads (where 'smart' is with PAYGo activation and/or device control, and 'basic' is without).

There are four parts to the Technical Guidelines which combine to form the 'interoperability stack';[15] this includes the following layers:

1. Connector (also known as the plug and socket);
2. Electrical characteristics (such as voltage, current, etc.);
3. Communications protocol; and
4. PAYGo Activation and Device Control.

Manufacturers may choose to adopt the Technical Guidelines to different levels depending on their strategy and products. For cash sale products with no device control ('Basic loads'), it is only necessary to comply with Layers 1 and 2. For products sold on PAYGo and/or with Device Control ('Smart loads'), it is also necessary to comply with Layers 3 and 4. There are also additional considerations to make sure the SHS Kit and Appliances are well matched in terms of energy and power (see Consumer Satisfaction and Quality Assurance section).

Figure 6 - The Connect Interoperability Stack

4a	PAYGo Activation (lock/unlock)	Digital Handshake	4b	Load management	Data feedback
Nexus Channel (secured): *Manages secure PAYGo pairing and activation of appliances based on commands from software platform.*			**Nexus Channel Core (not secured):** Enables load management (sharing limited battery energy), data feedback (to view performance or faults) and other functions.		

3. Communications protocol
Open PAYGo Link: A communication channel on which Nexus Channel can 'speak' between SHS Kit and Appliance.

2. Electrical Characteristics
The voltage current, etc. ranges to ensure compatibility.

1. Connector
The physical connector (plug and socket) that joins the SHS Kit and appliance.

Using Nexus Channel with OpenPAYGo Link is like agreeing that we will speak English and talk on the telephone.

12 In future they may develop into Technical Standards. Technical Guidelines are appropriate for an early stage of industry cooperation as they are less detailed and less prescriptive. They will be updated to reflect innovations and requirements as the initiative develops.
13 IEC Technical Specification 62257-9-5 and 62257-9-8. Quality Standards (VeraSol.org)
14 Based on the VeraSol and IEC 12V definition of 10.5V to 15V.
15 For more detailed information about the 'Interoperability Stack' and the respective Technical Specifications view the documents on the Technology area on the Member space of GOGLA's website. They are also available from GOGLA upon request.   11

The Connect Technical Guidelines

The Connector and Electrical Characteristics

The choice of universal connector is a significant decision for any industry, given its wide-ranging use, prominence to consumers, and implications for technology combinations. This is true for the OGS sector. USB has been a game changer for mobile phones and other consumer electronics and is now an iconic technology for consumers. The Connect Initiative aims to define a 12V DC equivalent that includes and expands on USB for off-grid solar products and customers.

The Universal Family of Connectors for 12V SHS Kits will support power delivery and communications for lights, phone charging and many appliances. Given the range of loads and appliances (and their associated power ratings), and the Basic and Smart nature of these loads, it is necessary to have a Family of Connectors.

There is a wide range of connectors on the market, and the selection of connectors involves a complex set of technical, commercial, and strategic considerations. The criteria for selection include durability, cost, size, electrical safety, user-friendliness, and brand identity. A task force of the Technology Working Group – including

Greenlight Planet, Azuri Technologies, Fosera, BBOXX, SolarWorX, Global Ice Tec and Chris Moller (Evonet) – has been working for the past 15 months to define the selection. The specifications listed here are provisional, with the final decision planned later in the year.
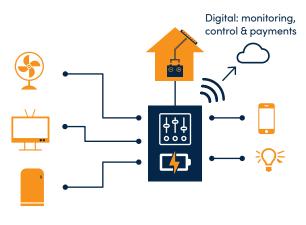
Lights and Basic Loads – a 5.5mm barrel connector.[16] It is the most prevalent connector on the market and is widely used for non-QV and non-branded goods.[17] This means that adopting this standard would open the door for these products.

Mobile phones (Basic and Smart) – The familiar USB-A is ubiquitous and well understood by consumers. It is already the de facto standard.

Fans, TVs, Fridges, and other loads (Basic and Smart) – There are two options: either a two-pin connector, with the 5.5mm barrel (same as the Basic Load) combined with communication pin that can carry up to 3.5 Amps; or, three-pole barrel connector (laptop-style) with integrated power and comms that can carry up to 8 Amps.

Figure 7 - SHS Kit & Appliance schematic, Universal Family of Connectors

SHS Kit and Appliances

Universal Family of Connectors

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16 Both the 5.5/2.5- and 5.5/2.1-barrel connectors are prominent on the market. A decision will need to be made about a preferred option.

17 Based on a survey conducted by GOGLA and product data from popular consumer electronics marketplaces such as Alibaba and Bang-good.

The Connect Technical Guidelines

USB-C is an optional extra, but not a foundation

We see USB-C as a strong option, particularly as it is bound to be a feature of the OGS market in the future, but we think it is not a good foundation for a universal OGS standard. USB-C is a good choice for some SHS business models and markets, but it is not suitable for everyone. This is especially the case in developing countries where USB-C has drawbacks that include:

- USB-C is small and fiddly; it was not designed for rural Africa where it can suffer with dust, humidity and extreme heat.
- USB-C has 24 pins and a complex set of protocols and voltage levels, which necessitates additional components and cost for SHS Kit and Appliances.

- It is expensive; the unit costs are still high (though will likely drop) and if appliance manufacturers want to use the USB-C logo, they must pay USD 5,000 per year to the USB-C Implementers Forum.[18]
- There are many functions supported by a USB-C socket, but no standardised way for a user to know what the socket will and will not support (e.g. a user may assume that because they have a USB socket on their device that they can do a fast charge of their smart phone, but may be disappointed to find that their power source doesn't have the right protocol and charging their phones will take in excess of 24 hours).

It is also essential that the electrical characteristics of the SHS Kit and Appliance are within certain ranges for reliable and safe operation. The important parameters to check are the normal operating voltage range, peak operating current and in-rush current, and possibly also operating power, typical duty cycle, and galvanic isolation requirements.

PAYGo Activation and Device Control

PAYGo technology is well established in the OGS industry. SHS Kits packaged with TVs, fans, etc., are sold to a customer with a remote lock-out function that stops the product from working until the next payment has been made. However, there are challenges, particularly as home systems become larger and more complex. For example, if a consumer buys an SHS Kit on PAYGo, then six months later buys a TV on PAYGo, they will need two keycodes. This can create problems for the user and for the technical support; for example, if the keycodes are entered in the wrong order or incorrectly it can be hard to troubleshoot. Another challenge is the differing communication protocols and firmware between different manufacturers, that could result in products not working together or loss of functionality.

Adopting the firmware layers (3 and 4) will provide **device-to-device interoperability** that enables:

- the secure activation and deactivation of appliances based on PAYGo via the SHS Kit (vice versa is also possible, where the appliance controls the SHS Kit). This will enable SHS Kits and Appliances to be sold on PAYGo at different times, and to be from different product manufacturers (though with the same PAYGo provider);
- the identification and verification of appliances so that they only work on the SHS Kit they are connected to / have been sold with (the 'digital handshake'). This can be deactivated when the payment has been completed and the consumer owns the product outright. This mitigates the risk that consumers will take expensive appliances to alternative power sources and cease making payments (a risk that is partly mitigated today by using proprietary connectors);
- Verification of electrical compatibility to ensure SHS Kit and appliance are not damaged when they are connected to each other;
- Enhanced device control such as load management (e.g. if the battery is running low the system may automatically reduce the brightness or volume of the TV to conserve energy for priority services such as lights); and

The Connect Technical Guidelines

- Data feedback on the status and performance of the appliance to the SHS Kit (e.g. in the event of a fault) that can be logged and even transmitted to the cloud for monitoring by the PAYGo provider.

To achieve this requires Technical Guidelines for the hardware and firmware layers. These comprise a hardware layer developed by Solaris – OpenPAYGO Link,[19] and a PAYGo protocol developed by Angaza – Nexus Channel.[20] The functionality of these layers can be described using this analogy. If we want to communicate, we need to agree on the language and the medium of communication. If we all agree to speak English, we can understand each other, but if we don't agree how we will communicate – telephone, email, letter – we cannot successfully connect with each other. Using Nexus Channel with OpenPAYGO Link is like agreeing that we will speak English and talk on the telephone.

Angaza and Solaris have developed the Nexus Channel and OpenPAYGO Link specifications in close collaboration and to be fully compatible with one another. This enables the automatic verification, activation, and deactivation of PAYGo devices, the ability to check for electrical compatibility to avoid damaging appliances, and demand management. It also enables any software platform to develop the necessary workflows to manage all this functionality.

It is important to note that there already exists a level of **device-to-platform interoperability** between Angaza, PaygOps and Paygee (announced at the Global Off-Grid Solar Forum in February 2020). These three PAYGo platforms are compatible in a way that enables any SHS Kit that is integrated with one of the platforms, to also be usable with the two other platforms.[21] This makes it possible for distributors to work with the platform of their choice without manufacturers having to multiply integration efforts with all PAYGo Management Platforms and/or produce multiple inventories owing to platform compatibility restrictions.

Nexus Channel

Nexus Channel is an application layer for device-to-device communication which facilitates interoperability between constrained appliances produced by different manufacturers.[22] **Nexus Channel Core** is the foundation of the offering which enables smart appliances to do things like switch on lights and fans, or to change TV channels. Nexus Channel has an optional feature that enables the transmission of secure messages between devices, which is critical for PAYGo applications, and can be controlled by external platforms. Messages from the PAYGo account platform to controllers can be encoded in existing communication types (namely: keycode/token).

Nexus Channel Core is a subset of the Open Connectivity Foundation (OCF) Specification, an industry and ISO/IEC standard. OCF specifies a way to define appliance resource models (such as demand management or features such as light dimming) in a non-proprietary, highly interoperable format.

OpenPAYGo Link

OpenPAYGO Link is an open source, bi-directional communication system with an electrical interface (based on LIN) and a Data Link, Network and Transport layers. The goal is to provide a quick and inexpensive way (less than 50 US cents) of adding communication to a constrained device.[23]

The collaboration between Solaris and Fosera to establish OpenPAYGo Link could bring engineering time and cost savings for manufacturers and the industry as a whole. They estimate that adoption of the specification could save over 120 engineering days that would be required to develop an equivalent protocol.

Defining, maintaining and using the Technical Guidelines

Clear and robust Technical Guidelines, standardised product specifications (with new parameters listed), system design and marketing guidelines, and testing and verification will all become increasingly important as the number and range of manufacturers and distributors aligned with the Connect Initiative increases. A committee

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19 Detailed information and link to the Technical Specification: Efficiency for Access Research and Development Fund: Solaris Off-grid
20 Detailed information and link to the Technical Specification: Nexus Channel Core | Angaza Nexus Channel Core
21 *PaygOps, Paygee and Angaza are becoming interoperable!* (solarisoffgrid.com).
22 Angaza presents the functionality and benefits of Nexus Channel on this webinar.
23 Constrained in terms of data logging and transmission.

The Connect Technical Guidelines

will be established to further define and maintain the Technical Guidelines to ensure that they remain relevant and coherent. There is also scope for expansion into new product categories (e.g. productive uses and weak-grid applications) and for more functionality (e.g. guidance on mobile phone fast-charging protocols, Appliance resource models, and PAYGo Keycode Generation).

The Connect Initiative's technical partners are committed to keeping the Technical Guidelines publicly available. Both Angaza and Solaris are working with EnAccess Foundation[24] to define and maintain these standards for the industry.

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Off-grid solar companies are offering consumers larger systems and more appliances. Increasingly, they are adopting modular approaches and seeking VeraSol certification for multiple configurations at once, and not just a single kit. The Connect Initiative will enable the industry to take the next logical step toward greater choice for consumers

Ari Reeves, CLASP

"

© Mobisol

24 Homepage - The EnAccess Foundation

Benefits of the Connect Initiative

We believe that the Connect Initiative could bring substantial benefits, not just to the manufacturers and distributors of SHS Kits and appliances, but more importantly to the consumers of SHS Kits and appliances. Off-grid solar is a highly competitive market which is evolving fast, and the Connect Initiative could create a new dynamic, enabling specialisation, AI & IoT integration, new partnerships and business models, and fresh investment. However, we do not advocate or expect all companies in the OGS ecosystem to specialise and pursue a fully 'open' strategy. Vertically-integrated companies may wish to adopt elements of the interoperability stack whilst maintaining a limited QV product range and focused service offering.

> **"**
> Energy is aspirational, once you get a little, you want more. You start with a few lights, then want a TV, next a music system and fridge.
> **"**
>
> Godfrey Simiyu Katiambo, SUNami Solar

Benefits for consumers

Consumers will be the key beneficiaries of the Connect initiative, which could result in:

- Wider choice of appliances, digital services & suppliers;
- Easier access to repair and maintenance infrastructure which can serve a wider variety of products;
- Greater freedom to switch service providers once consumers have paid off their SHS Kits and appliances;
- More options for 'second-life', such as gifting and selling old or unwanted appliances; and
- Better consumer protection: if a company withdraws from a region or country, customers can more easily use their SHS Kits with other providers, rather than being left with obsolescent products and no customer support.

We believe the Connect Initiative could change the customer journey, which currently locks in customers to their service provider (see charts below). With Connect, once the customer has paid off the initial PAYGo term, they will have the option to buy appliances and services from rival companies if they are not satisfied with the offering of their existing service provider without having to start again with an entirely new system.
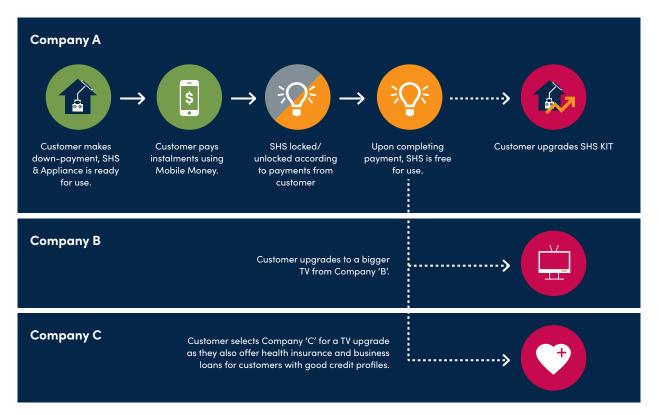
Figure 8 – Expected outcomes for consumers & companies

Appliance Manufacturer	SHS Kit Manufacturer	Distributor	Consumer
• Quicker, cheaper route to market for new products, e.g. Adopting standardised firmware integrations can save 80 engineer days per appliance (Fosera/Solaris data). • Reduced cost and increased quality with standard parts and suppliers. May encourage big appliance manufacturers to engage in market. • Shorter lead-time and Minimum Order Quantities (–> less capital required). • Increased flexibility to combine and customise SHS Kits and appliances (enabled by potential changes to the quality assurance framework in which they are verified separately);		• Wider product range customised to market needs. • Enhanced after-sales service and repair (e.g. easily replace a broken TV with a different brand). May also be hard to service wider range. • Opportunities for specialisation, e.g. appliance-only distribution.	• Wider choice of products to choose from. • More flexibility for upgrades (with different companies). • More options for 'second-life' (buy, sell, gift).

Benefits of the Connect Initiative

Figure 9 - The customer journey - today

Customers have limited choice of 'Follow-on products' from other companies because of different plug-socket types. If they want to upgrade either a SHS Kit or Appliance, they may have to 'start again' with both. Despite having gained a 'Credit Profile' customers often cannot benefit from this with other companies. These barriers to switching may 'lock' customers into a single provider.

Company A

| Customer makes down-payment, SHS & appliance is installed in home. | Customer pays instalments using Mobile Money. | SHS locked/ unlocked according to payments from customer | Upon completing payment, SHS is free for use. | Follow-ons: • SHS Kit and Components • Appliances & Mobile phones • Financial services • Digital services (TV, mobile data) |

Figure 10 - The customer journey – with Connect

Company A

| Customer makes down-payment, SHS & Appliance is ready for use. | Customer pays instalments using Mobile Money. | SHS locked/ unlocked according to payments from customer | Upon completing payment, SHS is free for use. | Customer upgrades SHS KIT |

Company B

Customer upgrades to a bigger TV from Company 'B'.

Company C

Customer selects Company 'C' for a TV upgrade as they also offer health insurance and business loans for customers with good credit profiles.

This has the potential to fundamentally change how the customer thinks about off-grid solar products; they are buying into an ecosystem of technologies and brands in a way that gives them greater flexibility and choice. This brings their experience and perceptions of off-grid solar closer to that of the much-desired grid.

Benefits of the Connect Initiative

What do the consumers want?

For this White Paper, we spoke to a small sample of consumers of SHS Kit and appliances in Kenya to try and capture their experience of proprietary connectors and their views on the potential of a universal connector. Here are our initial findings:

- Overall, the idea of a standard plug/connector was welcomed by consumers who understood the potential benefits it could bring;
- Interoperability was not viewed as a priority for consumers whose SHS Kit is relatively new and is working without any issues;
- However, it could be an advantage once the SHS Kit is older or faulty and consumers want to get additional appliances not provided by their PAYGo company; and
- All of those interviewed liked the increased flexibility a universal connector would give them to purchase appliances from a wider range of suppliers, and to gift or sell old SHS Kits and appliances.

More consumer research is essential to understand how consumers are experiencing the lack of interoperability between SHS Kits and appliances from rival companies and their support for interoperable features.

"
It would be easier to get other appliances, like a bigger TV screen.
"

"
This could reduce waiting times for repairs and replacements.
"

"
It would be a new and welcome development.
"

© MWEZI

Benefits of the Connect Initiative

Benefits for manufacturers

Adopting the Connect Technical Guidelines could bring a range of benefits for manufacturers, including:

- Standardisation and simplification of the design and manufacturing process;
- Reduced time and cost and increased quality of SHS Kits and appliances, made with standard hardware and suppliers, and firmware integration (i.e. it is easier to adopt Nexus Channel and/or OpenPaygo Link than to develop a proprietary firmware);[25]
- Increased flexibility to combine and customise SHS Kits and appliances to meet customer segments and country contexts (enabled by changes to the quality assurance framework in which SHS Kits and Appliances are verified separately);

- Shorter lead-time and smaller Minimum Order Quantities for appliances, which requires less capital (in theory, appliance manufacturers could offer appliances off-the-shelf instead of doing bespoke integrations of connector and firmware);
- Increased chance of sourcing compatible appliances and spare parts locally (as distributors would be encouraged to stock these products knowing there is demand).

Can the Connect Initiative bring benefits for vertically-integrated players?

It may appear that vertically-integrated companies with control of their product range and service offering have little to gain from enhanced interoperability. However, many of the benefits identified for manufacturers and distributors are also relevant for vertically-integrated players. Through the course of our consultations these potential benefits have been suggested by some vertically-integrated players:

- increased supply chain efficiencies, including better quality and reduced cost of connectors, and increased likelihood of better and lower cost appliances (either from smoother integrations with existing suppliers, or buying from new big entrants or on the local market);
- liberalisation of the quality assurance framework, enabling them to sell a wider range of appliances that are compliant with accepted standards;

- Creating opportunities for future business model pivots with forward compatibility; and
- Creating more value for their customers and distribution partners and reducing e-waste.

Furthermore, companies can adopt some or all the Technical Guidelines and get benefits, without giving up the opportunity for closed systems: one does not have to fully embrace horizontal specialisation and open systems to benefit from these shifts. As an analogue, Microsoft does allow more interoperability than Apple, but many of its design decisions maintain proprietary goals: for example, MS Excel files are designed to be proprietary, and generally are. (Non-MS tools can be used to view MS Excel files, but they are intentionally not easily editable by other software while maintaining MS Excel compatibility.)

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25 Fosera and Solaris estimate that standardised firmware integration could save 80 engineer days per appliance. https://efficiencyforaccess.org/publications/efficiency-for-access-research-and-development-fund-innovator-series-solaris-offgrid

Benefits of the Connect Initiative

Benefits for distributors
The Connect Initiative could also bring a range of benefits for distributors, including:

- The ability to better customise product offerings to meet market needs;
- Wider pool of potential customers (i.e. both 'first time' customers and SHS Kit owners seeking upgrades and add-ons);
- Enhanced after-sales service and repair (e.g. more easily replace a broken TV with a different brand, find a spare part for a broken cable, or troubleshoot and fix a firmware fault);
- Opportunities for specialisation: for example, appliance-only sales;
- Greater flexibility to switch between hardware and software providers (with interoperable hardware and firmware, backward and forward compatibility is less of an issue).

In the long-term (and with development of various market functions such as consumer education and labels), greater interoperability could help drive the transition of the OGS market to a point where electricity supply is provided through PAYGo SHS Kits and consumers buy their appliances from an array of interoperable vendors, just as the current grid model works in developed markets.

Benefits for investors
The Connect Initiative also offers advantages to investors in the OGS sector. The benefits for manufacturers and distributors above have the potential to help companies on their path to profitability, a clear win for existing investors and a necessity for future investors.

Securitisations and Special Purpose Vehicles (SPVs) could be game-changers for investment in the off-grid sector, but their potential has been constrained by the difficulty of servicing the assets following a company failure:

"

If only the PAYGo Company can service its own portfolio (largely the case), and that company is not profitable (also often the case), then the value of its receivables is likely to be severely impaired. Without a viable backup in the event of company failure, any investment into receivables is a bet on the financial health of the company.

"

Taming the Strange Beasts: Servicing and the future of PAYGo, CGAP & CDC (here)

Standardised and simplified technology and business models – including the hardware, firmware, and company and consumer data – reduce the friction for a third-party to service a company's portfolio and lessen this risk. This dynamic also facilitates Mergers & Acquisitions. An early-stage company would be a better acquisition target with reduced friction of adopting assets, giving a clearer exit strategy for early equity investors.

Benefits for the environment and sustainability
Industry adoption of Connect Technical Guidelines could have a positive environmental impact by reducing appliance obsolescence and enhancing repairability. This can help reduce the carbon footprint of the OGS sector, by extending the life of SHS Kits and appliances, and can help reduce the risk of pollution associated with improper disposal of e-waste and the burning of obsolete cables for their copper.

Risks of the Connect Initiative

The Connect initiative is designed to boost innovation and growth in the OGS market. However, the Connect Initiative also entails risks for consumers, companies, and the market as a whole, including:

Consumer satisfaction and brand equity

A universal connector will open the door for consumers to buy and use low-quality and low-cost products that fail to meet minimum quality standards. This represents a consumer protection risk, particularly for consumers that are unable to recognise quality and brands. Customers may also find it hard to receive sales advice and after-sales support for off-brand appliances, increasing the risk of problems. Faults and poor performance on any part of the system risks damaging the reputation and brand equity of PAYGo companies.

The PAYGo model is expected to continue dominating the market for larger SHS Kits and appliances. The model is self-regulating to some extent – the consumer must be satisfied, and willing and able to pay, for the company to see the revenue. The onus is on the distributor to ensure both that the system works well, and that the consumer is well-informed and satisfied. Distributors need a bigger toolkit to ensure quality, satisfaction, and protection. The VeraSol program and the GOGLA Consumer Protection Code together offer a framework for this, though this framework needs to be developed further to meet the needs of a changing industry.

In a market where consumers can buy the SHS Kit and appliances separately (perhaps the ultimate step of interoperability, see Connect Roadmap section) it is much harder to ensure that the combination of the SHS Kit and the appliance will perform to a high standard and meet the consumers' expectations. For example, there risk of a mismatch in sizing (e.g. buying a big TV to run on a small battery), that would result in low run times.

Customer education in the market today is weak, and it will be increasingly important to ensure consumers are aware of the features and risks, and can make well-informed decisions about their products and providers. The quality assurance framework needs to be strengthened to help companies ensure quality. One proposed solution is to put QR codes on all SHS Kits and appliances. Distributors and consumers could scan these with their smartphones to verify the voltage and compatibility of their kits and devices. This will require close coordination between the testing and certification agencies, manufacturers and distributors to ensure that the information is correct and understandable.

Consumer safety

There is the potential for increased safety risks to consumers in relation to the use of non-verified appliances with SHS Kits. The issue is especially important for appliances that have onboard lithium batteries, as non-QV devices that manage their batteries poorly or that have poor quality batteries can lead to a fire risk. If such devices can be used more easily with branded / QV SHS Kits due to a universal connector, consumers may unknowingly open themselves up to new safety risks. However, it is worth noting that this risk already exists for devices charged through USB ports (and other cases where customers manage to connect non-QV appliances).

Increased competition and diminished profitability

The Connect initiative presents a number of risks to the PAYGo companies, notably on profitability and financial sustainability. The increased competition could break companies' long-term relationship with their customers, leading to lost revenue from the upgrades and add-ons, which may threaten the company's profitability and long-term financial sustainability.[26]

Competition will come from both brand rivals and the grey market. The 'Basic' connector in the Family (the 5.5/2.X mm barrel) has been selected based on its commonality in grey market products. However, this is a double-edged sword, facilitating consumer flexibility and choice, as well as easier integrations with the wider market, but also opening the door to low-quality and low-cost products that fail to meet minimum quality standards.

Risks of the Connect Initiative

PAYGo companies may also struggle to offer warranty & after-sales support for off-brand appliances used with their SHS Kits, which could increase the company's service costs and hurt its brand equity.

One commonly cited challenge of a universal connector is that of increased credit risk; that the consumer could pay a deposit for an SHS Kit and TV, then power the TV from a neighbour's SHS Kit and cease making payments. Proprietary plugs are a common method of reducing this risk (though not fool-proof). The 'digital handshake' outlined in Section 2 of this White Paper presents a more robust solution and is compatible with interoperability.

Transition costs

The transition to universal connector standards will bring operational challenges, particularly for companies with large product fleets already in the field. There will be costs associated with transitioning to the new standards, in design, manufacturing, engineering and firmware modification. However, given the rapid development of solar technology, companies will not need to retrofit their existing products (which will become obsolete soon), but rather could

use the new standards for their next generation of SHS Kits and appliances. If the standard is well designed and electrical parameters are compatible, it should be possible to create passive adapters between different connectors (including legacy connectors).

Nevertheless, PAYGo companies with large product fleets already in the field will have to consider backwards compatibility after the transition. Stocking spare parts for old stock and adapters for new stock can help minimise the friction.

Government regulation

As with any standard, there is the risk that the Connect Standards are misused. A principal concern is that a government may adopt the Connect Standards (or parts thereof such as the connector) as a mandatory national standard and shut out proprietary models. A less severe example could be that a donor program or fund manager includes the standard in its eligibility criteria.

This would be a mistake; both Proprietary and Interoperable business models have roles to play in the OGS market, and both are able to deliver consumer value and protection.

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26 Many companies struggle to make a unit profit on their first sale to a customer given the high acquisition costs. The importance of follow-on products and services is therefore key to their profitability.

The Connect Roadmap

The decision to adopt the Connect Technical Guidelines and transition to a more interoperable market will come from companies that see value in cooperation. We propose to convene a Roundtable with Executives of companies interested in aligning their strategy with the Connect Technical Guidelines later this year. The session will give participants the opportunity to hear expressions of interest and action plans from their peers. We are seeking feedback on this White Paper which we will compile and share ahead of the meet.

Widespread adoption of the Connect Technical Guidelines will enable the 'systems integration function' (the ability to match together SHS Kits and appliances) to move down the supply chain. To date and currently it is performed by the manufacturer. The next step is to empower the distributor, and perhaps eventually the end-user to be able to mix-and-match components to meet the needs. This transition will be stepwise and over a number of years, and will require supporting functions and services (supported by GOGLA and industry partners) to enable the system integrator to package product combinations in a way that ensures compatibility and good performance.

As this White Paper has presented, there are also benefits to adopting the Technical Guidelines even if the company's aim is not to specialise and pass the system integration role to distributor partners and consumers. Early adopters of the Connect Technical Guidelines are already incorporating the connectors and firmware into new products; for example, Angaza and Solaris are already offering the Nexus Channel and OpenPAYGo Link.

The Connect Initiative is in its early days, and much more work is needed in such areas as quality assurance frameworks, consumer research, and expanding the technological scope. We are keen for manufacturers and distributors to work together on rolling out the Connect Technical Guidelines without compromising quality or undermining their business models, and we are seeking development partners and foundations that are interested to support the initiative.

GOGLA fully supports a diverse market and membership, one where Proprietary, Connect Affiliate and Open models exist side by side, and the vertically-integrated and specialist business models flourish. We encourage SHS companies, manufacturers and distributors to explore the opportunities that the Connect Initiative could bring to them and seek to understand how it could fit into their long-term strategy.

Figure 11 - A phased approach: moving 'system integration' down the supply chain

1. Manufacturers adopt Connect Technical Guidelines

- Technical Guidelines finalised and available
- Early adopters ensure compatibility in-house/with partners

2. Distributors empowered to mix and match

- Product specs for compatibility checks
- Testing & verification of SHS Kit, Appliance & firmware
- System design tools
- Sales & marketing guidelines
- B2B mark (possibly)

3. Consumers empowered

- Consumer-facing labels (possibly such as QR codes)
- Consumer awareness campaigns

Call to Action

We believe that a Universal Connector and PAYGo firmware for SHS Kits and appliances could catalyse market growth and offer benefits to companies, consumers, and the environment. This White Paper has laid out the case for Connect, and we are keen to start a debate on the potential benefits and how we can work together to overcome the obstacles. We welcome your feedback and suggestions, which we will review and discuss in the Technology Working Group later this year.

Here are some questions to start:

1. Does the Connect Initiative present a compelling value proposition for your company, and the industry? What is the value for your company?
2. How will your customers, supply chain partners and investors react to Connect?
3. What do you feel are the main challenges/risks of an industry transition to the Connect initiative? Can these be overcome, and how?
4. Would you like to adopt the Connect Technical Guidelines?
5. How can we work together to make this a reality?

Please provide your feedback to these questions – and any other points – to the GOGLA team via email or arrange a call to discuss. We welcome all views, both supportive and critical.

The EnAccess Foundation has created a community forum to discuss the benefits and risks of the Connect initiative. We encourage people to sign up and share their ideas:

Open Source For Energy Access Community Invite link

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The Voice of the Off-Grid Solar Energy Industry