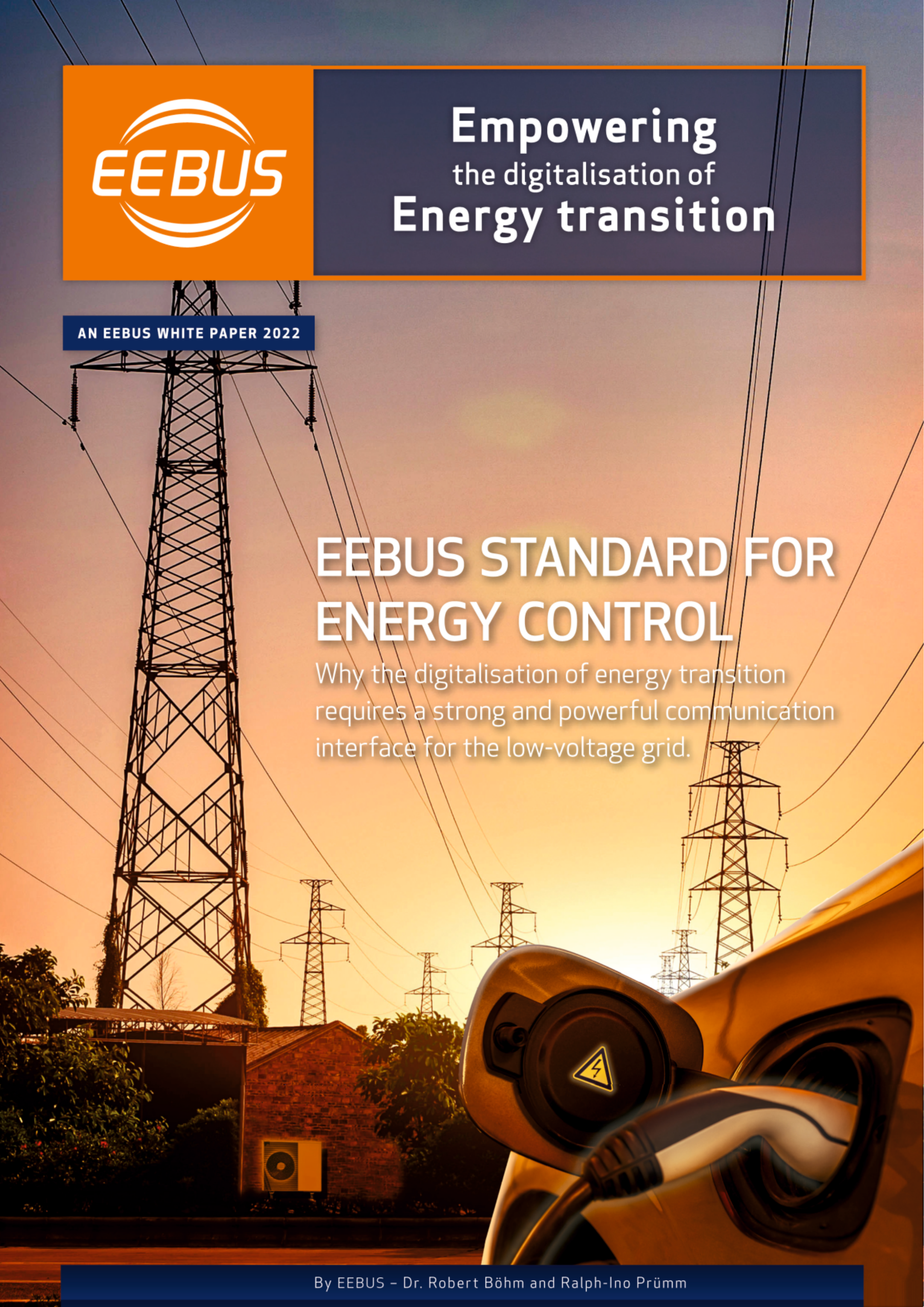

EEBUS

Empowering
the digitalisation of
Energy transition

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EEBUS STANDARD FOR ENERGY CONTROL

Why the digitalisation of energy transition requires a strong and powerful communication interface for the low-voltage grid.

By EEBUS – Dr. Robert Böhm and Ralph-Ino Prümm

EEBUS Standard for Energy Control

Why the digitalisation of energy transition requires a strong and powerful communication interface for the low-voltage grid

by Dr. Robert Böhm (EEBUS) and Ralph-Ino Prümm (EEBUS)

ABSTRACT

- The increasing share of renewable energies as well as further electrification of our world generate new communication requirements between various stakeholders coming from different technical backgrounds.

- This communication to be effective and allow for broad participation must be internationally standardised.

- Effective communication between the different stakeholders requires more than just standardised data exchange: the communicating parties must also be aligned with respect to content and communication flow process via the same use case applications. By "communication interface" we refer to this combination of data model and transport protocol required for the data exchange as well as relevant use case descriptions.

- Such communication interface to be successful and future-proof must fulfil seven key requirements: it has to be
  1) Technically standardised
  2) Easy to install: plug & play on the premises
  3) Holistically applicable
  4) Dynamically flexible
  5) Reliable
  6) Security compliant for critical infrastructure
  7) Broadly supported

- EEBUS technology fulfils all of the above key requirements and is already available in serial products.

MOTIVATION

Both the energy transition from fossil fuels to renewables as well as the electrification of energy consuming sectors change our way to handle electricity dramatically.

On the one hand, low-voltage grid stability has already become an issue of concern in some countries and will do so even more in the future with rapidly increasing electrification of the transport and heating sector.

On the other hand, new energy business models emerge that make use of bidirectional flexibilities of assets such as electric vehicles or stationary batteries.

In principle there are three main types of stakeholders that need to align and thus require a standardised interface to communicate with each other:

- The Distribution System Operator (DSO) who is responsible for the stability of the low-voltage grid up to the buildings' grid connections
- Energy market participants in the field of electricity sales and supply as well as aggregation of small-scale installations
- Device manufacturers that want to make their devices part of a larger energy eco-system and offer new services

EEBUS standardises this required communication interface at and behind the grid connection point in order to allow for the development of energy-related and manufacturer-specific business models that are compliant with physical limits at the grid connection and thus ensure stable low-voltage grid operation.

EEBUS communication interface

THE SEVEN KEY REQUIREMENTS FOR A SUCCESSFUL COMMUNICATION INTERFACE

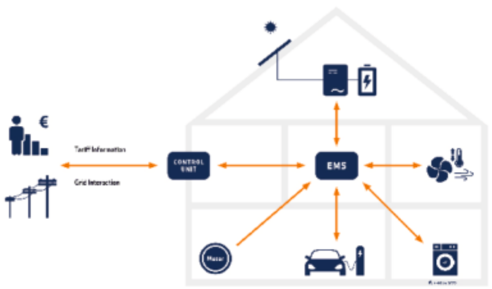
1) Technical standardisation

First of all, a standardised communication interface of course has to be non-proprietary: a larger energy eco-system can only be established when it is manufacturer and service provider independent and when the communication interface implementations are testable via an openly available test specification.

For the eco-system of interconnected energy relevant controllable devices from numerous buildings to reach a critical mass, as required by the accelerating energy transition, the communication interface must be technically standardised to allow for mass market suitable serial products. In the long run a successful international standardisation process will require that a *de facto* standard developed by industry actors converges into a *de jure* standard, i.e. that the standard becomes mandatory and accepted by all stakeholders.

2) Easy installation: plug & play on the premises

This requirement is related to a dynamically evolving eco system where more than simple 1-to-1 relations need to be managed and optimised.



Looking at the architecture picture above, if a building starts with a single device, e.g. a charging station for the Electric Vehicle (EV), "only" the grid interaction of this single device needs to be taken care of. As soon as one or more other devices, e.g. a heat pump, a stationary battery, a PV system or controllable white goods are added, the resulting interacting system as a whole needs to be considered and internally aligned in such a way that the physical limits of the grid connection are respected.

The plug & play requirement is essential in the sense of minimising adjustment efforts when new devices or device features are added to the system. The EEBUS solution to this requirement is given by a self-discovery mechanism for the exchange of data: devices can communicate their self-description through machine readable information that even may change over time. This key element of the EEBUS architecture enables the system to network devices automatically and request the devices' capabilities through EEBUS discovery. This discovery mechanism leads to self-updating systems with trustable functionality of the connected devices. Without such an automated mechanism any system enhancement would have to be manually configured to be followed-up by a new system test: the complexity would be shifted from the communication interface to the system configuration and validation.

When it comes to implementations on the premises, the end-user cannot be considered as a technical expert but wants to participate in and contribute to the ongoing energy transition. The link is the educated craftsman that understands and installs costly devices such as charging stations, heat pumps, PV systems or stationary storage systems: for a mass roll-out, such devices need to be designed and equipped with a communication interface that is easy to implement and automatically recognised by other interconnected participants of a larger energy eco-system.

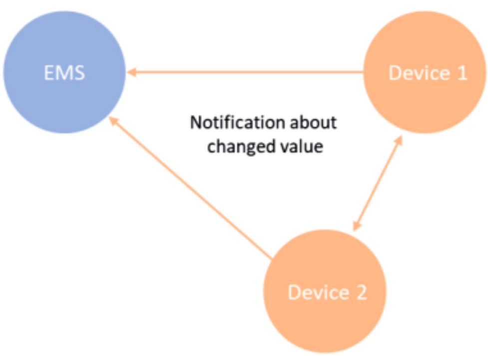
It is to that respect that the already described discovery mechanism plays a crucial role in both installer and end-user acceptance: an automated plug & play mechanism without the need for specialists' costly configuration tools to integrate devices into an overall eco-system will path the way to a broader acceptance for energy optimised setups.

3) Holistic application
All energy relevant devices from cross sector domains need to be able to interact and the interaction with the low-voltage grid needs to be properly managed.

EEBUS enables such a holistic application by its use case specifications employing the domain unspecific data model SPINE (Smart Premises Interoperable Neutral-Message Exchange). In fact, the wish for cross-domain useability was the reason for companies from various industry sectors to found the EEBUS initiative in 2012. Irrespective of device type or stakeholder role, it is the generic data model allowing for a broad range of use cases.

Furthermore, information symmetry is implicitly guaranteed – there is no single point of information and control: any device can exchange energy related data via its implemented use case(s), irrespective of the underlying system architecture. Whereas an Energy Management System (EMS) functionality might be useful for the orchestration of various devices at the same time, there are applications in which devices need direct access to other devices' data. EEBUS has applied the concept of subscription and binding:

Subscription to 2 devices



Binding of 2 devices

Whereas the subscription mechanism allows for various network participants to receive data from another participant, the binding mechanism can establish a command hierarchy: an efficient communication interface in a network of numerous participants must allow for both – data exchange on equal footing as well as the possibility of exclusive access rights.

4) Dynamic flexibility
This is an essential and technically highly advanced feature of the EEBUS standard as opposed to other potential realisations of a communication interface.

The EEBUS data model SPINE has been designed from the very beginning to allow for a maximum degree of flexibility:

- Via the categories of "device", "entity" and "feature" any kind of device with its functionalities can be described in an interoperable manner
- The meaning of data to be exchanged is implicit part of the data model itself → concept of self-describing data

This data model design is not only flexible with respect to cross-domain applications but also dynamic in the sense that data points may change over time: as an example, just think about EV specific charging values that need to be exchanged between an EMS and a charging station (different EVs with their specific charging parameters connecting to the same charging station of a building at different points in time) to support e.g. phase balancing or bi-directional EVs. In the EEBUS self-describing data model these dynamics are taken care of by an automated and standardised "detailed discovery" which allows for a machine-to-machine communication of the according information.

The above-described dynamic flexibility comes of course at the cost of complexity of the underlying data model: in order to allow for implementable solutions at affordable costs, the concept of use cases has been invented. The data structure serves as a basis for the use cases that select and combine required elements in a modular principle: it is then these use cases that are agreed upon and standardised in domain specific as well as cross-domain working groups of the EEBUS initiative with its cross-industry membership structure. The result is a growing macrocosmos of use cases where the underlying modular design principle allows for consistent use case combinations and interplay.

Finally, the overall generic application requirement for a domain agnostic data model with modular use case design is met via the EEBUS use case discovery methodology: without the need of any central authority, devices communicate in an automated manner the use cases that they support, and this information can be read and adequately interpreted by all other devices being part of the same interconnected eco system.

This technological communication interface design with its incorporated dynamic flexibility has a couple of outstanding advantages for the participants of the interconnected eco-system:

- Not every device has to support every use case → it is up to the device manufacturer to decide which functionality he wants to support by choosing the use cases to be implemented into his product(s)
- Even if the communication interface itself is standardised, each device manufacturer still has the freedom of differentiation → there is no limitation in terms of product design for interoperable solutions with respect to data elements
- Due to the allowance for dynamic changes with respect to the device capabilities, updates can be implemented and will be automatically recognised by other devices

The modular and flexible data model design is a pre-requisite for consensus building among the various stakeholders: without its underlying complexity the different interests could not have been integrated into jointly aligned and interoperable use cases.

<u>5) Reliability</u>

Even the technologically most advanced and economically most feasible solutions have to be reliable when it comes to grid relevant implementations. EEBUS ensures reliability with respect to its SPINE data model in the following manner: use cases depending on a reliable connection implement a fail-safe/watchdog mechanism - if the communication behind the grid connection fails, the heartbeat mechanism of the EEBUS ensures that the devices operate in a fail-safe mode and return to a normal operation as soon as the communication is re-established.

<u>6) Security compliance for critical infrastructure</u>

A sufficiently high level of security is mandatory: different to comfort related smart-home applications, energy supply systems are categorised as critical infrastructure with high security requirements to make sure there will be no external intervention.

The security requirements may differ from country to country. In principle, any transport protocol can be used for transmission of the EEBUS SPINE data: EEBUS members have deliberately chosen an IP approach and developed the Smart Home IP (SHIP) transport protocol in order to be best-in-class with respect to cyber security and energy networking inside buildings.

For finding and networking devices, the EEBUS discovery mechanism applies mDNS/DNS-SD (multicast Domain Name System/Service Discovery) while secure communication is enabled through the high security TLS (Transport Layer Security) communication standard as well as elliptic curves. Both the EEBUS discovery and applicable elliptic curves are state-of-the-art security technology and are compliant with the German Federal Office for Information Security (BSI). Furthermore, via SHIP we have implemented remote certificate update procedures that can be applied during ongoing device operation without required user interaction.

Finally, a trust level mechanism allows device manufacturers to individually pre-configure which other devices shall be trustfully interconnected via public key acceptance procedure.

<u>7) Broad support</u>

Last but not least, a strong and powerful communication interface must of course be backed-up by a broad support base. Within EEBUS we are fulfilling this requirement via

- An open cross-sector consortium of all relevant stakeholders that constantly further develop our standard
- Manifestation of our technical standard in international standardisation bodies

CONCLUSION

For the various stakeholders in the context of optimising energy flows in the low-voltage grid, a common communication interface is the core enabler to exchange data in a standardised way and align their different interests. This communication interface must fulfil seven key requirements if a large energy eco-system is to be build up supported by cross-sector industry players: a priori such a communication interface is by far more than a simple data exchange format but a complex and well aligned framework including agreed-upon use case descriptions for defined interactions EEBUS not only fulfils these seven requirements but is already in implementation phase in various serial products such as charging stations, heat pumps and energy management systems.

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