S2 WHITE PAPER

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Introduction

This white paper explains the S2 standard (also known as EN 50491-12-2). S2 aims to solve the interoperability challenge for managing the energy consumption and production of devices. Example devices are heat pumps, electrical vehicles, PV, and batteries. This is necessary in order to utilize the energy flexibility of these devices for all kinds of optimizations that can alleviate the grid, such as congestion management and demand-side management, or optimize for certain goals such as self-consumption maximization and for the use of price incentives. S2 makes this possible in a future-proof manner.

S2 is called S2 because that is the name of this interface in the European Smart Grid Architecture developed in Mandate 490 of the European Commission, and because it is easier to pronounce than EN 50491-12-2.

This white paper will explain the reasons for creating such a standard, the key take-aways for using S2, and the many benefits for its stakeholders in the energy domain. The paper concludes with a description of how the S2 architecture fits any use case and how that is achieved by analysing different flexibility patterns.

Why do we need Energy Flexibility?

Over recent decades, energy production and its consumption patterns have changed dramatically. Today we are faced with an increase of energy consumption due to the increased electrification of our society and introduction of more sustainable energy resources. This leads to additional load on the grid for which it was not designed, also known as congestion, making it more difficult to keep the grid reliable.

Although central top-down energy production without communication is still dominant, distributed production with renewables is growing. In an electricity system production needs to be in balance with consumption. With centralized energy production, the energy production follows the energy consumption and with this approach it is easy to align the energy production with the energy consumption because centralized production is easy to control.

The trend for distributed production is distinctive following an increasing number of renewables. Alternative energy sources are highly intermittent (e.g. wind is not blowing constantly and the sun could be shaded by clouds) in their production capabilities. The energy production (short term) forecast is not so easy which may result in grid operators and energy utilities facing increasingly difficulties to keep a balance between energy production and consumption caused by the intermittent energy sources. For both aspects (congestion and balancing) it is mandatory to introduce the flexibility for energy consumption / production.

A Smart Grid that allows a grid operator and participating balancing parties to be flexible and reactive is needed. Such reactivity requires a communication flow between energy consuming and producing entities, from single family houses to large factories.

ENERGY FLEXIBILITY IN THE BUILT ENVIRONMENT

Energy flexibility in the built environment (both commercial and residential buildings) has a huge potential as shown in Figure 1.

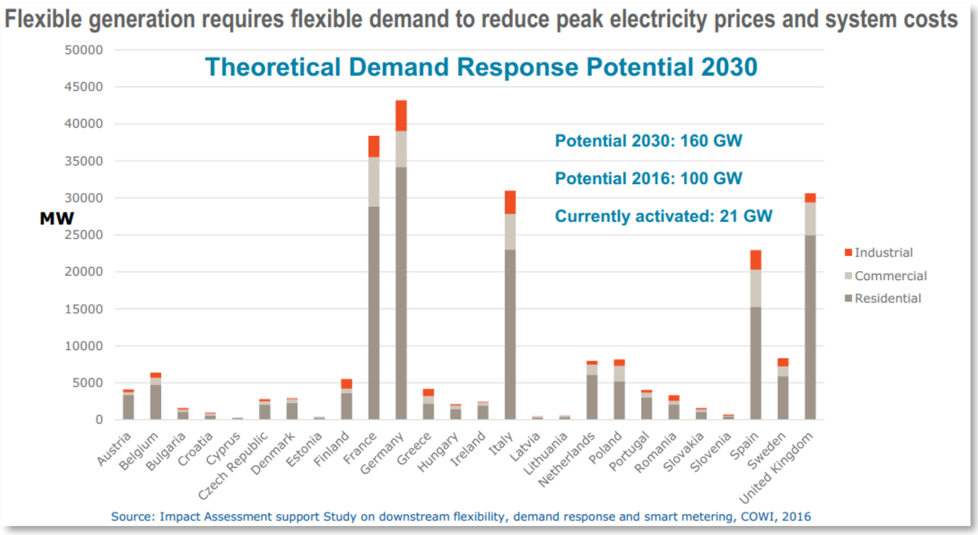


Figure 1: Comparison of Industrial vs. Commercial and Residential flexibility (COWI 2016)

However, in practice only a small amount of that flexibility potential in the built environment is being used, while industrial flexibility has already been successfully applied on a large scale for years. Why is it so hard to tap into the full flexibility potential that the built environment has to offer?

An important part of the answer to that question is that the nature of built environment flexibility is very different to that of its industrial counterpart. Here are some key aspects that illustrate these differences:

- **Flexibility volume per asset.** In general, a single industrial asset will consume/produce a lot more energy than those in the built environment. The flexibility margin of industrial assets is therefore also significantly higher. Because of this high margin more time and money can be spent on unlocking industrial flexibility compared to that in the built environment.
- **Fragmented effort to unlock flexibility.** In an industrial setting the number of flexible assets will typically be relatively low, which means that the effort required to unlock that flexibility can be focused on a limited set of assets. In the built environment, however, a same amount of flexibility must come from many assets (EVs, PV, heat pumps, batteries, etc.) which also

come in a large variety of makes, models and communication/IoT protocols (if any). It requires a huge, fragmented effort to make that flexibility available to a smart grid.

- **Limited liability requires more predictability.** The operation of industrial assets follows carefully planned production processes which makes the flexibility they have to offer highly predictable. In comparison, assets in the built environment operate in a more arbitrary fashion, with less liability compared to industrial flexibility.

In short, it is a lot costlier to unlock flexibility from assets in the built environment, while it is less valuable than industrial flexibility. To make it profitable the costs should be brought down to a bare minimum. This can be achieved by introducing a standard way to unlock and control flexibility across a wide range of assets. Such a standard has been developed by CENELEC TC205 under the umbrella of the EN50491-12 series, also conveniently called the 'S2 standard'. S2 is the name of the interface between the energy management system (EMS) and smart devices in the European Smart Grid Architecture, developed in M/490 of the European Commission[1]. This series of standards addresses all of the issues described above and creates the much-needed interoperability on energy flexibility in the built environment.

Key takeaways for S2

Manage only energy flexibility

S2 only focuses on exchanging energy flexibility information between devices and Energy Management Systems (EMS). It has been a deliberate choice to not expand on that scope with other functionality such as device configuration, and remote maintenance. The wider the scope, the more complex the protocol will need to be which has a negative impact on interoperability. By restricting the scope to energy flexibility only, it is much easier to implement and maintain S2.

Future-proof interoperability

As it is still unclear which use cases for energy flexibility will be implemented in different countries, it is very difficult to create a future-proof protocol that accommodates all these unknowns. Most energy management solutions develop their protocols only with specific (currently known) use cases in mind. S2 takes a completely different approach with a focus on the specification of the device's capabilities for energy flexibility, instead of what a device should do in a particular use case. The powerful IT principle of separation-of-concerns moves all energy management-related use cases to the EMS and creates a use-case agnostic protocol. At the same time, it renders all devices that implement S2 interoperable for any use case available now and in the future.

Simplicity is key

Energy management is complex, to say the least. Time-of-use tariff optimization, congestion and capacity management, self-optimization and portfolio optimization are example schemes that use energy flexibility of devices. S2 is able to handle this complexity by defining only five different device capabilities to cover all combinations of use cases and devices. Device OEMs, on the one hand, are free to define which features of the five capabilities fits their devices best, e.g. simple curtailment of EV charging versus detailed modelling of battery charging schemes. EMS manufactures, on the other hand, only need to support the five device capabilities, and don't need to know the details of the myriad of the devices and their functionalities out there.

[1] More information about the reports for M/490 of the Smart-Grid Coordination Group: https://www.cencenelec.eu/areas-of-work/cen-cenelec-topics/smart-grids-and-meters/smart-grids/

S2 does not interfere with the OEM

OEMs invest heavily in developing safe and efficient products that provide the best user experience possible. The last thing that an OEM needs is an EMS that interferes directly with a carefully designed control loop for their device, jeopardizing an optimal user-experience or - even worse - safety constraints. With S2 the OEM always remains in control about which part of the available energy flexibility is being exposed to an EMS, while it is also possible to specify device constraints. It is also important to emphasize that an EMS never has direct control over a device; a device can always opt to ignore an EMS instruction when this goes against safety or user comfort constraints.

End-user in control

Support of end-users is key in adoption of energy flexibility management schemes, such as demand response. It is therefore crucial that the end-users' comfort requirements and privacy are not compromised. S2 supports incorporation of comfort requirements of end-users in S2 communication and puts the end-user in the driving seat over how much flexibility is exposed to the EMS. Different deployment models are supported by S2, which enables end users to find the right level of privacy they are comfortable with.

S2 is add-on to existing protocols

There are already many existing (proprietary) protocols to control devices, such as Zigbee, OpenADR, KNX or Matter. S2 is not here to replace protocols that are already there, because S2 defines an energy flexibility application model that does not yet exists in protocols. Due to its constrained focus on energy management only, it fills a specific gap. It is not a replacement for features that other protocols provide such as device configuration features, firmware updates and supporting device apps. S2 can leverage existing protocols to extend their functionality with energy flexibility management features.

Open market for EMS

Adoption of EMS in consumer premises is low, due to lack of standardisation and the explosion of (proprietary) IoT communication protocols. S2 turns this around by providing a simple protocol for energy flexibility management. This creates a level-playing field for all EMS manufacturers and lowers entry barriers for start-ups. Customers are protected from vendor lock-ins as S2 makes it possible to easily switch from one EMS solution provider to another.

Proven technology

S2 is not just a concept on paper, it has already been proven in practice. The principles behind S2 have been developed and tested in practice in numerous field trials and projects with many partners. EU Projects like H2020 Holisder, H2020 InterFlex and H2020 InterConnect have all added to the success of this protocol. National (Dutch) projects such as Heerhugowaard, Energie Koplopers and GO-e have battle tested the protocol.

BENEFITS FOR STAKEHOLDERS

There are many stakeholders in the energy domain that benefit from an energy flexibility standard, e.g.:

DSO & TSO

S2 enables DSOs & TSOs to benefit from the Energy Flexibility potential of large number of assets in the built environment. DSOs and TSOs will be given an alternative to (time-consuming and expensive) grid enforcement by enabling them to use the flexibility potential of large numbers of electrical devices to keep their grid stable. This will speed-up the energy transition, as the grid capacity utilization is improved. It provides the capabilities behind the meter to react on emergency signals from the DSO. Grid operators can send information to their flexibility service providers, such as energy suppliers and end users, enable them to control and optimize their energy consumption and feed-in while supporting the grid. This allows for new (flex)markets, (price) incentives and contractual constraints (such as specific grid-constraints or bandwidth usage).

Device manufacturers

Adoption of S2 brings about many advantages for OEMs. Devices that support the S2 standard can participate in a wide range of energy flexibility services. This makes a device more attractive to consumers as they can not only use for its intended purpose but also the energy flexibility it offers. As S2 does not interfere with the control logic of the device and the autonomy of the device is respected, the impact of incorporating S2 is low. The versatility of S2 allows the OEM to decide how much flexibility is being exposed to an EMS, which makes it easier to support different types of optimizations and distinguish themselves from competition. Additionally, the OEM is free in choosing what deployment option is chosen, e.g. in the cloud or with dedicated functionality in the device.

Energy market parties, such as energy (service) suppliers and aggregators

S2 helps energy market parties to reduce the barrier to unlock flexibility from a myriad of devices, as these devices offer a single standard to communicate energy flexibility. It supports many business models to make money with energy flexibility, such as supporting the TSOs and DSOs with their grid operations in case of congestion or supporting customers to get the best out of their dynamic tariff schemes.

HEMS manufacturers and ‘tech flex unlockers’

The S2 standard significantly reduces the integration effort to interact with a wide range of devices from different manufacturers, the biggest blocker for large scale roll-out of HEMS. The choice for S2 instantly supports all flexible devices, now and in the future, at once. The clear separation of concerns between energy management and device capabilities allows the HEMS to be the place to provide the intelligence for energy management. This allows differentiation among competition by providing specific energy management features, such as smart optimizations, attractive incentives and promising business models. Here too, different deployment options are available (e.g. a box at home or in the cloud).

System integrators

System integrators deploy fully working energy management systems that integrate seamlessly with all smart devices. For them similar benefits as the HEMS manufacturers are present, as they can support device and HEMS manufacturers, aggregators and consumers with their knowledge about S2 to create and integrate systems for managing energy flexibility at a large scale.

Consumers

S2 offers consumers an improved experience in terms of privacy, comfort and freedom of choice. For devices that support S2, no vendor lock-in is possible and therefore they are free to choose what device, HEMS or service provider they want to use for managing their energy flexibility. Comfort requirements can be taken into account and from the different deployment models that S2 supports they can choose the one that fits their privacy best.

Policy makers, governments and regulators

S2 is an official European standard that allows policy makers to create a level playing field for energy flexibility and measures like demand-side management at European level. One flexibility standard reduces the investment risks for OEMs, HEMS, energy suppliers / aggregators and consumers. To speed up the energy transition policy makers can develop regulation on unlocking flexibility to accelerate adoption by market parties and solve the situation that there are no flexibility services because there are no interoperable flexible devices (and vice versa). S2 is technology neutral (it co-exist with existing standards) and protects the consumer's privacy and protects them from vendor lock-ins.

ARCHITECTURE

The design philosophy of the S2 interface is to divide the energy management responsibilities between the Customer Energy Manager (CEM) and the Resource Manager (RM), see Figure 2. The Resource Manager describes the 'technical' flexibility capabilities and constraints, whereas the CEM focuses on how to utilize the value of that flexibility by considering incentive schemes for example.

It is not possible to create an exhaustive list of all possible smart devices and all possible CEM strategies for the expected lifetime of the S2 specification, let alone all possible combinations of devices and CEMs. For this reason, the S2 interface supports a clear separation of concerns between devices and CEMs by focusing on a generic description of energy flexibility. The flexibility capabilities that smart devices provide can be mapped onto this generic description of flexibility, while it also does not impose any limitations on CEM algorithms to exploit this flexibility in a specific way.

The architecture for S2 is depicted in the figure below.

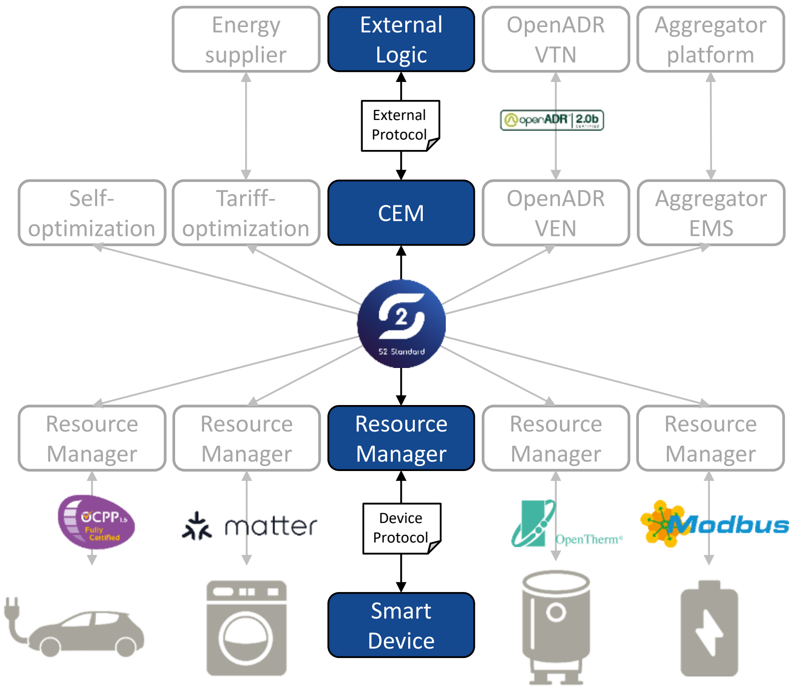


Figure 2: S2 Architecture showing integration with existing device protocols (bottom) and multiple ways to implement the CEM functionality (in grey, top), e.g. by creating a CEM that optimizes for tariffs or self-consumption, a DSO that deploys an OpenADR VEN at the CEM or an aggregator that deploys a cloud-based EMS for its customers.

The S2 interface is used to communicate the energy flexibility of smart devices to the Customer Energy Manager (CEM). The CEM also uses S2 to send instructions to smart devices to exploit their flexibility in a specific way. The components involved in the S2 communication are described below.

- **Smart Device.** Smart Devices can offer energy flexibility via the Resource Manager (see below) by deviating from their normal consumption/production pattern. These devices can be controlled externally so that they can be integrated into the premises smart grid system. Smart devices are very diverse and perform a wide range functions within a home or a building, such as whitegoods, PV, HVAC, etc. A smart device can also reflect systems that are composed of a group of devices that work together for a single application. Think of a HVAC system that is composed of components such as fans, chillers, radiators etc. Controlling a single component within such a system for flexibility purpose might disrupt the correct functioning of the complete system. Therefore the entire system with all of its components should be treated as a single source of flexibility.

> **S2 AND SAREF**
>
> SAREF is an ontology to enable interoperability between solutions from different IoT providers. S2 is mapped to SAREF in its latest version, making it compatible with initiatives that use SAREF, such as the Code of Conduct for Energy Smart Appliances of the European Commission.

As is apparent these devices are very diverse in their functionality. This also goes for the protocols that are used to control the devices externally. Examples of such (IoT) protocols are KNX, OCPP, ModBus, EEBUS/SPINE, Zigbee, Bluetooth, WiFi, Z-Wave, but also proprietary protocols. The same holds for the data models/parameters that are used. It is virtually impossible for a Customer Energy Manager to be aware of and support all possible permutations of functionality, protocols and data models. This is where the Resource Manager and the S2 interface come in.

- **Resource Manager.** The Resource Manager is an intermediary logical component that on one side communicates with the smart devices using its native protocol and data model and understands the functionality that the device performs. On the other side it communicates the energy flexibility options of the devices to the Customer Energy Manager (CEM). The CEM is only interested in the flexibility that the device has to offer, not in all of the available detailed device parameters and protocols. These would simply overwhelm the CEM and would require adaptations to be made to the CEM every time a new device would be connected.

> **S2 AND EXISTING PROTOCOLS**
>
> S2 does not replace existing protocols, but leverages them to enable flexibility services. S2 is designed to work together with established protocols like KNX, ModBus, OCPP and OpenADR.
>
> KNX for example already supports S2 in one of its specifications.

The Resource Manager translates the device-specific information into information about energy flexibility that is offered to the CEM via the S2 interface. This is not a straightforward mapping; information that is not relevant for energy flexibility needs to be filtered out while other information needs to be enriched to make it relevant for energy flexibility. Take a thermal buffer for example; a Resource Manager will have to understand what the capacity of that buffer is and how fast it can be heated. The S2 Control Types sections below describes in more detail which energy flexibility information is conveyed over the S2 interface. The Resource Manager will also receive instructions over S2 from the CEM to use the flexibility in a particular way.

In providing flexibility to the CEM, the Resource Manager will also take user comfort as well as the operational boundaries/safety margins of the device into account. These aspects will also be checked if the Resource Manager receives an instruction from the CEM. If user comfort or the operational boundaries/safety margins are compromised by executing a CEM instruction it is the responsibility of the Resource Manager to reject that instruction.

- **Customer Energy Manager.** The CEM takes into account the flexibility that is being provided by all Resource Managers on the premises. Based on its optimization objectives and additional external information/incentives, it will decide how to use that flexibility so that its objectives will be met as closely as possible. Examples of CEM objectives could be to optimize on dynamic energy tariffs, promote self-consumption as much as possible or to help the DSO alleviate congestion. After the CEM decided on how to use the flexibility, it will send instructions to the Resource Managers over S2.
- **External Logic or Third Party.** In some cases, the CEM will work autonomously, e.g. when it tries to be as autarkic as possible. In most cases however, the CEM will base its flexibility optimization objectives on incentives provided by a third party, such as the tariff information of an energy supplier. Other examples are an Aggregator that aggregates flexibility from different households to optimize its portfolio, and a DSO that requests a consumption reduction from the CEM for a specific part of the grid.

By using S2 a lot of the implementation details of the devices are hidden for the CEM and it can focus on its core business: managing energy flexibility. This enables the CEM to connect to a wide variety of devices with little effort thus promoting interoperability, while at the same time harvest the merits of the key take-aways that S2 has to offer.

FLEXIBILITY PATTERNS

By analysing many use cases and device capabilities for energy flexibility, several flexibility patterns have emerged that provide an abstraction for the flexibility that a device can offer. These flexibility patterns are described in more detail below.

1. Limit production or consumption

Some devices produce or consume energy that in principle is not controllable, but can be limited if necessary. Typical examples are solar panels and wind turbines, which only produce energy when there is solar irradiation or wind available respectively, but they can be limited in production, which is typically referred to as curtailment.

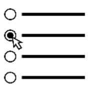
2. Shift production or consumption in time

Another flexibility pattern is the ability to shift an entire production or consumption pattern over time. A good example of a device that offers this flexibility pattern is a washing machine with a delayed start option.

3. Pause a task

A device might be able to pause while performing a task. For example, some washing machines have the possibility to pause between parts of the program, e.g. between the heating and washing cycle. Some devices can pause at arbitrary points, others can only pause at predetermined points in the program. Usually there is maximum pause time, or a deadline for completing the task.

4. Alternative power profiles



This pattern offers multiple options to perform a certain task, while using the same energy type. Dish washers, for example, have the ability to heat the water quickly with a lot of power, or slowly with less power. The resulting power profiles for both options are different, however in both cases the water will be sufficiently heated.

5. Power modulation

This pattern describes devices that are able to modulate their energy production or consumption, without any consequences for the flexibility of the device. Typically the purpose of these devices is to balance a micro grids. A diesel generator is a good example as it can produce power at will. Another example is flaring; disposing of excess energy, typically in the form of heat.

6. Buffer energy

Some devices are able to buffer energy in some way. There is a component that puts energy in the buffer and converts it into another form, while another component can retrieve the (converted) energy from the buffer. A good example would be an electrical water boiler for providing hot tap water.

7. Store energy

When energy is buffered, it is not possible to transform the buffered energy back to the original form or energy, e.g. hot water cannot be converted back into electricity. In the storage pattern energy can be retrieved in the same form as it was put in. A typical example is a battery storage, where electricity can be stored in the battery, and at a later moment in time be retrieved.

8. Switch energy type

The last flexibility pattern is the ability of a device to choose between different forms of energy to reach the same objective. For example, a heat pump can be complemented by a gas boiler.

FIVE CONTROL TYPES TO COVER ALL USE CASES

The flexibility patterns show overlap in their control behaviour. This renders a total of five control types to cover all energy flexibility use cases. These five control types are shown in the Table 1 below and explained in the text below.

A Resource Manager will map the flexibility of the device it represents, onto one of these control types. The CEM will only have to implement these five control types to be able to connect to all devices via their respective Resource Managers.

Resource Managers are all capable (if supported by the underlying smart device) to provide power/energy measurements and forecasts.

	Curtail	Shift	Alternative	Pause	Modulate	Buffer	Store	Switch
Power Envelope Based Control	✔							
Power Profile Based Control		✔	✔	✔				
Operation Mode Based Control					✔			
Fill Level Based Control					✔	✔	✔	✔
Demand Driven Based Control					✔			✔

Table 1: Five control types (left) cover the 8 flexibility patterns.

- **Power Envelope Based Control.** This control type is used for devices that cannot be controlled by the CEM to adhere to a specific value for their production or consumption. They can however be asked by the CEM to not exceed certain power limits over time. A typical example of such a device would be a PV installation/inverter. The CEM cannot directly control its production as this is dependent from the amount of sunshine, but it can ask the PV panel to not exceed a certain production limit, also known as curtailment. This feature is very useful for congestion management for example. When there is too much production for the local grid to handle, this control type can be used to limit the output of the PV panel to a manageable level.

EXAMPLE DEVICES

- PV Panels / inverter
- EV (IEC 61851, curtail only)

- **Power Profile Based Control.** The power profile based control type is typical for devices that perform a function with a corresponding power profile that is known or can be predicted beforehand. Their main flexibility comes from the ability to change the start time of that power profile. White goods, such as a washing machine with a delayed start option, are good examples of this category. A consumer fills the washing machine with dirty clothes, selects a program and chooses the final time by which this program should be finished. The CEM can then decide what the best possible start time is, giving its optimization objectives.

  Another type of flexibility is offered by this control type is the ability to choose between multiple alternative power profiles. The heating cycle of the washing machine might have alternative profiles, e.g. one that consumes less power but requires more time to heat the water and one that consumes more power and takes less time to reach the target temperature. The CEM can then choose which one of these alternative to use.

EXAMPLE DEVICES

- White goods, e.g.:
  - Washing machine
  - Dishwasher
  - Tumble dryer

- **Operation Mode Based Control.** Devices that fall within this control type have the possibility to control the amount of power they produce or consume, without significant effects on their future flexibility options. Typical examples for this control type are diesel generators and variable electrical resistors. Such devices are often useful for balancing microgrids. Operation mode devices

EXAMPLE DEVICES

- Power generators
- Variable electrical resistors

offer a lot of flexibility; they can assume a range of power levels at almost arbitrary moments in time. When this type of flexibility would be modelled with power profiles, as used for power profile based control, the number of possible permutations would rapidly grow beyond practical limits.

To avoid such issues, the operation mode control type is modelled as a state machine. A resource manager can declare multiple operation modes for a device. An operation mode is a mode/state that a device can find itself in, that is associated with a specific power value. For example, a diesel generator can have three operation modes: one for being off, one for running at reduced power and one for running at full power. The `off' operation mode has a power value of 0 W associated with it, the `reduced power' operation mode has a power value of -1 800 W (a negative value denotes production), and the `full power' operation mode has a power value of -3 000 W.

Transitions between operation modes are also explicitly specified. This way, the possible transitions between operation modes may be restricted. Transitions can also be equipped with timing constraints: a device can for example express that it needs to run for a minute in `reduced power', before it can move on to `full power'. This can be achieved by defining a ‘minimum on time’ timer that blocks the transition when its value is not equal to 0.

The CEM can send instructions that will tell the Resource Manager which operation mode to go to next. These instructions also contain timestamps to inform the Resource Manager on when the transition to a next operation mode should be made.

- **Fill Rate Based Control.** The fill rate-based control type can be used for devices that have the ability to store or buffer energy. How energy is stored or buffered does not matter, as long as there is a means to measure how full the storage or buffer is.

  There are many examples of devices that can store or buffer energy. Stationary batteries and electric vehicles are examples of devices that store energy in batteries. Heating devices such as CHPs, (hybrid) heat pumps or boilers can buffer energy in a dedicated heat buffer (typically a thermally insulated water tank), but a room with an allowable bandwidth for the temperature can also be used as a buffer.
  Finally, there are also devices that produce cold, like air conditioners, fridges and freezers. Just like heat, cold can be buffered. There are even more ways to buffer or store energy imaginable, such as storing energy in the form of hydrogen, air pressure, water pressure or angular momentum.

  The main component of this control type is the storage itself. A device shall be able to inform the CEM about its fill level, a measure of how full the storage is, and the lower and upper bounds that the fill level should remain within. If applicable it can also inform the CEM about its target fill level and by when that should be reached. This would be useful when charging an EV for instance. In addition to the storage there are also actuators that can affect the fill level of the storage. E.g. an electrical heating element in a hot water buffer.

  The behaviour of the actuators is described with a state machine, just like the operation mode based control type. In this case however the states also specify what their influence on the fill level of the buffer is.

EXAMPLE DEVICES
• Battery • Water buffer • E-boiler • Heat pump with buffer • Fridge • Freezer • CHP • EV (IEC 15118, smart charging) • EV (V2G)

- **Demand Driven Based Control.** Demand Driven Based Control can be used for systems that are flexible in the type of energy carrier they use, but are not capable of buffering or storing energy (in that case Fill Rate Based Control should be used). A typical example is a hybrid heat pump, that generates heat using either electricity (using a heat pump) or natural gas (using a gas boiler), but doesn't have a thermal buffer. The hybrid heat pump must deliver a given amount of heat (hence demand driven), but can still decide whether to generate this heat using electricity or natural gas. Typically, such systems favour the heat pump, but use the gas boiler in case the heat demand cannot be fulfilled by the heat pump alone or when there is a shortage of capacity in the electricity grid.

  Similar to the Fill Rate Based Control, Demand Driven Based Control has the concept of multiple actuators. Again the behaviour of these actuators is described using a state machine. This time the states do not specify their influence of the fill level of the buffer is, but they specify a supply rate that can be matched with the demand. The CEM can select a state for each actuator as long as the demand is being matched by their aggregated supply.

EXAMPLE DEVICES

- Hybrid Heat Pump

As is apparent from the enumeration above, the control types can be used to support the flexibility of a wide variety of devices. Often, the flexibility of a device can be mapped to multiple control types, e.g. the flexibility of home EV charging can be expressed via both Power Envelope Based Control and Fill Rate Based Control. This provides an additional level of control to an OEM as they can opt for a simpler control type that provides less flexibility or a more complex control type that unlocks more flexibility.

Conclusion

S2 is an open and interoperable European – and in future worldwide – standard that benefits many stakeholders in the energy transition. It allows to unlock the flexibility of wide variety assets in the built environment in a cost-effective, future-proof and scalable manner.

INTERNATIONAL STANDARDISATION

S2 is currently a European standard, which has been picked up by IEC SC23K to make it into a global standard as IEC 63402-2.

For further information please refer to the FAN website at https://flexible-energy.eu/ and https://s2-standard.org. Developer resources, such as the S2 reference implementation and the associated Wiki can be found on GitHub https://github.com/flexiblepower/s2-ws-json and https://github.com/flexiblepower/s2-ws-json/wiki