This document summarizes the intermediate conclusions of the technical study commissioned and supervised by the European Commission services (DG ENERGY) towards the development of a smart readiness indicator for buildings. The smart readiness indicator is part of the revised Energy Performance of Buildings Directive. A Smart Readiness Indicator (SRI) for buildings shall provide information on the technological readiness of buildings to interact with their occupants and the energy grids, and their capabilities for more efficient operation and better performance through ICT technologies. This technical study explores the potential characteristics of the indicator via a transparent, open and interactive process, with the objective to support and inform the policy making process.

**MOTIVATION - SMART BUILDINGS**

There is a clear need to accelerate building renovation investments and leverage smart, energy-efficient technologies in the building sector. Smart buildings integrate cutting edge ICT-based solutions for energy efficiency and energy flexibility as part of their daily operation. Such smart capabilities can effectively assist in creating healthier and more comfortable buildings with lower energy consumption and carbon impact. Smart buildings have also been identified and acknowledged as the key enablers of future energy systems for which there will be a larger share of renewables, distributed supply and energy flexibility on the demand side.

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1 Technical study carried out by VITO, Waide Strategic Efficiency, Ecofys and OFFIS for European Commission DG Energy. Reference: Verbeke S., Waide P., Bettenhäuser K., Usslar M.; Bogaert S.; “Support for setting up a Smart Readiness Indicator for buildings and related impact assessment - second progress report executive summary”; June 2018; Brussels

2 See https://smartreadinessindicator.eu for further information on the study.

The ‘Smart Readiness Indicator’ (SRI) aims at making the added value of building smartness more tangible for building users, owners and tenants. The indicator should be an informative tool, whose objective is to raise awareness about the benefits of smart technologies and ICT in buildings, in particular from an energy perspective. The indicator can also improve policy linkages between energy, buildings and other policy segments, in particular in the ICT area, and thereby contribute to the integration of the buildings sector into future energy systems and markets.

Smartness of a building refers to the ability of that building or its systems to sense, interpret, communicate and actively respond in an efficient manner to changing conditions in the operation of technical building systems or the external environment (including energy grids) and to demands from building occupants.

A Smart Readiness Indicator (SRI) for buildings shall provide information on the technological readiness of buildings to interact with their occupants and the energy grids, and their capabilities for more efficient operation and better performance through ICT technologies.

**THIS STUDY AND ITS PROGRESS**

This study commissioned and supervised by the European Commission services (DG ENERGY) is intended to provide technical support to feed the discussions on the definition and provision of a smart readiness indicator for buildings. In particular, this study proposes a methodological framework for the SRI and the definition of smart services such an indicator can build upon. It is also provides a preliminary evaluation of potential impacts of the proposed indicator at EU scale. This work is being carried out iteratively in close consultation with stakeholders. As part of the consultation process, a first stakeholder meeting has been organised in June 2017, a second meeting in December 2017 and a last one in May 2018. After each meeting, stakeholders were invited to provide written feedback to the reports and accompanying annexes. This feedback has led to important updates in the second progress report compared to the interim report distributed in December 2017, as described in the following paragraphs.

The catalogue of smart ready services has been significantly amended in light of stakeholder comments. In total 13 new services have been introduced and 21 of the services listed have been updated (modification of properties such as functionality levels or impact scores). Furthermore, the need for a well-established process to review and regularly update the catalogue has been advocated.

The methodology has been adapted and further streamlined to reflect the changes in the smart services catalogue. Based on growing insights and feedback received, a streamlined SRI methodology is proposed that uses a consolidated set of services which are relevant in the scope of the EPBD, have significant impacts, are actionable now and can be assessed in practice. Further consideration has been given to how the SRI methodology can be tailored to address specific contexts and how it can link to other assessment procedures and initiatives. Significant attention has been given as to how a flexible structure can be set up that allows the SRI (methodology) to be adapted over time and to make use of data available at that time (e.g. to make it possible to use quantified impact scores or actual measured data for specific impacts).
METHODOLOGY UNDERPINNING THE SRI

The study has developed a prospective SRI methodology and scoring system, in accordance with the following guiding principles:

- The methodology aims to create a technology-neutral level playing field for market actors through the definition of functional capability rather than the prescription of certain technological solutions.
- An initial assessment of building user expectations has orientated the approach towards a simple, expressive and easy to grasp indicator which conveys transparent and tangible information.
- The methodology balances the desire for a sufficiently detailed assessment with the desire to limit the time and cost requirements of assessing the smartness of a building.
- A multi-criteria assessment method allows for the incorporation of multiple distinct domains (e.g. both heating services as well as electric vehicle charging capabilities) and multiple distinct impact categories (e.g. energy efficiency, energy flexibility and provision of information to occupants).
- The SRI methodology can adapt to relevant contextual factors, which include variations by building type, climate, culture and the collective impact these have on the demand for certain services.

The resulting approach, as set out in the streamlined methodology and demonstrated via two in-field case studies, follows a simple checklist process that is straightforward and ready to implement currently.

Based on a site visit, an assessor inspects which smart ready services are present in a building, and to what functionality level they are implemented. This is assessed based on a simple check-list approach in which each smart service is defined in a technology-neutral way, e.g. “control the power of artificial lighting”. Each of the services can be implemented with various degrees of smartness (referred to as ‘functionality levels’), e.g. “manual on/off control of lighting”, “automatic on/off switching of lighting based on daylight availability”, or even “automatic dimming of lighting based on daylight availability”. A higher functionality level is expected to provide more beneficial impacts to the users of the building or the connected grid compared to a lower level.

In the proposed SRI methodology, the impacts of the smart services have been evaluated for eight domains: Energy savings, Flexibility for the grid, Self-generation, Comfort, Convenience, Health & Wellbeing, Maintenance & fault prediction and Information to occupants.

The SRI assessor follows a check-list approach to define which services are relevant for a building and to which functionality level they are implemented. These data are fed into an assessment interface and a simple analytical tool can be used to calculate the resulting scores. These may be aggregated by ‘domain’ (e.g. ‘heating’, ‘controlled ventilation’, etc.) and/or by impact criterion. In this multi-criteria assessment, weightings can be attributed to domains and impact criteria to reflect their relative contributions or importance.

<table>
<thead>
<tr>
<th>DOMAINS</th>
<th>SERVICES</th>
<th>FUNCTIONALITY LEVELS</th>
<th>IMPACT SCORES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>EV Charging Capacity</td>
<td>• Level 0: Not present</td>
<td>• Energy savings on site</td>
</tr>
<tr>
<td></td>
<td>EV Charging Grid</td>
<td>• Level 1: Low charging capacity</td>
<td>• Flexibility for the grid and storage</td>
</tr>
<tr>
<td></td>
<td>balancing</td>
<td>• Level 2: Medium charging capacity</td>
<td>• Self generation</td>
</tr>
<tr>
<td></td>
<td>EV charging information</td>
<td>• Level 3: High charging capacity</td>
<td>• Comfort</td>
</tr>
<tr>
<td></td>
<td>and connectivity</td>
<td></td>
<td>• Convenience</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Wellbeing and health</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Maintenance &amp; fault prediction</td>
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<td></td>
<td></td>
<td></td>
<td>• Information to occupants</td>
</tr>
<tr>
<td>Cooling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSM</td>
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<td></td>
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<tr>
<td>Electric</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Vehicles</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
CATALOGUE OF SMART SERVICES

The proposed SRI methodology builds on the inspection of smart ready services in a building. Services are enabled by (a combination of) smart ready technologies, but are defined in a technology neutral way, e.g. ‘provide temperature control in a room’. Within the project and strengthened by stakeholder feedback, a catalogue of smart ready services has been developed. Many of these services are are based on international technical standards.

In accordance with the revised EPBD, three key functionalities of smartness in buildings have been taken into account when defining the smart ready services in the SRI catalogue:

- The ability to maintain energy efficiency performance and operation of the building through the adaptation of energy consumption for example through use of energy from renewable sources
- And/or
  - The ability to adapt its operation mode in response to the needs of the occupant paying due attention to the availability of user-friendliness, maintaining healthy indoor climate conditions and ability to report on energy use
- And/or
  - The flexibility of a building’s overall electricity demand, including its ability to enable participation in active and passive as well as implicit and explicit demand-response, in relation to the grid, for example through flexibility and load shifting capacities.

In total, the catalogue currently contains 112 smart services. Not all of these services are equally viable to be included in a practical SRI assessment. For some of the services listed, relevant standards and methodological frameworks are currently lacking. For others, it is technically difficult to conduct an assessment on site, e.g. because the impacts are sensitive to the nature of the control algorithms applied. Finally, for some services the impacts are perceived low and not in balance with the assessment efforts needed. In consideration of these issues, the catalogue has been streamlined in order to focus on the most impacting and actionable services (see next section).

A STREAMLINED SET OF SERVICES FOR A PRACTICAL SRI ASSESSMENT

The time and resources needed for an SRI assessment will depend on multiple variables, such as the number of services to be inspected, the detail of the assessment of each of the services, the size and accessibility of the building and the expertise and experience of the assessor. The costs for deriving a SRI will also be affected by the requested qualifications of the assessor and the additional efforts needed for operating any accompanying calculation software, administrative tasks, travel time to the inspection site, etc. An important consideration in deriving the SRI methodology is thus to balance the desire of a sufficiently detailed assessment with the desire to keep the time and cost requirements limited.

The long-list of 112 smart ready services has been streamlined to ensure prioritisation of services with the highest expected benefits, maximum accordance with the EPBD scope and the highest potential for a viable practical assessment on-site. In the current proposal for a streamlined methodology, a reduced set of 52 actionable smart ready services has been selected. Even in the case of this proposed restricted set of services, further developments are needed to be unambiguously define services and functionality levels during a practical site visit, e.g. through the creation of inspection protocols.

In theory, a maximum of 52 smart services can be inspected in the streamlined methodology. In practice, this will be further reduced in a triage process, since some of the services will not be relevant for a particular building. If the building does not feature some of the technical systems such as a heat pump, a storage vessel for domestic hot water or heat recovery ventilation, the respective services controlling these systems obviously do not have to be assessed.
FIELD TEST ON CASE STUDY BUILDINGS

The streamlined methodology was tested in two field case studies: a traditional single family house located in Manchester (UK) and a contemporary office building located in Genk (Belgium). In each assessment, the following steps are undertaken:

**Step 1**: Triage process to assess which services are relevant for a particular building. For the residential building this resulted in 23 relevant services. For the more intricate office building 44 services were to be assessed, also including services with respect to cooling, electric vehicle charging and shading control.

**Step 2**: For each of the applicable services it was assessed to what functionality level they are implemented in the building. This was done based on information gathered from a visual inspection during a walk-through of the building, an interview with the building occupant or facility manager and the review of documentation of the technical building systems.

**Step 3**: For each of the relevant services, the functionality level is filled out in a calculation tool (currently a simple spreadsheet). This tool retrieves the impacts on each of the 8 impact categories from a predefined dataset.

**Step 4**: The calculation tool aggregates all scores and weighs them by domain and impact scores. In the case study examples the domain weightings are different for the residential building and the office building to reflect a different importance of for example cooling and lighting in the distinct building types.

**Step 5**: The maximum obtainable weighted impact score is calculated by the calculation tool. This solely depends on services selected after the triage process.

**Step 6**: The overall SRI score is calculated as the ratio of the actual impact score (step 4) and the maximum attainable score (step 5).

The result of the SRI assessment could be presented as a an overall single score, as a relative score (e.g. indicating that a building achieves 65% of its potential smartness impacts) or as a label classification (e.g. SRI label class ‘B’). Sub-scores could also be presented (e.g. 72% on energy savings and 63% on comfort). Additionally, recommendations could be presented to the building occupant/owner/manager on the options to increase the smartness of their building (e.g. to improve the score by reaching higher functionality levels on well targeted services).

With the streamlined list of services and the triage process in place, the time taken to conduct assessments is found to be similar to the time it takes to conduct EPC assessments in many countries.
A MODULAR, FLEXIBLE AND EVOLUTIONARY SRI

The SRI assessment procedure can evolve over time. The current working assumption is that of a competent assessor making a site visit to the premises to conduct the SRI assessment and compute its score. This may evolve over time into more sophisticated and less intrusive - thus less costly - assessment processes as the scheme becomes established. Examples include the use of Building Information Models (BIM) to facilitate the assessment process and the emergence of some form of standardised labelling present on packages of smart-ready products.

The proposed SRI calculation methodology itself can also evolve over time. It provides a modular framework, allowing flexibility to further specify and update the method over time:

- It can be tailored depending on which services are pertinent or practicable in specific contexts (e.g. type of buildings or climate).
- It may be adapted to include additional domains, services, functionality levels or impact categories. Therefore, a process will need to be implemented to allow introducing new services and service levels, update weightings and impact scores, based on the evolution of smart ready technologies available on the market.
- The current methodology is based on ordinal scores ascribed to each service functionality level. The method is however flexible to be expanded to allow more differentiation in impact scores (e.g. differenting by building type) or also use cardinal impact scores derived from calculations, or even a blend of scoring mechanisms. It could also evolve to allow measured performance outcomes for some specific services and impact categories. In the event that outcome-based assessments using dynamic metering become viable then it may no longer be necessary for the specific service to be assessed manually but rather it could be done via a display interface to the user and/or assessor.
- The SRI assessment can be linked to other assessment schemes and voluntary labels, and for example also inform the user on the EC broadband ready label of a building. This approach could also potentially allow engagement of voluntary schemes introduced by some industry and service sectors that go into greater depth for specific smart services.
SRI - CALCULATION METHODOLOGY

ONE SINGLE SCORE CLASSIFIES THE BUILDING'S SMART READINESS

total score is based on average of total scores on 8 impact criteria

8 IMPACT CRITERIA

<table>
<thead>
<tr>
<th>energy</th>
<th>flexibility</th>
<th>self-generation</th>
<th>comfort</th>
<th>convenience</th>
<th>health</th>
<th>tech. follow-up</th>
<th>info to occupant</th>
</tr>
</thead>
<tbody>
<tr>
<td>80%</td>
<td>60%</td>
<td>40%</td>
<td>90%</td>
<td>90%</td>
<td>70%</td>
<td>60%</td>
<td>80%</td>
</tr>
</tbody>
</table>

an impact criterion score is expressed as a % of the maximum score that is achievable for the building type that is evaluated

not every domain is considered to be relevant for each impact criterion

an impact criterion is the weighted average of 10 domain scores

10 DOMAINS

heating

this % is the weight the domain contributes to the impact criterion

the qualitative scores for the different heating services are aggregated into a quantitative measure

domestic hot water

18%

a domain score is based on the qualitative evaluation of the implemented services on the impact criterion considered

EACH DOMAIN COVERS A SET OF SERVICES

the qualitative evaluation depends on the service's functionality level

QUALITATIVE IMPACT OF A SERVICE ON ALL IMPACT CRITERIA

for each service several functionality levels are defined

the higher the functionality level, the higher it's expected contribution to an impact criterion
BENEFITS AND COSTS OF A SRI

As part of the technical study, an impact assessment is performed to analyse benefits and costs of implementing a SRI in buildings to support an increased uptake of smart ready technologies in buildings in the EU. It also aims to understand the impact of accompanying policies to enhance the impact of the SRI. The methodology for assessing the potential impacts of the SRI is split into two steps. The first focuses on the modelling of the evolution of the EU building stock within the framework of the revised EPBD. The building sector pathways used in this analysis describe the general development of the building sector calculated in five geographic zones across the EU. They take into account new buildings, demolition of buildings and retrofits regarding energy efficiency measures to the building shell and the HVAC systems.

In the second part of the impact assessment, the effects of an uptake of smart ready technologies and the SRI are modelled. The analysis is done in three different packages, dependent on whether a building has heating systems, cooling systems or both in place. This assessment has given only preliminary results and will be completed in the final stage of the study.

In the impact assessment a sensitivity analysis will be performed to (i) understand the influence of different relevant parameters, which is necessary to detect the most critical ones and (ii) get an impression of the uncertainties of the results of the previously determined scenarios. This work is ongoing and not yet covered by the second progress report.

First conclusions of the impact assessment suggest that the impacts of the uptake of smart ready technologies can be significant. Total effects of thermal energy savings by 2050 can be found in the range of 153 TWh per year, which is approximately 10% of the final energy demand for heating in 2050. Demand-side management in buildings (commercial and residential) could also be significantly enhanced, with a load-shifting potential of about 150 GW by 2030 and eventually even more by 2050. Heat pumps in buildings alone could account for 60 GW by 2050. If the 60 GW load shifting capacity would be used for an average of 1h per day, this would produce approx. 22 TWh of energy shifted in 2050.

NEXT STEPS

The second progress report is made available to stakeholders mid-June with the possibility to provide written comments to the study team by the end of June. This will lead to the final report of this technical study, to be delivered end of August 2018.

The policy making process towards the establishment of the SRI will be undertaken by the European Commission and will formally start when the revised EPBD enters into force. The revised EPBD requires the establishment of two legal acts: a delegated act for the definition and calculation methodology of the SRI and an implementing act for detailing the technical modalities for the effective implementation of the SRI scheme. Both legal acts shall be adopted by 31 December 2019.