ePANACEA

Smart European Energy Performance Assessment & Certification

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Guidelines on how national Energy Performance Certificates (EPCs) schemes and the Smart Readiness Indicator (SRI) could be linked

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OVERVIEW OF THE ePANACEA PROJECT

After 10 years of track record, the current EPC schemes across the EU face several challenges which have led to a not full accomplishment of their initial objectives: lack of accuracy, a gap between theoretical and real consumption patterns, absence of proper protocols for inclusion of smart and novel technologies, little convergence across Europe, lack of trust in the market and very little user awareness related to energy efficiency.

The objective of the ePANACEA project is to develop a holistic methodology for energy performance assessment and certification of buildings that can overcome the above-mentioned challenges. The vision of ePANACEA is to become a relevant instrument in the European energy transition through the building sector.

ePANACEA comprises the creation of a prototype (the Smart Energy Performance Assessment Platform) making use of the most advanced techniques in dynamic and automated simulation modelling, big data analysis and machine learning, inverse modelling or the estimation of potential energy savings and economic viability check.

A relevant part of the project is to have a fluent dialogue with European policy makers, certification bodies, end-users and other stakeholders through two types of participatory actions: a feedback loop with policy makers, carried out through the so-called Regional Exploitation Boards (REBs) covering EU-27+UK+Norway on the one hand, and dialogue with end-users, established by means of specific thematic workshops, on the other.

Thanks to these participatory actions, the acceptance of the ePANACEA approach will be tested and validated in order to become aligned with and meet the needs of national public bodies, end-users and other stakeholders.

ePANACEA will demonstrate and validate reliability, accuracy, user-friendliness and cost-effectiveness of its methodology through 15 case studies in 5 European countries.

EXECUTIVE SUMMARY

Buildings are dynamic environments that have an impact on the comfort and health of its occupants. Latest data-technologies are enabling further capabilities such as the interaction with the occupants or the surrounding built environment. While the Energy Performance Certificate (EPC) is the scheme of reference to assess building energy performance, the consideration of new services requires the enlargement of its assessment scope. The Energy Performance of Buildings Directive as amended by Directive (EU) 2018/844 (EPBD) requires all Member States (MSs) to transpose new EU rules on the use of energy in buildings into national law by 10 March 2020. This includes the use of new data technologies to accelerate the rate of building renovation, strengthen the energy performance of new buildings and make them smarter. Ensuring data interoperability and transparency, using metering data, smart building management systems or increasing the compliance with other data standards are described as potential ways to accomplish this. The Smart Readiness Indicator (SRI) is conceived as a new common European assessment scheme to evaluate the readiness of a building to provide services to the occupants of the building, the smart operation and maintenance of the building, and its interactions with the grid. The SRI can be implemented as a standalone instrument, but many of its characteristics make it highly complementary to the EPC, providing added value and enlarging its scope.

Nevertheless, implementing a combined EPC-SRI assessment presents many practical challenges such as a potential increase of the assessment costs or the need for additional training. In addition, there are also administrative and social issues such as the differences in readiness for digitalisation across MSs or the need to earn the trust of both the general public and the experts.

This report gathers the results of several exercises, performed with the help of an international group of experts representing the ePANACEA target countries (i.e., Austria, Belgium, Germany, Greece, Finland and Spain), to provide some first answers and recommendations to the following main questions:

- Can a combined EPC-SRI assessment bring additional value to lessen issues currently encountered with the EPC?
- How should this combined approach be implemented to maximise efficacy?

From the above-mentioned work regarding a successful implementation of a combined EPC-SRI approach, there proves to be a clear need for (1) favourable cost-benefits analyses showing that the benefits outweigh the increase in cost, (2) proper and user-friendly communication with the broad public including, but not limited to the additional value offered by the approach, (3) a real opening for new market opportunities linked to the integration of the new data technologies in the assessment, creating business models for current and future stakeholders and (4) digitalisation of the services, eventually leading to an increased accessibility to information – in line with the development of digital building logbooks.

GLOSSARY

The following abbreviations are used in this report:

AT	Austria
BACS	Building Automation and Control Systems
BE	Belgium
ePANACEA	Smart European Energy Performance AssessmeNt And CErtificAtion
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
FI	Finland
DE	Germany
GR	Greece
MS	Member State
SME	Small and Medium Enterprise
SP	Spain
SRI	Smart Readiness Indicator
SRT	Smart Ready Technologies

1. INTRODUCTION

This ePANACEA report investigates and provides guidelines as to how relevant aspects of the Smart Readiness Indicator (SRI) could best be integrated within the available national Energy Performance Certificate (EPC) schemes in the ePANACEA countries (see Table 1 below).

Since the launching of Directive 2010/31/EU, the EPC scheme has become the main reference on building energy performance across a large number of MSs. Nevertheless, EPCs also raise concerns about the quality and reliability of the data collected and the inferences made about final energy consumption (Sunikka-blank, Galvin, Sunikka-blank, & Galvin, 2012). Research shows that, in many EU countries, there often are differences between the theoretical energy consumption reported in the EPC and the real energy consumption (the so-called "*energy performance gap*") (Hårsman, Daghbashyan, & Chaudhary, 2016; Herrando et al., 2016; Majcen, Itard, & Visscher, 2013). In addition, the implementation of EPC schemes faces important challenges of acceptance and market-uptake across the different MSs (BPIE, 2014).

The SRI is conceived as a new, common European assessment scheme to evaluate the readiness of a building to provide services to building occupants, the smart operation and maintenance of the building, and its interaction with the grid. The use of data technologies assessed in the SRI can accelerate building renovation rates, strengthen the energy performance of new buildings, and make them smarter. Ensuring data interoperability and transparency, using metering data, smart building management systems or increasing the compliance with other data standards are described as potential ways to accomplish this (Pasichnyi, Wallin, Levihn, Shahrokni, & Kordas, 2019). The SRI can be implemented as a standalone instrument, but many of its characteristics make it highly complementary to the EPC, providing added value and enlarging its scope.

While a combined EPC-SRI approach could contribute to an increase in the use of EPCs and improve their accuracy, it also presents many practical challenges such as a potential increase of the assessment costs or the need for additional training for the assessors.

The purpose of the present report is to explore and identify benefits and challenges of the combined approach.

The report is organised as follows: Chapter 1 provides the context and state of the art regarding EPC and SRI schemes, describing their basic methodology. Chapter 2 presents possible synergies between the two schemes, from both a technical and an economical point of view. In addition, the additional market value that the combined assessment could generate is evaluated in the last section of the chapter. Chapter 3 gives an overview of opportunities and challenges of a combined EPC-SRI assessment. Finally, Chapter 4 is a summary providing final policy recommendations.

Country	EPC data		Geographical Area
	Residential	Non-residential	
Austria	✓	✓	Central Europe
Belgium	✓	✓	Western Europe
Finland	✓	✓	Northern Europe
Germany	✓	✓	Central Europe
Greece	✓	✓	East-Southern Europe
Spain	✓	✓	West-Southern Europe

Table 1: *List of ePANACEA countries.*

2. CONTEXT

2.1 State of the art of EPC schemes

The EPC indicates the energy efficiency of a building, taking into account the building envelope and building installations. The energy performance label or energy score (with label categories differing per country) is used to give insights into the energy performance of the building.

An important benefit of the EPC is that it can be used as a tool to raise public awareness about the need to make buildings more energy efficient. Apart from informing consumers, EPCs can influence the building's property value (Heijmans & Loncour, 2017).

The EPC can also be useful to map the energy performance of the building stock and give insights into the effectiveness of building policies, and can therefore function as a tool to support the transition towards low-energy buildings. (Arcipowska, Anagnostopoulos, Mariottini, & Kunkel, 2014)

As stated in the BPIE report on energy performance certificates across the EU (Arcipowska, Anagnostopoulos, Mariottini, & Kunkel, 2014), it is important that the implemented EPC schemes should be supported by well-functioning management, control and monitoring mechanisms in order to achieve these benefits. The remaining of this chapter dives deeper into the challenges experienced with the EPC schemes within different MSs.

In order to understand the opportunities of integrating the SRI into existing EPC schemes, it is necessary to first get some insights into the state-of-the-art of EPC schemes in the different countries within the ePANACEA project. To capture these insights, the project partners have been asked to fill out a form (see Annex I) that includes questions about their national EPC schemes on the following topics which are further discussed within this chapter:

- ✓ 2.1.1 Impact on building users - recommendations
- ✓ 2.1.2 Impact on the national economy
- ✓ 2.1.3 Readiness for digitalisation
- ✓ 2.1.4 Readiness for smart data and ICT technology

2.1.1 Impact on building users - recommendations

The EPC schemes within the examined countries (Austria, Belgium, Finland, Germany, Greece and Spain) include recommendations to improve **energy efficiency**. These recommendations can be generic, although in some countries (e.g., Finland) they are entirely up to the EPC expert.

In most countries (Austria, Belgium, Finland, Germany), there are common public guidelines available. While relevant communication in some countries is **user friendly**, in others it is for the average citizen not easy to understand. Experts from Spain and Greece indicated that there is room for improvement in their countries. In Austria, e.g., the guidelines are technical documents, and are mainly intended for specialists. In Germany on the other hand, the consumer association provides additional explanation for building occupants to understand and interpret the EPC results. A country expert pointed out that the presentation of results in the EPC itself is not entirely user-friendly as end users often do not understand the unit kWh and cannot relate the energy indicators to their everyday life. This was also one of the findings from the stakeholder interviews executed as part of the investigation of users' perception of EPC schemes, earlier conducted as part of the ePANACEA project. Also in Finland, there is a user-friendly website and material publicly available.

On the other hand, most EPC schemes do not explicitly include guidelines on **user comfort** (Austria, Belgium, Germany, Greece, Spain) or **grid connectivity** (Austria, Belgium Germany, Greece, Spain). However, the recommendations on energy efficiency in some cases indirectly address user comfort. In some countries (e.g., Finland), recommendations for operation and use of the building that do not affect the indicator are optional for the EPC assessor to add.

2.1.2 Impact on the national economy

To gather insights on the impact of EPC schemes on the national economy, proven benefits of EPCs on residential and non-residential buildings' value were evaluated regarding:

- ✓ Selling price and final market value
- ✓ Renting price
- ✓ Market trust
- ✓ Environmental impact.

To capture these insights, a country expert from each of the project countries was asked to fill out a questionnaire on their national EPC schemes. This approach allows for country specific insights that go beyond theoretical information as the experts combine their expertise on EPCs with a broader view on other aspects of importance, such as national policies and user perspective. The limitation of this approach however is that the conclusions for a specific country are based on the expert opinion of an individual, not on the collective conclusions of an extensive expert panel. This being said, the country experts are well positioned to provide valuable insights on the current state of the EPC within their country.

In Greece, the EPC is likely to have an impact on both the selling and renting price. Also in Belgium, the EPC score is reported to have an impact on the selling price (Sven Damen, 2019). In Spain, there is a limited impact of the EPC on market trust and the environment, however the amount of deep renovations seems to increase. Still, in most countries (i.e., Finland, Germany), the EPC has little or no proven impact on any of the above factors. This is also the case for Germany where:

- The standardised determination of the market value is not influenced by the EPC (Hofer, 2011); the EPC is a policy tool that does not allow to make holistic statements about the profitability of real estate. Especially, where it concerns the consumption-based EPC, influence on the market value can be excluded as the energy assessment is dependent on the user behavior (Hofer, 2011). The EPC will only have an impact on the market value if buyers or tenants are provided with alternative offers and there is possibility to choose comparable equipment and location (Hofer, 2011; cf. stakeholder interviews). Nevertheless, a recent German market study has suggested that publication of the EPC calculation results during the selling process delivers a selling price decrease of up to 12 % for buildings with a bad performance[1].
- The above also explains why EPCs play a minor role during the decision-making when renting a dwelling/building (cf. stakeholder interviews).
- The EPC is focused on *past* performance, which is found to be a major reason for the lack of trust the market has in the EPC.
- The EPC does not have a proven environmental impact. Public awareness of the EPC in Germany is low and the EPC is most of the times used (only) in order to comply with legal requirements. The EPC thus plays a minor role in affecting purchasing decisions (Amecke, 2012).

2.1.3 Readiness for digitalisation

The readiness for digitalisation of the EPC schemes within the different ePANACEA countries will impact how easily the SRI can be added to the EPC; a good readiness for digitalisation makes the integration of the SRI into the national EPC scheme easier. To avoid confusion, it is important to note that the SRI provides information on digital technologies available in the building (further explained in section 2.2); in contrast, a digital EPC means the EPC is uploaded and/or accessible online. In

[1] https://www.welt.de/finanzen/immobilien/article166472789/Beim-Energieausweis-sind-die-Ehrlichen-die-Dummen.html

case of the latter, the readiness for digitalisation is to be understood as whether the national EPC can be consulted online (by different stakeholders), whereas the readiness in the Smart Readiness Indicator refers to the capability of the building to adapt its operations to the needs of the occupant while in parallel optimising building energy efficiency and overall performance, and to adapt its operation in reaction to signals from the grid (energy flexibility)[2]. Table 2 shows an overview of the readiness for digitalisation of the EPC schemes.

	Online accessibility	Entity to upload EPC data	Reporting/ managing entity	Reporting system	Data protection
Austria	Only in some regions	Energy agency or EPC assessor		Online registry	(data not publicly available)
Belgium	Only in some regions (see *Woningpass)*	EPC assessor or 3rd party actors	Data accessible for authorised experts	Online registry	GDPR
Finland	First two pages of the EPC	EPC assessor	ARA	Online registry	GDPR + No data is public for buildings with only one or two apartments
Germany	No	EPC assessor (only general data[3])	(data not publicly available)	(data not publicly available)	(data not publicly available)
Greece	No	Energy auditor	Departments of Energy Inspection of the Directorate General of Audits and Inspections – Ministry of Environment and Energy	Annual EPC reports	(data not publicly available)
Spain	Only in some regions	Regional authorities	Certifying technician/owner of building	Published on the website of the regional government in some regions	GDPR

Table 2: *Readiness for digitalisation of the EPC in ePANACEA countries.*

2.1.4 Readiness for smart data and ICT technology

To evaluate the readiness of the ePANACEA countries to integrate information generated by new data technologies into their current EPC, we considered the **qualitative input** provided by ePANACEA partners/ experts on the EPC-SRI synergy, interoperability, use of international standards, updated data and the energy gap. It should be noted that this is an expert individual opinion, not an official position of a country.

AUSTRIA

- **EPC-SRI synergy:** As the Austrian EPC does not consider energy consumption, but only energy demand, there is little interest in the added value coming out of new smart technologies.
- **Interoperability:** the Austrian EPC is an independent scheme and no attempt has been made so far to link it to other buildings schemes.

[2] smartreadinessindicator.eu

[3] *name and address of the EPC assessor, federal state and postal zip code of the building, type of EPC and building, date of issuance, new construction or existing building*

- **Use of international standards:** the EPC assessment relies primarily on national guidelines, the so-called "*OIB Richtlinie 6*"[4].
- **Updated data:** Once a building is assessed and the EPC calculated, there are no updates foreseen until a whole new evaluation is performed. Therefore, including some dynamic information as assessed by the SRI would require technical adjustments to the current scheme.
- **Energy gap:** The purpose of the EPC in Austria is of a mere asset rating. As energy consumption is neither considered nor predicted, there is no need to adjust the methodology.

BELGIUM:

- **EPC-SRI synergy:** With EPC schemes gaining popularity as building quality references during the last years, some inherent limitations of the methodology are being identified: the energy gap, the lack of a tailored renovation roadmap or the absence of new smart services in the calculation (batteries, grid integration, etc.) are some of the identified limitations. Integrating information from the SRI scheme represents a good opportunity to tackle these problems.
- **Interoperability:** There is an ongoing attempt to link information from the EPC with other external databases and resources (the "*Woningpas*", i.e., "building passport"). This initiative also includes legal requirements such as the authorisations to third party actors to use and/or update this information.
- **Use of international standards:** the Belgian EPC is based on ISO and CEN standards, both compatible with the SRI.
- **Updated data:** There is no automatic update of EPC data to date; see Woningpass above.
- **Energy gap:** If well-defined and integrated, data fields considered in the SRI, including feedback on building performance or calibrated methods, can help to minimise the energy gap.

FINLAND:

- **EPC-SRI synergy:** With the current regulations, the Finnish EPC is merely designed to compare static building features while operation and maintenance services are excluded. Some of the information assessed by the SRI could be included in the EPC assessment as improved system efficiencies, but the effect would be minor.
- **Interoperability:** Although not included in the regulations, building owners are encouraged to order the EPC together with other inspections, e.g., with building audits or condition inspections. Costs for the on-site assessment would be divided into multiple purposes and the results will end up being more accurate. There is then room for a potentially coordinated EPC-SRI assessment.
- **Use of international standards:** The Finnish EPC assessment procedure does not by default consider international standards. There are several reasons for this. First of all, the regulation should be available in national languages and free-of-charge, which is not the case for the standards. In addition, in certain cases, Finnish regulations require the use of approaches more sophisticated than these standards (e.g., commercial simulators used to calculate dynamic simulation for buildings with cooling systems), and using the standards would represent a step backwards from a technical perspective.
- **Updated data:** There are currently no automatic updates of the EPC data.
  Energy gap: Following current legislation, the EPC assesses the energy performance of the building but does not take into account the impact of user behaviour on this assessment; this results in an energy gap. An energy gap is thus expected when the use of the building differs from the standard profiles. If the purpose of the EPC is changed or a new purpose that includes the use of the building is added, the SRI methodology could help in understanding the use of the building and how it is operated and managed.

[4] https://www.oib.or.at/de/oib-richtlinien/richtlinien/2019/oib-richtlinie-6

GERMANY:

- **EPC-SRI synergy :** the <u>EPC assessment would benefit from the integration of smart technologies but a proper linkage is required.</u> Considering smart aspects in the building evaluation, e.g., smart grid integration, smart electricity metering or building management systems (BMS), can certainly help to improve energy consumption estimations and the overall services of the building.
- **Interoperability:** the presence of a unique building information reference is essential in Germany to ensure data gathering and exchange between different sources. The connection or even replacement of the current EPC scheme with the so-called "individueller Sanierungsfahrplan" (iSFP) - (individual renovation roadmap) is under debate. The reason behind this is that it provides more information about energy efficiency measures.
- **Use of international standards:** the German EPC and SRI rely in many cases on the same international ISO/CEN standards. For instance, the heat-transferring area A of a residential building in m² is to be determined according to Annex B of DIN EN ISO 13789: 1999-10, case "external dimensions."
- **Updated data:** There is no updated data taken into account for the assessment procedure. The EPC is valid for 10 years and within this period the energy rating is static. The assessment procedure could profit from it in the sense that accuracy could be improved (e.g., if updated conversion factors were taken into account).
- **Energy gap:** Smart data in general offers higher data resolution, making the energy assessment more accurate. In theory, it is possible to remove the effect of the occupants and produce metrics that specifically and accurately represent the thermal performance of the building and/or its heating system. In this line, information coming from the SRI could help to close the gap between the real and the theoretical energy consumption, by making the energy assessment more accurate (e.g., if smart building technologies would take over part of the user behaviour in the building (e.g., set of thermostat, ventilation, etc.), the "behaviour" would be more predictive which could be more correctly assumed in the energy assessment.

GREECE:

- **EPC-SRI synergy:** The current EPC assessment procedure must be updated to benefit from the inclusion of the fields assessed by the SRI. In its current state, the EPC assessment is unable to use more accurate information or to include new.
- **Interoperability:** the Greek EPC is connected to the "*building properties database*" which might facilitate the integration of new information and its eventual updating. The existence of this central database could be considered as a facilitator for a common EPC-SRI assessment.
- **Use of international standards:** International standards are considered for both the Greek EPC and SRI schemes.
- **Updated data:** Although EPC data is not updated in a regular manner, the existence of common databases might facilitate this in a near future. This can also favour the consideration of some of the data fields assessed by the SRI.
- **Energy gap:** Integrating the use of more accurate (as potentially brought by the SRI) data sources during the EPC assessment could help to better understand the reasons behind the energy gap and eventually reducing it.

SPAIN:

- **EPC-SRI synergy:** the SRI might act as a facilitator to identify smart technology opportunities but not as a direct source of data. The reason is that current EPC schemes use tabulated values (e.g., temperatures) for demand and consumption calculations and therefore, the consideration of technical facility details provided by the SRI will not be used. Nevertheless, the consideration of new elements accounted in the SRI, such as storage capacity or smart grid integration, could be an asset if well integrated.
- **Interoperability:** Potential linkages with other schemes and sources of data are currently being investigated in the country.
- **Use of international standards:** The Spanish EPC scheme is based on ISO/CEN international standards whenever possible.

- **Updated data:** As of today, the evaluation is carried out with the information available to the technician at the time of performing the EPC. Including data systems that facilitate the gathering of this information could be simplified and make future EPC measurements more accurate.
- **Energy gap:** Home automation and monitoring systems having an impact on the energy consumption would surely contribute to reducing the gap between predicted and real energy use.

Main insights

To identify the main barriers for successful implementation of the EPC in the respective countries, a workshop was organised with the project partners. Societal acceptance was identified as one of the most important barriers. In Finland, this is mainly due to the high cost of the EPC assessment, although not the sole reason. In fact, even the cheap EPC in Finland does not have wide public support at the moment. The EPC assessment costs are further discussed in chapter 3.1.

Another important barrier is the assessment accuracy. In some countries (e.g., Greece), the accuracy found during energy performance checks is not as expected.

Political support on the other hand is in most countries not a barrier; most parties agree on the need for the EPC.

EPC recommendations for building users are limited to energy efficiency of the building. There is room for improvement concerning recommendations on user comfort and grid connectivity. Linking the SRI to the EPC can add value in this respect. This is further elaborated in the next chapter.

The impact of the EPC on the national economy is limited in most countries. Whether the SRI can improve this, is also discussed in the following chapter. In general, the readiness for digitalisation/smart data and ICT technology is limited, as the EPC is not, or only in some regions, accessible online.

2.2 SRI definition and scope of implementation

A greater uptake of smart technologies is expected to lead to energy savings in a cost-effective way, while also helping to improve indoor comfort and health in a manner that enables the building to adjust to the needs of the user. The smartness of a building is its “capacity to use information and communication technologies and electronic systems to better suit the needs of occupants and the grid, improving energy efficiency and overall building performance” (VITO & WSEE, 2020). Smart buildings have been identified as enablers of future energy systems since they favour the inclusion of renewable local energy sources, storage systems, distributed supply and demand-side energy flexibility.

One of the main highlights of Directive (EU) 2018/844 (EPBD) is to promote the potential of Smart Ready Technologies (SRT) to enhance existing building services and offer new ones. The “*Smart Readiness Indicator*” (SRI) is a voluntary European scheme for rating the technological readiness of a building to make use of smart technology.

The SRI aims at making the added value of building smartness more tangible for building users, owners, tenants and smart service providers. The SRI should promote the value of building automation and electronic monitoring of the technical building systems while ensuring cybersecurity and appropriate personal data management.

Hence, the SRI is intended to raise awareness about the benefits of smart buildings including energy efficiency and fault detection, user occupancy experience and grid flexibility (see Figure 1). In addition, its implementation is expected to stimulate investments in smart building technologies and support the uptake of technology innovation in the building sector.

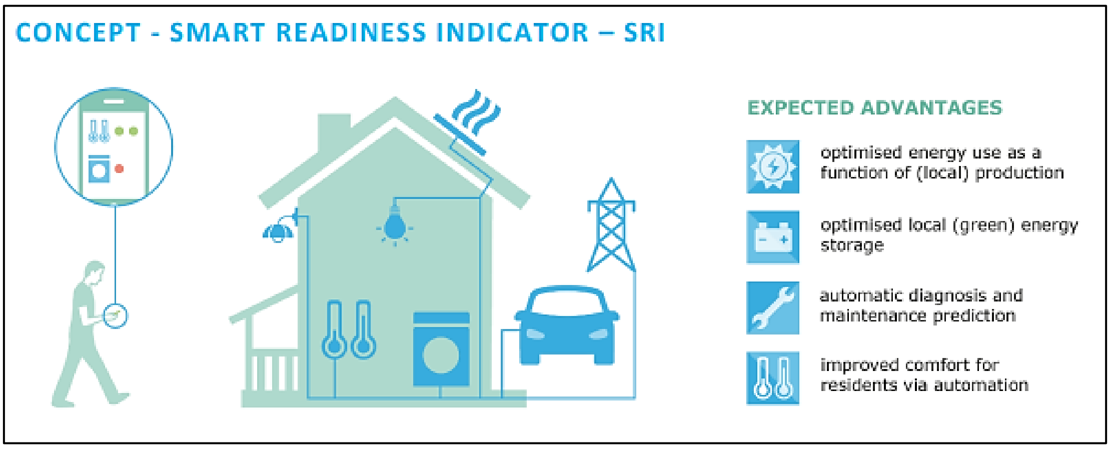

Figure 1: *Overview of Smart Readiness Indicator services. Source: Technical Support study on the Smart Readiness Indicator for Buildings.*

In contrast to other existing schemes, such as the EPC, the calculation for the SRI is intended to share a general methodological frame for all MSs implementing this optional common union assessment scheme. This framework is described in Commission Delegated Regulation (EU) 2020/2155 of 14 October 2020 supplementing Directive (EU) 2010/31/EU of the European Parliament and of the Council by establishing an optional common European Union scheme for rating the smart readiness of buildings[5]. The framework leaves room for flexibility for MSs in defining service catalogues, weighting factors, etc. Suggestions on a possible structure of such a catalogue can be found in the final report of the "Technical support studies on the establishment of the SRI" - https://smartreadinessindicator.eu/ (VITO & Waide, 2020)[6].

The SRI methodology is applicable to all types of buildings, including residential and non-residential as well as existing and new ones. It is conceived to be applicable to all buildings independent of size. Two parallel methodologies have been developed and tested so far to optimise SRI evaluation capabilities depending on the building targeted. These methodologies vary in the amount of information required and the skills needed by the assessor to perform the assessment. *Abbreviated method A* is composed by a simplified checklist that can be performed by the building assessor in a time window of less than one hour for simple residential buildings. The relative simplicity of Method A could potentially allow for self-assessment by building owners or facility managers. This makes the method ideal for assessing SRI levels in single- and multi-family dwellings and to some extent to small commercial and office buildings. *Extended method B* uses a more extensive service catalogue, including more detailed information about the building smartness components. It is particularly suited for larger and more complex private (residential, offices) and public (schools, hospitals, etc.) buildings.

The content of the SRI is strongly dependent on information and communication technologies. This fact makes it more, but not exclusively, relevant for new and renovated buildings. Some other models and initiatives which are instructive for the SRI's governance are, among others, the Ecolabelling scheme, and CEN/CENELEC standards.

Besides the above-mentioned delegated regulation, the Commission's Implementing Regulation (EU) 2020/2156 of 14 October 2020 detailing the technical modalities for the effective implementation of an optional common Union scheme for rating the

[5] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32020R2155&qid=1613991300428

[6] https://op.europa.eu/en/publication-detail/-/publication/f9e6d89d-fbb1-11ea-b44f-01aa75ed71a1/language-en?WT.mc_id=Searchresult&WT.ria_c=37085&WT.ria_f=3608&WT.ria_ev=search.

smart readiness of buildings (Text with EEA relevance) C/2020/6929[7] defines implementation pathways. Both SRI acts have been published on 21 December 2020 and entered into force on 10 January 2021.

The following sections will explore different technical, economical and additional market value generated by the combination of EPC and SRI schemes.

[7] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32020R2156&qid=1613991300428

3. EXPLORING SYNERGIES BETWEEN NATIONAL EPC AND SRI SCHEMES

This section explores challenges associated to a potential synergy between EPC and SRI schemes, based on a review of the technical feasibility, economic viability and additional market value of linking the two schemes.

Towards this aim, three collaborative exercises were conducted together with partners. First, the ePANACEA expert partners were asked to fill out a list with EPC input values for their respective country, as well as some economic parameters, e.g., cost of the EPC assessment and EPC training. The data was then compared with the SRI input data fields. The methodology and results are further discussed in 3.1 and 3.2. Second, a workshop was organised to collect insights from the project partners on the main challenges for a successful implementation of EPCs as well as the opportunities of linking the SRI to the EPC on different levels. Finally, the project partners were asked to fill out a form, including qualitative questions, in order to dive deeper into these topics. The results of this exercise are explained in 3.1 and 3.3 (Annex I).

3.1 Technical feasibility: Insights from an explorative approach on common data fields

3.1.1 Evaluating data similarities by means of the Jaccard distance

Coordinating the assessment of the EPC and the SRI requires a good understanding of which data fields are common between that the two schemes. It can be assumed that some of the necessary input data is the same or comes from the same source. To explore this possibility, we conducted an exercise to quantify the tangible synergies between the SRI and the EPC in the ePANACEA countries. In a first step, a list of data fields was used (building further upon a form created within the Horizon 2020 project X-tendo, https://x-tendo.eu), to quantify the inputs required to assess the schemes. All inputs were organised in the following categories:

- General building information, e.g., climate region, address, terrain type, etc.
- Building Envelope, e.g., roof insulation thickness, windows orientation, etc.
- Building Systems, e.g., heating, lighting, ventilation, etc.
- Functionalities & Information to occupants, e.g., reporting information regarding local electricity generation, monitoring and control, etc.
- Storage & Connectivity, e.g., thermal energy storage and shifting of thermal energy, etc.

For each ePANACEA country, two EPC methodologies were considered, one for residential and one for non-residential buildings (see **¡Error! No se encuentra el origen de la referencia.** in chapter **¡Error! No se encuentra el origen de la referencia.**).

EPC experts from the ePANACEA contributing partner organisations completed, for their respective country, fields indicating whether the input field was required (1) or not (0) for the EPC assessment (see in *Annex I* an overview of this Input sheet by country). The same exercise was repeated for the test version of the SRI assessment method delivered by the SRI technical support studies (Abbreviated Method A; -VITO & WSEE, 2020).

To evaluate data synergies between the fields required for the EPC and the SRI (method A) assessments, the Jaccard distance was computed (see Figure 2 below), i.e., a statistic indicator that identifies the differences between two datasets (Virtanen, P., Gommers, R., Oliphant, T. E., Haberland, M., Reddy, T., Cournapeau, 2020). This choice was made to avoid computing the empty fields as similar (i.e., data fields not included, and thus with value 0). The Jaccard distance is complementary to the Jaccard index and is calculated as follows:

$$\text{Jaccard similarity} = \frac{|y_i \cap \hat{y}_i|}{|y_i| + |\hat{y}_i| - |y_i \cap \hat{y}_i|} \qquad \text{Jaccard distance} = 1\text{- Jaccard similarity} = \frac{|y_i \cup \hat{y}_i| - |y_i \cap \hat{y}_i|}{|y_i \cup \hat{y}_i|}$$

Where y_i and $\hat{y}_i$ represent the datasets considered. Due to the inversion, the **closer the value is to 0, the more similar the two datasets are**. On the opposite, a value of 1 indicates that the datasets do not share any field/are completely different.

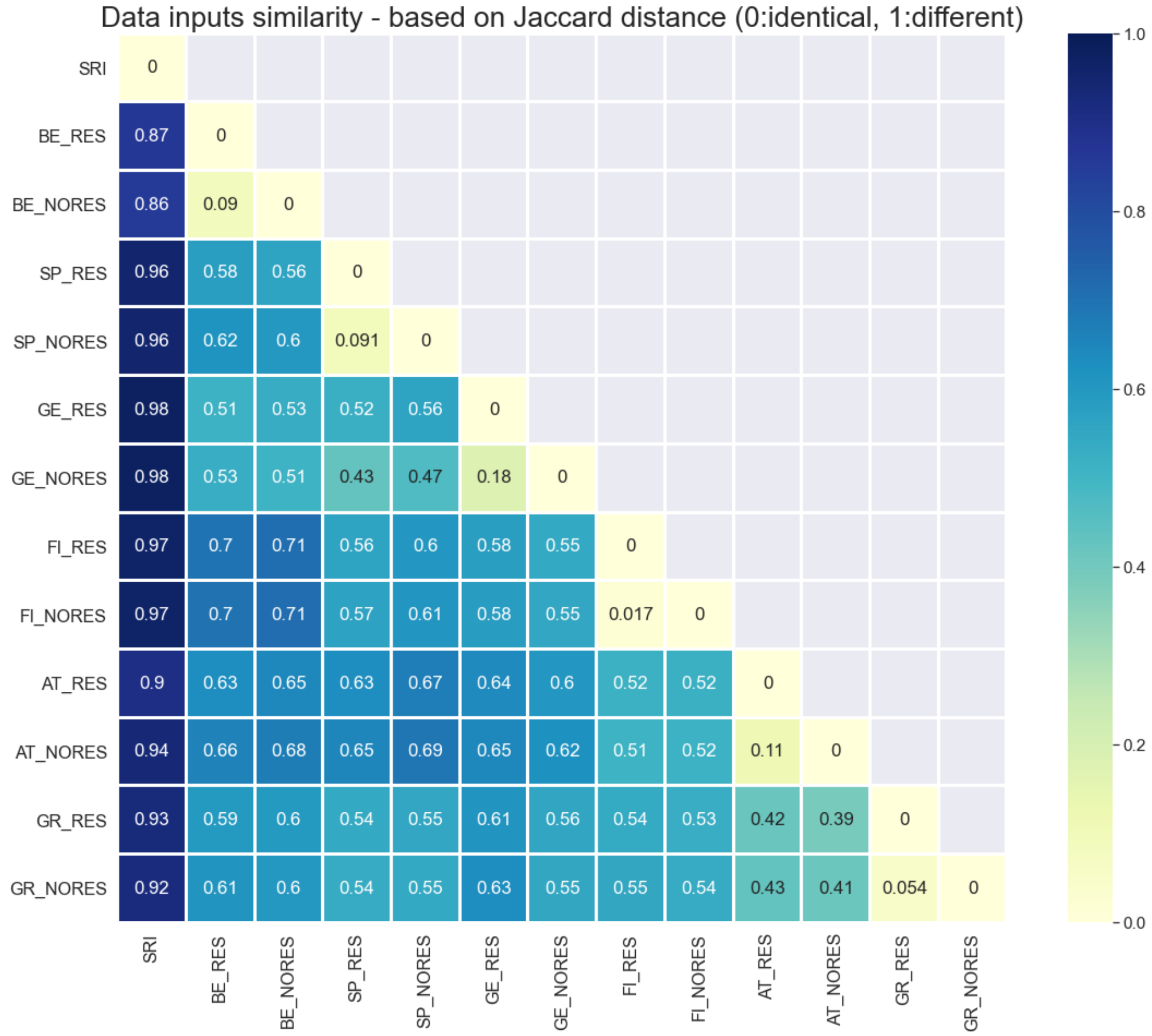

Figure 2: *Matrix of Jaccard Distances comparing countries' EPC and SRI data fields. Acronyms RES and NONRES stand respectively for Residential and Non-residential buildings. The value 0 indicates a perfect synergy of the fields required to assess the schemes across each combination.*

The main findings of this exercise are presented hereafter.

1. <u>There is a substantial degree of similarity between countries' EPC methodologies</u>

Overall, observed Jaccard distances suggest substantial similarities between the data required for the EPC assessment for residential (all averaged = 0.573) and non-residential buildings (all averaged = 0.572) across the ePANACEA countries. Nevertheless, results also disclose large variations between countries (with scores varying between 0.39 and 0.7). EPC methodologies in Austria and Greece shared a significant amount of common data fields due to similarities on building and technical building system inputs. On the contrary, Belgian and Finnish EPCs show larger divergences on EPC input data.

The similarities and differences can be interpreted in the context of Directive 2010/31/EU that describes some common points to create national EPC schemes while also leaving room for adaptation to country specific needs.

Results from the above exercise also show a high degree of similarity between residential and non-residential buildings across each country, showcasing that input data for the assessment of various types of buildings differentiate only slightly within one MS.

2. High complementarity between the SRI and the national EPC schemes

The analysis above, that is based on the Jaccard distance, shows very little synergies between the data included in the EPC assessment of the ePANACEA countries and the fields required to assess the SRI using Method A. Yet, some countries appear to be better positioned to integrate the SRI methodology into their current EPC scheme. This is the case for Belgium, for both residential and non-residential buildings, as well as for residential buildings in Austria. For Belgium, the synergies are explained by the consideration in the Belgian EPC of **technical building system information** concerning heat emissions control, generator control and ventilation systems. In some cases, this information is also **reported to the building occupants**, which increases the number of fields common with the SRI. The Austrian EPC also includes information about heat emissions and generator control.

This outcome shows that:

- A common EPC-SRI assessment needs the consideration of additional information that is currently not required for the EPC assessment.
- There is a good complementarity between the data fields required by both schemes.

When the information required differs, EPC and SRI data fields are obtained through the same building components. This means that acquiring the additional information to assess the SRI could be integrated in the EPC assessment in a time and cost-efficient manner. This is further elaborated on in section 3.2. Yet, the SRI cannot be calculated with the data stored from previous EPC assessments, as specific SRI information is normally not gathered during on-site EPC visits.

3.1.2 How can the SRI improve the quality and reliability of current EPC evaluation?

If well-coordinated with the EPC assessment, the SRI scheme might not only provide new information but also help improving the quality and reliability of current EPCs. The reason behind this is that, although the EPC and the SRI share very little common input fields, they require information on the same systems.

For instance, the presence of sun protection elements (shading), classified in the category *building envelope* > *window*, is part of the information already included in the EPC assessment of Austria, Belgium, Greece and Spain. This means that the assessor will require access during the on-site assessment to evaluate their presence and typology. Considering, during this step, the degree of automatisation of the shading will allow the SRI methodology to evaluate the dynamic envelop of the building as well. From an EPC perspective, having this information could significantly affect the thermal energy performance of the building, as dynamic shading can reduce overheating, space cooling demands and air conditioning use. The level of smartness of the envelope dynamics as assessed by the SRI can be integrated to the physical information reported in the EPC as a way to improve the accuracy of the energy use. Literature shows that the presence of dynamic shading systems can promote energy savings ranging from 11% to 29% when compared to a reference building (Konstantoglou & Tsangrassoulis, 2016). The SRI represents an opportunity to bring dynamic information to the EPC.

As data-driven services become more common in the built environment, the consideration of smart technologies in the EPC assessment becomes essential to avoid the scheme becoming obsolete. As stated in the example above, the integration of the SRI methodology within current EPC schemes contributes to closing this gap. Beyond contributing to improving existing fields, the SRI can introduce new domains of assessment to future EPC schemes, e.g., building storage capacity or grid balancing capabilities.

Table 3 provides an overview of some building systems whose accuracy could be improved through synergies of the EPC with the SRI methodology.

Table 3: *Example of building systems whose accuracy could be improved thanks to potential synergies of the EPC with the SRI scheme.*

Examples of service	Building systems category	How is the service considered in current EPCs	Added value from synergy with SRI
Smart thermostat	Control systems and/or smart controllers	Whereas the existence of heat emissions control devices is included in the EPC of some of the ePANACEA countries (Austria, Belgium, Greece), cooling emissions control is not considered or could be more accurate.	Including not only its presence but also its degree of automation (e.g., central automatic control, individual room control) would have direct impacts on energy savings on site and convenience.
Report information regarding building systems (e.g., cooling, heating, electricity, etc.)	Information to occupants	Only two countries consider the reporting of information to the occupants in their EPC. They do it in relation to local electricity generation (Austria and Belgium). The Belgian EPC also takes into account data inputs on heating, cooling, and domestic hot water systems.	Beyond the energy savings documented in a large number of studies (Karlin, Zinger, & Ford, 2015), reporting of performance of building systems can promote predictive management and fault detection.
Lighting system control for indoor occupancy	Lighting system	Only non-residential buildings in Belgium and Greece currently consider lighting system control in their EPC.	Smart lighting systems have proved to contribute to significant decreases in the final energy consumption while improving comfort and convenience of occupants (Al-Ghaili, Kasim, Al-Hada, Othman, & Saleh, 2020).
Generator control air flow control at the room level	Control systems and/or smart controllers	Air flow control for ventilation is considered for all building types in Belgium and for residential buildings in Greece.	Local demand control based on air quality sensors (CO_2, VOC) can improve comfort, convenience, as well as health and wellbeing. These types of systems are gaining popularity during the COVID-19 pandemic. In addition, automation of air exchange can lead to an optimisation of the air exchange that reduces the energy required to heat a room.

Main insights

A good degree of complementarity exists between EPC and SRI schemes. Beyond the addition of valuable content, the information required to assess the SRI can be used to improve the quality and reliability of current EPC schemes. Although certain differences were observed between the countries analysed, the findings are more or less applicable to all.

3.2 *Economic viability: Combined assessment*

Before looking into the economic viability of linking the SRI to the EPC, a cost analysis of the EPC was made.

3.2.1 EPC cost analysis

EPC assessment costs are not fixed and usually differ depending on the type and the size of the building and/or the type of the assessment. In Belgium, e.g., while costs for an EPC assessment start at 120 € for a simple terraced house, they can reach up to 250 € for a detached house. Also in Finland, prices vary: the EPC assessment for a new single-family house costs 200 €, while this is 300 € for an existing one. Other prices depend on size and complexity. In Germany, different types of EPC assessments are possible. The cost for a consumption-based EPC ranges from 50 up to 100 €, while the price for a more complete assessment ranges between 300 and 500 €. The large variability of prices observed aligns well with the findings of other studies addressing the issue in detail (BPIE, 2014).

Also, regarding EPC training costs, the differences between countries are significant. This is mainly due to the fact that not all countries require EPC assessors to follow a training. While training is mandatory in Belgium and Germany, with training costs reaching 2.000 € and higher, training is not mandatory in Finland, Spain and Greece. In Austria, people working in specific crafts, e.g., builders, chimney sweepers, etc., are allowed to issue EPCs, but specialised training is not required. In contrast, educational offers, which range from 300 to 3.000 € (incl. VAT) exist for learning how to use the EPC programmes, tools, etc.

3.2.2 SRI/combined assessment cost analysis

One way to look at the economic viability of a combined EPC-SRI assessment is to consider the cost avoided due to the combination of the SRI with the EPC. These costs can be categorised into:

- **Training costs**
- **Assessment costs (dependent on the amount of time it takes the assessor to execute the assessment)**
- **Administration costs.**

These are further elaborated in more detail as follows:

Training costs

For countries that do not require their EPC assessors to follow a training (e.g., Greece), the relative cost that is saved by combining the schemes is 0% (training cost is already zero).

For countries that require the EPC assessors to follow a training, the relevant cost reduction depends on the training cost, which on its turn depends on the complexity of the training and therefore on the complexity of the EPC.

Assuming that the training cost for each country depends on the time required to complete the training, and therefore, on the amount of knowledge that has to be taught, this knowledge can be divided into different input categories as shown in Table 4.

Table 4: *Input categories to organise the building data.*

Building	Envelope	Renewables
Administrative data	Door	PV or electricity generation
Comfort	External Wall	Solar thermal
Energy performance indicator	Roof	
Geometry	Window	**Technical Building systems**
Recommendations	Floor against ground	Ventilation system

Technical Energy System		Cooling system
Indoor environmental quality	**Reporting functionalities**	Domestic Hot Water system
Outdoor conditions	Electricity	Heating system
	Monitoring and control	Appliances
Storage & connectivity	Envelope	Lighting system
Electric vehicle charging		
Thermal energy		

For both the SRI and the EPC assessment, basic knowledge on all these themes is needed. Some of the overlapping input parameters are easy to assess, while others are technically more complex and the assessor needs to master knowledge on the concerned systems. Although, as discussed in the previous section, the overlap between the SRI and the EPC input parameters is on itself limited, once the assessor has knowledge of the concerned system, adding new parameters to the training is not significantly difficult. Figure 3 shows on which of the above categories the assessor needs to provide inputs for the SRI and the residential EPC assessment in the different countries. The overlap in Austria, Belgium and Greece is significant. Combining training can therefore result in a considerable cost reduction.

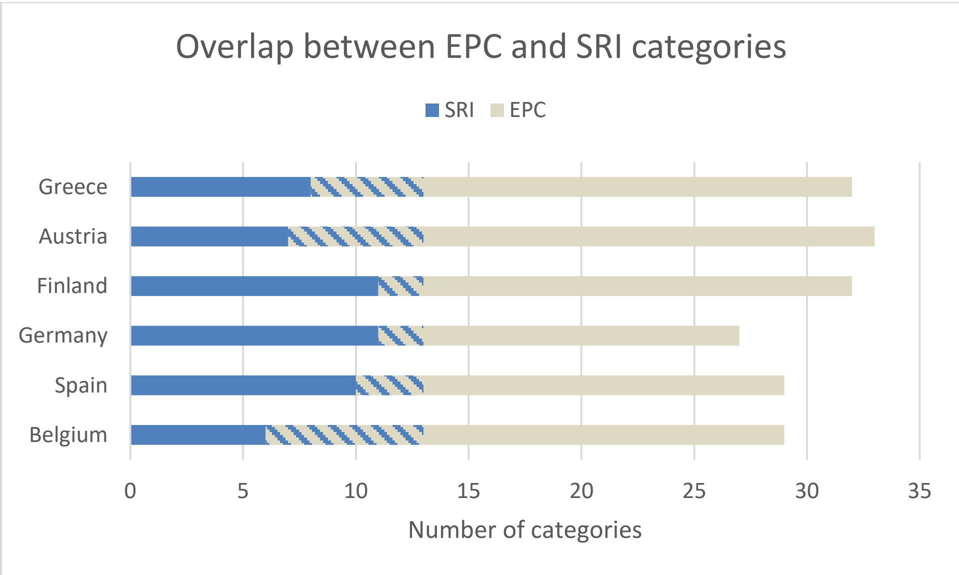

Figure 3: *EPC-SRI overlap of input categories as indicated by the dashed-bar.*

3.2.3 Assessment costs

The assessment costs depend on the amount of time the assessor needs to perform the assessment.

When using method A, the SRI assessment takes approx. 45-60 minutes per building. It is assumed that the additional cost that comes with adding the SRI to the EPC assessment depends on the additional amount of time needed to execute the SRI assessment. The graph in Figure 4 shows the additional time required for the different countries compared to the residential EPC assessment. The assessment time is estimated for each of the inputs, based on earlier research (BPIE, 2014). The additional cost depends on the assessment cost of the EPC. For example, in Belgium, an EPC assessment for a residential building takes 3-8 hours. For a simple terraced house, the EPC assessment costs 120-160 €, and is assumed to take 3-4 hours, depending on the building size and on the information (e.g., plans) available to the assessor. This includes transport, administration and overhead (invoicing, marketing, etc). The actual hourly rate of on-site inspection will therefore be lower.

- ✓ Travel costs: Assuming a travel distance of 22,9 km for a single ride, which is the average distance travelled to the work location in Flanders (Jobat, 2020), at a cost 0,35 €/km, the total travel cost will be 16 €. A single ride takes on average 41 minutes (Jobat, 2020). This travel time is included in the total assessment time.

- ✓ Administration: Whether a combined EPC-SRI scheme can reduce the administration time for the assessor depends on several aspects that are yet unknown, e.g., whether a combined platform is used. Administration costs are estimated to be low (5-10%) compared to the total cost, and therefore will not have a great influence on the cost of adding the SRI to an EPC scheme, as also discussed in section 3.2.4. For the sake of simplicity, it is assumed that the administration cost is included in the hourly rate.

- ✓ Overhead costs: About 25% of the remaining costs are overhead. This overhead is also to be taken into account for an SRI assessment, and therefore included in the assessor's hourly rate.

Deducting the travel costs from the EPC assessment costs results in a rate of around 35 €/h (including 21% of taxes). Adding the SRI, which would take an additional 35 minutes, would therefore cost 20,5 €, resulting in a total assessment cost of 140-180 €.

In Greece, the EPC assessment is estimated to take about 6 hours for a 100 m² residential building and would cost 150 €, excluding administration costs in the range of 10 €. Assuming a travel distance of 12,6 km for a single ride, which is the average distance travelled to work in Greece (*Numbeo*, 2021), at a cost 0,24 €/km, results in a total travel cost of 6,3 €. Therefore, the hourly rate results in 24 €/h. The additional 50 minutes to include the SRI results in a cost of 20 €. The total cost is therefore estimated at 170 €.

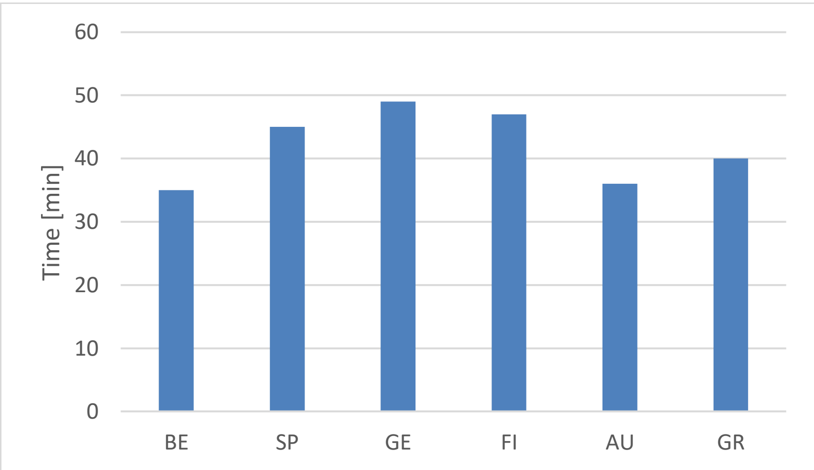

Figure 4: *Additional assessment time when adding the SRI to the EPC.*

The largest potential for reduced assessment costs can be found in Austria and Belgium, while in Germany, Finland and Spain this is limited. It should be noted that the EPC schemes that show the highest overlap in number of inputs required for the assessment, are not necessarily the ones with the lowest additional cost for a combined EPC-SRI assessment, as some inputs take more time to assess than others. For Belgium, e.g., most of the overlapping inputs are 'whether information on systems is reported towards the user'. Hence the benefit of combining the SRI and the EPC assessments in terms of time is limited.

3.2.4 Administration costs

In some countries, the costs of issuing an EPC (i.e., registering the EPC to the EPC database) are charged separately. It can be assumed that when combining the EPC and the SRI assessment, the administration cost of the latter is avoided. Following this assumption, there is potential for reduction of the administration costs; the order of magnitude of this reduction is estimated at around 10-15 € per EPC depending on the administration entity.

For countries that do not charge additional administration costs, this fee is indirectly included in the EPC assessment price. In this case, a limited percentage (e.g., 6% in Greece, and less than 5% in Finland) of the total EPC assessment cost can be assumed to be saved.

Main insights

The EPC and SRI schemes are complementary rather than overlapping and thus a combined approach which integrates both within one assessment has limited impact on cost reduction, as could be expected.. Combining the EPC and the SRI can add value on a technical level as discussed in 3.1.

3.3 Generation of additional market value

A successful implementation of the SRI scheme relies on its capacity to bring additional value to the building assessment. While evidence tends to demonstrate that the EPC assessment is an effective mechanism to determine the theoretical energy performance of the building and to propose certain renovation recommendations, it also presents certain gaps and inaccuracies. The EPC barely considers the assessment of comfort and wellbeing, and completely lacks the consideration of data technologies such as fault detection, grid connectivity or storage. Based on the input provided by the ePANACEA experts, this section explores how a potential synergy between the EPC and the SRI could generate new market value assessed in terms of their "*impact on the national economy*", "*impact on the building users trust*", *"impact on renovation rate and building energy efficiency", "methodological benefits" and "implementation".*

3.3.1 Impact on the national economy

Sub-section 2.1.2 presented the impact of the EPC schemes on the national economy. Here, the analysis is extended to the effects of a combined EPC-SRI scheme on the national economy. For this purpose, ePANACEA EPC experts were asked to evaluate the potential benefits that the addition of the SRI scheme might have in their countries in terms of building selling price, renting price and environmental impact.

Although the expert answers were limited by the fact that the SRI scheme is still under investigation, their answers proved to be already very "country-dependent".

Whereas in countries as Greece, linking the SRI to the EPC could strengthen the impact on both selling and renting prices, in others (e.g., Spain) there is no clear advantage on the building value expected. In certain cases, the capacity of the SRI to influence real estate prices will depend on its capacity to improve the final building performance (e.g., Germany). A good SRI rating score could add up to the EPC rating by increasing the final real estate value of the property. Another important aspect highlighted is that the capacity of the SRI scheme to provide comprehensive information might also have a positive impact on the buyers because there is no technical expertise expected from them to understand the building characteristics. In the case of Germany, it was even highlighted that this might substitute the age of the building as the principal price driver for both selling and renting prices. However, renting prices are above all, dependent on the supply and demand of the regional market.

The case of Austria is more particular as there exist strong differences between regions. Rather than on EPC price, the impact of the SRI is more likely to be observed in terms of the environmental impact (although the Austrian ePANACEA expert also mentioned the need to consider the impact of embodied energy -grey energy- and life cycle analysis of the building materials in a future EPC version). Besides, the aggregation of some of the SRI fields to current EPC schemes could also help in identifying the required renovation of the building. As stated by Surmeli-Anac & Hermelink, 2018, (Surmeli-Anac & Hermelink, 2018) and also identified in chapter 2.1, the lack of trust in the EPC scheme is mostly due to a lack of EPC accuracy. Where the EPC is much more focused on asset rating performance, the SRI takes into account smart control of energy assets, which can impact the accuracy and therefore the trust in the scheme. Overall, it is simpler to develop an accurate model of a smart building (automated control) rather than a stochastic model based on use behaviour. In this line, it might be expected that buildings with higher SRI scores allow for more accurate energy consumption models. Nevertheless, to fully benefit from these aspects, EPC building simulation models must be capable to consider automated control strategies and novel technologies (e.g., through dynamic simulation tools) that are currently not available in most of the countries.

All experts agreed that the SRI has significant potential to bring added value to the EPC by integrating the energy grid factor. The SRI can provide more information on the environmental impact as the integration and use of energy from renewable energy sources can be increased when taking into account the energy grid needs, which is something the current EPCs do not take into account (Surmeli-Anac & Hermelink, 2018).

3.3.2 Impact on users' trust

The current EPC scheme has overall a positive impact on the buildings' energy efficiency in most participating countries (i.e., Greece, Finland and Spain). Yet, some country experts report that this is not always as high as expected (e.g., Germany) or that it does not have a positive effect at all (e.g., Austria). As the SRI covers complementary to the EPC fields, most experts agreed that, if well communicated, the SRI could improve users' trust on the EPC scheme.

Most country experts acknowledge that proper and efficient EPC-SRI linkage would add useful information for the users, on different levels (e.g., grid connectivity, impact of smart controls on occupant comfort and well-being – which might have become more important during the Covid-19 pandemic). It is crucial however, that the information is presented in a user-friendly way, favouring a good understanding of the SRI concept and its advantages. SRI scores need to be easily shared with the general public.

Trust in the SRI scheme is important in order to acquire societal acceptance of the combined scheme and communication should be target specific; building occupants do not necessarily see added value in an overload of technical information while the same information might be valuable for building professionals.

3.3.3 Impact on the renovation rate and on building energy efficiency

The combination of the EPC and the SRI schemes is expected to improve the renovation rate in most countries as it could more easily expose building flaws and promote renovation. Nevertheless, as described above, better modelling techniques are needed to maximise these opportunities. De-risking of energy efficiency measures could be achieved, increasing the confidence in the profitability of energy efficiency measures (Surmeli-Anac & Hermelink, 2018). In this line, the Austrian expert pointed out an important advantage of the combined EPC-SRI approach. In particular, recommendations on energy efficiency measures are by default included in most current national EPC schemes (in line with ISO 52xxx), while the SRI suggests the inclusion of a catalogue on automatisation measures and their impact on energy efficiency. A combination of the two would suggest an interesting approach to the next generation of EPCs which promotes energy savings based on Building Automation and Control Systems (BACS).

Moreover, the SRI could complement the EPC in identifying the building's potential in maintaining the performance level (e.g., fault detection) and can raise awareness about advanced technologies for increased efficiency and flexibility beyond more traditional measures such as building insulation (Surmeli-Anac & Hermelink, 2018).

Two side notes are made here:

1. Increasing the renovation rate could also be done in other ways, e.g., through financing programmes.
2. It is not clear yet what this would look like in practice as the SRI has not been implemented yet.

The EPC expert from Spain predicted that linking the SRI to the EPC schemes will not affect the number of renovations but rather the type of renovation, including comfort and connectivity aspects to the actual renovations. This might result in more deep renovations.

3.3.4 Methodological benefits

As discussed in chapter 3.2, the cost of a combined scheme strongly depends on each country. The accuracy of a combined scheme can be higher and result in a better evaluation of the building (see section 3.1).

The combination of the EPC and SRI schemes would allow more reliable cost assumptions, considering the operation of the building and the savings after renovation (Surmeli-Anac & Hermelink, 2018).This would be the basis for a more reliable assessment of potential cost reductions. Also, buildings with a high SRI rating will have a higher probability to maintain energy savings because technical building systems monitor the functioning of installations (Märzinger & Österreicher, 2019; Surmeli-Anac & Hermelink, 2018).

The combined use of the two assessment schemes (EPC and SRI) has been cited among the best practice examples in providing the most accurate representation of actual energy performance (Märzinger & Österreicher, 2019; Surmeli-Anac & Hermelink, 2018; Vigna, Pernetti, Pernigotto, & Gasparella, 2020). One reason for this is that the uncertainty regarding user behaviour can be lessened through the use of smart technologies and the consideration of the SRI (technologies meet the needs of occupants and are more predictable than users). Yet, this will strongly depend on the calculation procedure used for the energy assessment. Moreover, smart technologies could help to determine the right timing for having a new EPC assessment carried out and its reliability, thus driving lifecycle energy performance (Sümeli & Hermelink, 2018).

3.3.5 Implementation

Country experts in Austria and Spain argue that a simplified SRI methodology should be incorporated into the EPC scheme. A more complex calculation should be used in more specific cases – for example, linking it with the building renovation roadmap, where more detailed information is required. Also, in these specific cases, the building owner might be willing to pay more for the assessment (e.g., non-residential sector).

It was also highlighted that the SRI scheme should first be introduced and approved separately to avoid disturbing the EPC scheme's functioning. This is especially the case where the existing EPC scheme has a good societal acceptance and works relatively well (e.g., Finland). If the SRI scheme is directly integrated into the EPC, without trust from the broad public, there is a risk that also the EPC will lose public acceptance. Introducing initiatives - such as subsidies - that incentivise building owners to take energy measures in order to improve the EPC label and SRI score, can help to achieve a successful implementation of an integrated EPC-SRI scheme.

4. IMPLEMENTATION OPPORTUNITIES AND CHALLENGES

As we have seen, implementing a combined EPC-SRI assessment presents notable opportunities but also some challenges. The following figure presents an overview of these aspects:

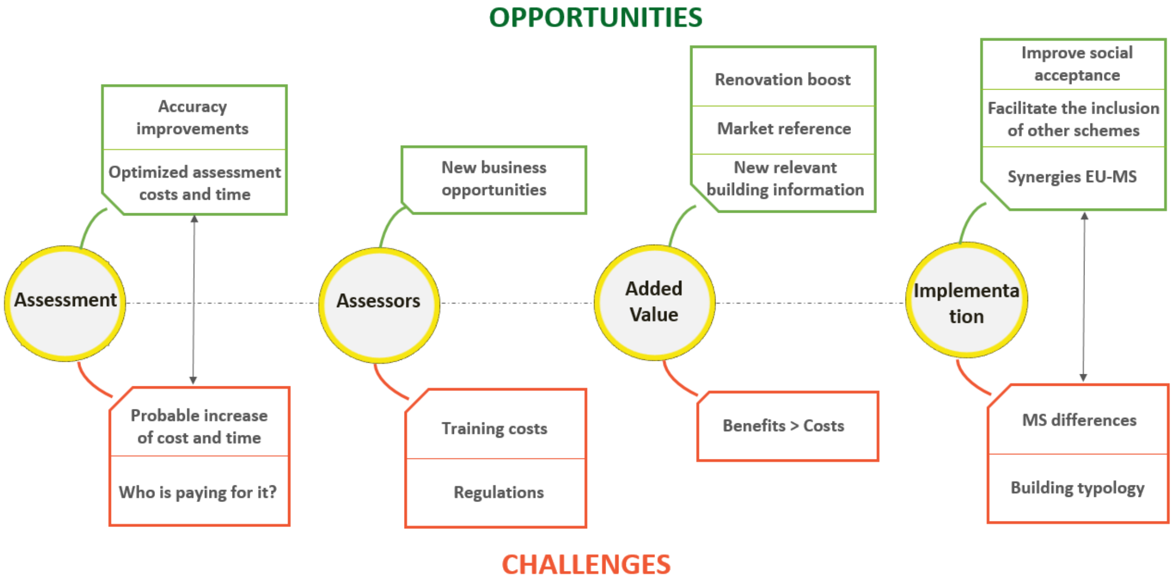

Figure 5: *Schematic view of the main Opportunities (green) and challenges (red) of integrating the SRI with the EPC scheme. Arrows indicate that some aspects can be considered in both categories.*

Opportunities

- **Accuracy improvements:** The presence of new information required to assess the SRI can be used to improve the technical calculations of the EPC (e.g., cooling emission control or monitoring systems for building occupancy). Nevertheless, its implementation requires the consideration of adequate energy assessment methods.
- **Optimised assessment costs and time:** Although strongly dependent on the MS context, the current analysis has shown a significant costs and duration reduction of the combined EPC-SRI assessment compared to the two individual schemes. Training requirements can also be expanded to allow assessors to perform one combined assessment, resulting in lower training costs.
- **New business opportunities:** The combined EPC-SRI approach could stimulate new business models, resulting in the creation of new companies or expanding of existing businesses (e.g., boost the installation of smart meters).
- **Renovation boost:** SRI information can help the end user to understand how the building works and what the impact of recommended renovation measures would be, indicate which buildings are more interesting for the execution of deep renovations and provide guidance regarding energy efficiency measures based on BACS.
- **Market reference:** Given the large impact of the building industry on the EU economy, adding SRI information to the current building assessment can promote the use and development of data technologies such as IoT, digital twins and cyber security.
- **New relevant building information:** As stated before, the SRI could complement the current EPC approach by adding important assessment information in relation to fault detection, occupant's comfort and health as well as grid and RES integration.
- **Improved social acceptance:** The SRI brings opportunities for social acceptance of the EPC but needs to properly highlight the information provided to the user, taking into account the complexity of the information as well as end-user aspects. A possibility could be to provide two different kinds of outputs: one for the general public and one for experts. User-friendliness is one of the main challenges, having a direct impact on the social acceptance of the EPC. Another barrier is the accuracy of the EPC. Often, the EPC does not represent the real energy use of the building. The SRI can

help to close this gap, which can improve societal acceptance. Adding the SRI provides additional information that might spark the interest of users.

- **Facilitate the inclusion of other schemes:** A combined EPC and SRI approach could pave the way for the future integration of other schemes and/or complementary information (especially when it is integrated in a common database, e.g., digital building logbook).
- **Synergies EU-MS:** In contrast to the EPC schemes implemented by each MS in a very specific manner, the SRI could bring wider implementation instructions, leading to increased synergies among MSs.

Challenges

- **Probable increase in terms of costs and time:** As stated before, the combined EPC-SRI results in a reduction in terms of cost and time when compared to independent assessments. Nevertheless, the high complementarity between the schemes observed in section 3.1 implies additional time to record new fields, when compared to the individual EPC assessment.
- **Financing of assessment costs:** Perhaps one of the major challenges is to determine who will be paying for the combined assessment cost. Is it the responsibility of the building occupants or of the public authorities? Similar questions have been affecting the EPC implementation during the past years and are MS-specific. This is food for further research.
- **Regulations:** As with the assessment costs, new challenges arise in relation to the existence of regulations and financial aid from public entities to support the implementation of the combined assessment.
- **Benefits > Costs:** The benefits of implementing the common assessment should exceed the costs of its evaluation. This aspect will directly affect the social acceptance of the combined scheme. As societal acceptance of the EPC is already low in most countries (see chapter 2.1), adding the SRI to it, might further decrease this societal acceptance.
- **MS differences:** While a common framework for MSs might have some benefits for the EU market, the large differences between MSs justify the use of flexible mechanisms capable of adjusting the schemes to their differences.
- **The existence of large divergences in relation to the different building typologies:** The large scope of building typologies (residential, non-residential, building size, etc.) are factors that need to be considered when implementing the combined approach. Non-residential large buildings are normally the ones requiring more detailed and longer assessments. Different methodologies must be considered in this regard.

5. GUIDELINES FOR MAXIMISING COMMON IMPLEMENTATION

The following table summarises the principal findings of the current analysis and provides recommendations for MS and European institutions to tackle them.

Table 5: *Guidelines to maximise the implementation of the combined EPC-SRI assessment.*

Key issue	Hypothesis investigated	Recommendation for a combined EPC-SRI assessment
EPC schemes fail to provide accurate estimations of the energy consumption (i.e., the energy gap)	The addition of the SRI fields could help improving the accuracy of the final energy consumption	The energy gap is mostly due to user's behaviour. The use of ICT technologies to record and report information as assessed in the SRI scheme could have a twofold impact: (1) optimise occupant's energy use and (2) improve the calculation method of current EPCs (e.g., smart thermostat).
		Recommended action: further studies are required to quantify this in real building settings: e.g., buildings having higher SRI scores should have a lower energy gap.
With the development of new ICT and data technologies, the information reported in the EPC can become obsolete	The new fields covered in the SRI represent an opportunity to complement the information assessed by current EPC schemes	The study results show good complementarity between the schemes. The addition of the SRI to the EPC can improve energy performance estimations and add new assessment dimensions on user comfort and grid connectivity.
		Recommended action: The combined EPC-SRI assessment is highly recommended from the perspective of added value.
The EPC scheme does not enjoy the same degree of recognition and acceptance across the different MSs	The combined EPC-SRI scheme could help improving trust in the EPC	Experts from countries where the EPC is well accepted (e.g., Finland) consider a link with another, not yet validated, scheme risky for the EPC. Paradoxically, experts from countries where the EPC is not largely used report the opposite, i.e., they expect the SRI to be negatively affected if linked to the existing EPC scheme.
		Recommended action: The SRI scheme should first be separately introduced and accepted to avoid disturbing the current EPC scheme.
Assessment costs of the combined approach would slightly increase the current EPC assessment costs	The final value of performing the combined assessment could increase the cost-efficiency of current EPC assessments	The addition of the SRI assessment would increase the EPC costs in a variable range across MS (17%-35%)[8].
		Recommended action: Specific cost-analysis needs to be performed in individual MSs.
General lack of understanding of the EPC by the general public	The combined EPC-SRI assessment can be a good opportunity to increase societal acceptance of the EPC	General acceptance of the schemes appears to be related to a good comprehension by citizens. Countries enjoying a good public acceptance of the EPC have dedicated institutions in charge of this matter (see Motiva in Finland[9] or the Danish Energy Agency extensions – Denmark specific case not included here).

[8] Calculated only for the countries having provided concrete EPC costs

[9] https://www.motiva.fi/ratkaisut/energiatodistusneuvonta/mika_on_energiatodistus

		Recommended action: The combined EPC-SRI assessment is a good opportunity to improve user-understanding of building performance. Nevertheless, this issue can also be addressed individually for the EPC only.
EU buildings' renovation rates do not reach the desired levels	The added value of the SRI assessment can promote the renovation of the building stock.	The presence of smart technologies derived from the SRI could be added to the EPC tailored-made recommendations to identify the best interventions to increase the portfolio of actions that optimise building energy use. The SRI will be a means to regulate and raise confidence in the benefits of automation and monitoring in buildings. Hence, the assessment can also act as a catalyser for smart service utility markets.
		Recommended action: The evidence gathered in this document identifies a positive role of the combined EPC-SRI assessment to accelerate the renovation of the EU building stock. It is however necessary that updated renovation recommendations include new technologies.
Lack of a common European frame for EPC assessments across MSs	The SRI can contribute to improving alignment of the current EPC frames across MSs	It appears that the first barrier regarding the integration of the SRI into the EPC is legislative. EPC schemes vary significantly across countries, based on country specific needs.
		Recommended action: Future technical studies should investigate this issue in detail. The present work captures arguments in both directions: to promote a more generalised EU approach and to leave room for MSs to decide which SRI aspects to implement.
The methodology of the SRI scheme is still under development	Addressing and including some of the issues raised in the present work and in recent publications would help to strengthen the SRI methodology prior to integrating it with the EPC.	The SRI should improve its accuracy – data-related (Vigna et al., 2020). Some evidence has reported room for improvements as some SRI fields might lead to subjective decisions and non-unique results by different assessors. Future SRI methodology updates should issue inspection guidelines to overcome such subjectivity.
		Recommended action: To cope with this limitation, detailed national guidelines, including a source hierarchy for the data collection and a comprehensive list of technologies with the relative functionality levels, is crucial for an effective implementation.
Digitalisation and ICT "momentum"	The SRI can act as a promotor of innovative smart building technologies	Potential linkages between the EPC and other schemes and data sources are currently being investigated in some countries. This represents a window of opportunity for the integration with some of the SRI aspects (e.g., digital building logbook initiatives). But readiness for digitalisation is not equal across MSs.
		Recommended action: It is a good "momentum" for the integration of the data perspective into the EPC; it is possible to integrate the SRI into new building assessments. Again, the issue should be addressed by considering the gaps in digitalisation between MSs.
In practice, the EPC principally considers static inputs while the SRI requires the integration of dynamic sources	The combined assessment could lead in an inclusion of new dynamic data that could be used to improve the accuracy of EPCs	Although EPC schemes differ across MSs, the EPC is generally calculated using static information acquired by the assessor during the on-site inspection. The addition of new data technologies assessed by the SRI is identified as a path to improve EPC accuracy and facilitate its update.
		Recommended action: Studies that investigate how the use of dynamic data can benefit future EPC schemes are recommended.
The novel character of the SRI together with the additional costs for implementation might	Public aid during the initial launching phases of the combined EPC-SRI approach can help to	The additional costs required to cover the assessment of both schemes might act as an implementation barrier. MS or EU subventions in the initial phases might be used to counter this potential problem until the combined assessment earn the

be a threat that can slow down its implementation	overcome this challenge	confidence of the market.
		Recommended action: Favourable MS-dependent regulation is advised during the initial phases of the SRI deployment.

Limitations

The present work represents a first attempt to explore the existent synergies between EPC and SRI methodologies and a way to identify the benefits and challenges of an integrated approach. Two main limitations must be acknowledged: first, data acquisition is based on information reported by a limited group of experts; second, the SRI methodology has not yet been implemented and the assumptions and guidelines suggested are primarily based on theoretical insights.

6. REFERENCES

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6.2. Table of tables

6.3. Other references

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ANNEX I: TEMPLATE OF THE FORM GATHERING SPECIFIC INFORMATION OF EPC ACROSS EPANACEA COUNTRIES.

This document was completed by an expert from each of the countries involved.

***

UNDERSTANDING THE LINKAGE OPPORTUNITY OF INTEGRATING SRI AND EPC SCHEMES

- Current impact of national EPC schemes

1. Impact on building users

The objective of this section is to understand whether the EPC outputs in your country impact building occupants.

1.1 Does your national EPC scheme include guidelines or tailored recommendations to improve:

(a) energy efficiency	
(b) user comfort	
(c) grid connectivity	

1.2 Are there common guidelines publicly available for the regular citizen to understand the EPC results? Is this presentation of results "*user-friendly*"?

1.3 Would the addition of the SRI to the EPC assessment add useful information to users?

2. Impact on national economy

The objective of this section is to evaluate the impact of the EPC scheme in your country on the local economy.

2.1 Are there proven benefits of the EPC scheme on residential and non-residential building value? If so, please, indicate upon which variables it has an impact and on what degree (indicate always sources).

		In your opinion, would the addition of SRI have a positive impact on them?
Selling price and final market value		
Renting price		
Market trust		
Environmental impact		
Others		

2.2 Can the combination of the EPC-SRI schemes improve the renovation rate in your country?

2.3 Are there any methodological improvements/benefits related to the combined EPC-SRI schemes such as reduced costs assessments or improved accuracy?

2.4 How should the combination of schemes be implemented in order to be successful?

- Future prospects

3. Readiness for digitalization

The objective of this section is to evaluate the degree of digitalization of the scheme in your country as well as its capability to be digitalized in a near future.

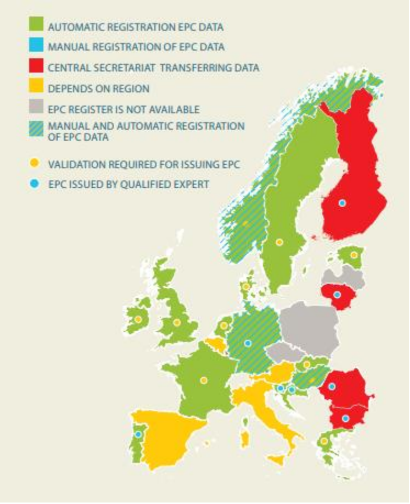
3.1 Is the current EPC accessible online?

3.2 Which entities are responsible to upload the EPC data?

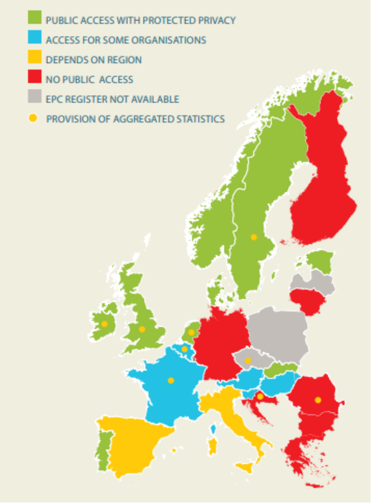
3.3 Who is in charge of reporting this information and how is this done (Which system is currently used for this, see below example)?

As an example, the following figures illustrate the situation in the year 2013.

UPLOAD OF EPC DATA (BPIE Survey 2013)



PUBLIC ACCESS (DOWNLOAD)TO EPC DATA (BPIE Survey 2013)



3.4 Are there any data protection and security strategies implemented/foreseen? If so, which ones?

4. Readiness for smart data and ICT technology

The objective of this section is to evaluate the readiness of your country EPC scheme to benefit from or integrate information generated by new data technologies.

4.1 Will the EPC assessment procedure in your country benefit from the use of smart data and ICT technologies?

From which types of smart data? (e.g. smart grid integration, EV grid balancing)

From which ICT technologies? (e.g. smart thermostat, distance control systems)

4.2 Do the national regulations in charge of the EPC assessment procedure in your country include ISO/CEN standards?

4.3 Do the national regulations in charge of the EPC assessment procedure in your country consider interoperability/connectivity with other existent schemes?

4.4 Does the assessment procedure currently benefit from the use of updated data? If not, could the procedure benefit from it?

4.5 To what level can the SRI be used to close the gap between the real and EPC predicted (theoretical) energy consumption?

Annex II: Input sheet EPC information by country

No.	Input data (Level 1)	Input data (Level 2)	EPC Input data (Level 3)	F1-SRI	BELGIUM (Flanders) RES	BELGIUM (Flanders) Non-RES	SPAIN RES	SPAIN Non-RES	GERMANY RES	GERMANY Non-RES	FINLAND RES	FINLAND Non-RES	AUSTRIA RES	AUSTRIA Non-RES	GREECE RES	GREECE Non-RES
1	Building	Administrative data	Address	0	1	1	1	1	1	1	1	1	1	1	1	1
2	Building	Administrative data	Building ID (cadatral identification)	0	1	1	1	1	1	1	1	1	1	1	1	1
3	Building	Comfort	Metabolic heat rate for activity level i	0	0	0	0	0	0	0	1	1	0	0	0	0
4	Building	indicator	Energy delivered for domestic hot water by energy carrier i	0	0	0	1	1	0	0	1	1	1	1	1	1
5	Building	indicator	Energy delivered for space heating by energy carrier i	0	0	0	1	1	0	0	1	1	1	1	1	1
6	Building	General data	Emission rates	0	0	0	1	1	0	0	0	0	0	0	0	0
7	Building	General data	Outdoor air quality index	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Building	General data	Type of the building/Function	1	1	1	1	1	1	1	1	1	1	1	1	1
9	Building	General data	Activity level profile per occupant	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Building	General data	Air tightness	0	1	1	0	0	1	1	1	1	1	1	1	1
11	Building	General data	Building gross heated volume	0	1	1	0	0	0	0	0	0	1	1	1	1
12	Building	General data	Building inertia	0	0	0	0	0	0	0	0	1	0	0	1	1
13	Building	General data	Climate data	0	0	0	0	0	1	1	1	1	1	1	1	1
14	Building	General data	Climate region	1	0	0	1	1	0	0	1	1	1	1	1	1
15	Building	General data	Construction type related to thermal capacity	0	1	1	1	1	1	1	0	0	1	1	1	1
16	Building	General data	Construction year	optional	1	1	1	1	1	1	1	1	1	1	1	1
17	Building	General data	Global solar radiation on horizontal plane	0	0	0	0	0	0	0	1	1	0	0	1	1
18	Building	General data	Heat degree days	0	0	0	0	0	0	0	0	0	1	1	1	1
19	Building	General data	Number of occupants	0	0	0	0	0	0	0	1	1	1	1	1	1
20	Building	General data	Outdoor air temperature	0	0	0	0	0	0	0	1	1	1	1	0	0
21	Building	General Data	Sea level	0	0	0	0	0	0	0	0	0	1	1	0	0
22	Building	General data	User profile	0	0	0	0	0	0	0	1	1	1	1	0	0
23	Building	General Data	Terrain type	0	0	0	0	0	0	0	0	0	0	0	0	0
24	Building	General Data	Conservatory present	0	0	0	0	0	0	0	0	0	0	0	0	0
25	Building	General data	Outdoor air pollutant concentration	0	0	0	0	0	0	0	0	0	0	0	0	0
26	Building	General data	Building state	optional	1	1	1	1	0	0	0	0	0	0	1	1
27	Building	Geometry	Net floor area	1	0	0	1	1	1	1	1	1	1	1	0	0
28	Building	Geometry	Building envelope area	0	0	0	1	optional	1	1	0	0	1	1	0	0
29	Building	Geometry	Building envelope area (heat loss area)	0	1	1	1	optional	0	0	1	1	1	1	0	0
30	Building	Geometry	Building orientation	0	1	1	0	0	1	1	1	1	1	1	0	0
31	Building	Geometry	Compactness (based on heat loss area)	0	0	0	0	0	0	0	0	0	1	1	0	0
32	Building	Geometry	Gross building area	0	1	1	0	0	1	1	0	0	1	1	1	1
33	Building	Geometry	Reference area	0	0	0	0	0	0	0	0	0	0	0	0	0
34	Building	quality	Indoor air temperature	0	0	0	0	0	0	0	1	1	1	1	1	1
35	Building	Recommendations	Measure (1 to n)	0	1	1	1	optional	1	1	1	1	1	1	1	1
36	Building	System	Space cooling service exists	0	1	1	1	1	1	1	1	1	1	1	1	1
37	Building	System	Space heating service exists	0	1	1	1	1	1	1	1	1	1	1	1	1

38	Building	Ventilation system	Fan power	0	0	0	1	1	0	0	1	1	1	1	0	0
39	Building	performance	Cooling primary energy demand (not renewable)	0	0	0	0	0	0	0	1	1	0	1	1	1
40	Building	performance	Cooling primary energy demand (renewable)	0	0	0	0	0	0	0	0	0	0	1	1	1
41	Building	performance	Global CO2 emission (heating, cooling, dhw, etc.)	0	0	0	1	1	1	1	0	0	1	1	1	1
42	Building	performance	Global primary energy demand (not renewable)	0	0	0	1	1	0	0	1	1	1	1	1	1
43	Building	performance	Global primary energy demand (renewable)	0	0	0	0	0	0	0	0	0	1	1	1	1
44	Building	performance	Heating primary energy demand (not renewable)	0	0	0	1	1	0	0	1	1	0	0	1	1
45	Building	performance	Heating primary energy demand (renewable)	0	0	0	0	0	0	0	0	0	0	0	0	0
46	Building	performance	Energy Needs for Cooling	0	0	0	1	1	0	1	1	1	1	1	1	1
47	Building	performance	Energy Needs for Heating	0	0	0	1	1	1	1	1	1	1	1	1	1
48	Building	performance	Primary energy demand for lighting (not renewable)	0	0	0	0	1	0	0	0	0	0	0	1	1
49	Building	performance	Primary energy demand for lighting (renewable)	0	0	0	0	1	0	0	0	0	0	0	0	0
50	Building	performance	renewable)	0	0	0	0	1	0	0	0	0	0	0	0	0
51	Building	performance	(renewable)	0	0	0	0	0	0	0	0	0	0	0	0	0
52	Building	performance	Transport primary energy demand (not renewable)	0	0	0	0	0	0	0	0	0	0	0	0	0
53	Building	performance	Transport primary energy demand (renewable)	0	0	0	0	0	0	0	0	0	0	0	0	0
54	Building	performance	Transport system efficiency	0	0	0	0	0	0	0	0	0	0	0	0	0
55	Building	performance	Transport systems are considered/exist	0	0	0	0	0	0	0	0	0	0	0	0	0
56	Building	performance	Useful electricity demand	0	0	0	0	0	0	0	0	0	0	0	1	1
57	Building	performance	Useful energy demand for heating	0	0	0	0	0	0	0	0	0	1	1	1	1
58	Building	performance	Useful energy demand for DHW	0	0	0	0	0	0	0	0	0	1	1	1	1
59	Building	performance	Useful energy demand for cooling	0	0	0	0	0	0	0	0	0	0	1	1	1
60	Building	performance	Useful energy demand for lighting	0	0	0	0	0	0	0	0	0	0	0	0	1
61	Building	performance	Useful energy demand for mechanical ventilation	0	0	0	0	0	0	0	0	0	0	1	0	0
62	Building	performance	Primary energy conversion factor for energy carrier i	0	0	0	1	1	1	1	1	1	0	0	1	1
63	Envelope	Door	Surface area	0	1	1	1	1	1	1	1	1	0	0	1	1
64	Envelope	Door	U-value	0	1	1	1	1	1	1	1	1	0	0	1	1
65	Envelope	External Wall	Sheltered sides	0	0	0	0	0	0	0	0	0	0	0	0	0
66	Envelope	External Wall	Factor for ambient on back side	0	1	1	0	0	0	0	0	0	0	0	0	0
67	Envelope	External Wall	Insulation thermal conductivity	0	1	1	1	1	1	1	0	0	0	0	0	0
68	Envelope	External Wall	Insulation thickness	0	1	1	1	1	1	1	0	0	0	0	0	0
69	Envelope	External Wall	Insulation type	0	1	1	0	0	1	1	0	0	0	0	0	0
70	Envelope	External Wall	Layer material (for n layers)	0	1	1	1	1	1	1	0	0	0	0	0	0
71	Envelope	External Wall	Layer thermal conductivity (for n layers)	0	1	1	1	1	1	1	0	0	0	0	0	0
72	Envelope	External Wall	Layer thickness (for n layers)	0	1	1	1	1	1	1	0	0	0	0	0	0
73	Envelope	External Wall	Overall flat thermal bridge U-value	0	1	1	1	1	1	1	1	1	0	0	1	1
74	Envelope	External Wall	Surface area	0	1	1	0	0	1	1	1	1	1	1	1	1
75	Envelope	External Wall	U-value	0	1	1	1	1	1	1	1	1	1	1	1	1
76	Envelope	ground	Surface area	0	1	1	1	1	1	1	1	1	0	0	1	1
77	Envelope	ground	U-value	0	1	1	1	1	1	1	1	1	1	1	1	1
78	Envelope	Roof	Surface area	0	1	1	1	1	1	1	1	1	1	1	1	1
79	Envelope	Roof	U-value	0	1	1	1	1	1	1	1	1	1	1	1	1
80	Envelope	Roof	Insulation thickness	0	1	1	1	1	1	1	0	0	0	0	0	0

81	Envelope	Window	Whole building solar absorption (g.A)	0	0	0	0	0	0	0	0	0	0	0	0	0
82	Envelope	Window	g-Value	0	1	1	1	1	1	1	1	1	1	1	1	1
83	Envelope	Window	Sun protection (Shading) - Degree of automation	1	1	1	1	1	0	0	0	0	1	1	1	1
84	Envelope	Window	Surface area	0	1	1	1	1	1	1	1	1	1	1	1	1
85	Envelope	Window	U-value (frame)	0	1	1	0	0	0	0	0	0	1	1	0	0
86	Envelope	Window	U-value (glazing)	0	1	1	0	0	0	0	0	0	0	0	0	0
87	Envelope	Window	Multiple glazed percentage	0	0	0	0	0	0	0	0	0	0	0	0	0
88	Envelope	Window	Windows orientation	0	1	1	1	1	1	1	1	1	1	1	1	1
89	Envelope	Window	yie-value periodic thermal transmittance	0	0	0	1	1	0	0	0	0	0	0	0	0
90	Envelope	Window	Frame factor	0	0	0	0	0	1	1	0	0	0	0	0	0
91	Envelope	Window	U-value (global)	0	optional	optional	1	1	1	1	1	1	0	0	1	1
92	Renewables	generation	Equivalent solar Area/net heated area Ratio	0	optional	optional	0	0	0	0	0	0	0	0	0	0
93	Renewables	generation	Installed capacity	0	1	1	0	0	0	0	0	0	1	1	1	1
94	Renewables	Solar thermal	Installed capacity	0	0	0	0	0	0	0	0	0	1	1	1	1
95	functionaliti	Cooling system	performance	1	1	1	0	0	0	0	0	0	0	0	0	0
96	functionaliti	DHW system	performance	1	1	1	0	0	0	0	0	0	1	0	0	0
97	functionaliti	Electricity	monitoring systems (smart meters, real-time feedback)	1	0	0	0	0	0	0	0	0	0	0	0	0
98	functionaliti	Electricity	Reporting info regarding local electricity generation	1	1	1	0	0	0	0	0	0	1	0	0	0
99	functionaliti	Electricity	Reporting info regarding energy storage	1	0	0	0	0	0	0	0	0	1	0	0	0
100	Connectivity	Electricity	Storage of locally generated energy	1	0	0	0	0	0	0	0	0	0	0	0	0
101	functionaliti	Envelope	Reporting information regarding performance	1	0	0	0	0	0	0	0	0	0	0	0	0
102	functionaliti	Heating system	performance	1	1	1	0	0	0	0	0	0	0	0	0	0
103	functionaliti	control	Central reporting of TBS performance and energy use	1	0	0	0	0	0	0	0	0	0	0	0	0
110	Connectivity	Thermal energy	Heating system storage and shifting of thermal energy	1	0	0	0	0	0	0	0	0	0	0	0	0
111	Connectivity	Thermal energy	Control of DHW storage charging	1	0	0	0	0	0	0	0	0	0	0	0	0
112	Connectivity	Thermal energy	Control of DHW storage charging - HP or electrict	1	0	0	0	0	0	0	0	0	0	0	0	0
113	building	Appliances	Electricity consumption (excl. space heating)	0	0	0	0	0	0	0	1	1	1	1	0	0
114	Building	Cooling system	cooled area	0	0	0	1	1	optional	1	0	0	1	1	1	1
115	Building	Cooling system	cooled bruto-volume	0	1	1	1	1	optional	1	0	0	0	0	1	1
116	Building	Cooling system	Cooling emission control	1	0	0	0	0	0	0	0	0	0	0	0	0
117	Building	Cooling system	Cooling energy source	0	0	0	1	1	optional	1	0	0	1	1	1	1
118	Building	Cooling system	Cooling system efficiency	0	0	0	0	0	optional	1	1	1	0	0	1	1
119	building	Cooling system	Energy delivered for space cooling by energy carrier i	0	0	0	0	0	optional	1	1	1	0	0	0	0
120	Building	Cooling system	Fuel type	0	0	0	0	0	optional	1	0	0	1	1	1	1
121	Building	Cooling system	Storage	0	0	0	0	0	optional	1	0	0	0	0	0	0
122	Building	Cooling system	Generator control for cooling	1	0	0	0	0	0	0	0	0	0	0	0	0
123	Building	Cooling system	Percentage from the total heat generation	0	0	0	0	0	0	0	0	0	0	0	0	0
124	Building	Cooling system	Nominal electrical power	0	0	0	1	1	0	0	0	0	1	1	1	1
125	Building	Cooling system	Nominal thermal power	0	0	0	1	1	0	0	0	0	0	0	1	1
126	Building	Cooling system	Number of units installed	0	0	1	1	1	0	1	0	0	0	0	1	1
127	Building	DHW system	DHW primary energy demand (not renewable)	0	0	0	1	1	0	0	0	0	0	0	1	1
128	Building	DHW system	DHW primary energy demand (renewable)	0	0	0	0	0	0	0	0	0	0	0	0	0
129	Building	DHW system	DHW service present	0	1	1	0	0	1	1	0	0	1	1	1	1
130	Building	DHW system	DHW system efficiency	0	0	0	0	0	1	1	1	1	1	1	1	1
131	Building	DHW system	Fuel type	0	1	1	1	1	1	1	0	0	0	0	1	1
132	Building	DHW system	Storage	0	1	1	0	0	1	1	0	0	0	0	0	0
133	Building	DHW system	Primary pipework insulation present	0	1	1	0	0	0	0	0	0	1	1	1	1
134	Building	Heating system	Fuel type	0	1	1	1	1	0	0	0	0	1	1	1	1
135	Building	Heating system	Heat emission control	1	1	1	0	0	0	0	0	0	1	1	1	1
136	Building	Heating system	Heat generation	0	1	1	1	1	1	1	1	1	1	1	1	1

137	Building	Heating system	Heat generator control (combustion and district heating)	1	1	1	0	0	0	0	0	0	1	1	1	1
138	Building	Heating system	Heat generator control (heat pumps)	1	1	1	0	0	0	0	0	0	1	1	1	1
139	Building	Heating system	Heat supply temperature	0	0	0	0	0	1	1	1	1	1	1	0	0
140	Building	Heating system	Heated area	0	0	0	1	1	0	0	1	1	1	1	1	1
141	Building	Heating system	Heated bruto-volume	0	1	1	0	0	0	0	0	0	1	1	1	1
142	Building	Heating system	Heating days	0	0	0	0	0	1	1	0	0	1	1	1	1
143	Building	Heating system	Heating energy source	0	1	1	1	1	1	1	1	1	1	1	1	1
144	Building	Heating system	Heating system efficiency	0	0	0	0	0	1	1	1	1	1	1	1	1
145	Building	Heating system	Indoor temperature	0	0	0	0	0	0	0	1	1	1	1	1	1
146	Building	Heating system	Main heat delivery system	0	1	1	1	1	1	1	1	1	1	1	1	1
147	building	Heating system	Net energy for space heating	0	0	0	1	1	1	1	0	0	1	1	0	0
148	Building	Heating system	Nominal electrical power	0	0	0	0	0	0	0	0	0	1	1	1	1
149	Building	Heating system	Nominal thermal power	0	0	0	0	0	0	0	0	0	1	1	1	1
150	Building	Heating system	Norm outdoor temperature	0	0	0	0	0	0	0	0	0	1	1	0	0
151	Building	Heating system	Number of units installed	0	1	1	1	1	1	1	0	0	0	0	1	1
152	building	Heating system	Operational thermal efficiency of the space heating system	0	0	0	0	0	0	0	1	1	1	1	0	0
153	building	Heating system	Central heating pump age	0	0	0	0	0	0	0	0	0	0	0	0	0
154	Building	Lighting system	Control system: for indoor occupancy	1	0	1	0	0	0	0	0	0	0	0	0	1
155	Building	Lighting system	Lamp type	0	0	1	1	1	0	1	0	0	0	0	0	0
156	Building	Lighting system	Lighting system efficiency	0	0	0	0	0	0	0	0	0	0	0	0	1
157	Building	Lighting system	Lightning is considered	0	0	0	1	1	0	1	0	0	1	0	0	1
158	Building	Lighting system	Total power	0	0	optional	1	1	0	1	1	1	0	0	0	1
159	Building	control	Interaction between TBS and/or BACS	1	0	0	0	0	0	0	0	0	0	0	0	0
160	building	Other services system	energy carrier i	0	0	0	0	0	0	0	0	0	0	0	0	0
161	Building	Ventilation system	Mech Vent system efficiency	0	0	0	0	0	1	1	0	0	1	1	1	1
162	Building	Ventilation system	Mech Vent system present	0	1	1	1	1	1	1	1	1	1	1	1	1
163	Building	Ventilation system	Air flow control al the room level	1	1	1	0	0	0	0	0	0	0	0	1	1
164	Building	Ventilation system	Filter type/class	0	0	0	0	0	0	0	0	0	0	0	1	1
165	Building	Ventilation system	Heat recovery efficiency	0	1	1	0	0	1	1	1	1	1	1	1	1
166	building	Ventilation system	Operational thermal efficiency of the heat recovery unit	0	0	0	0	0	0	0	0	0	0	0	0	0
167	building	Ventilation system	Temperature of ventilation return air	0	0	0	0	0	0	0	0	0	0	1	0	0
168	building	Ventilation system	Temperature of ventilation supply air	0	0	0	0	0	0	0	0	0	0	1	0	0
169	building	Ventilation system	Ventilation air flow rate	0	0	0	0	0	0	0	1	1	1	1	1	1
170	Building	Ventilation system	Ventilation Rate	0	0	0	0	0	0	0	1	1	1	1	0	0
171	Building	Ventilation system	Ventilation Type	0	1	1	1	1	1	1	1	1	1	1	1	1