Self Assessment Towards Optimization of Building Energy

Deliverable

D9.8 – Risk, Innovation and Data Management Plans

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Table of Contents

List of Figures

List of Tables

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EXECUTIVE SUMMARY

This document constitutes deliverable D9.8 - Risk, Innovation and Data Management Plans, of the H2020 project SATO – Self Assessment Towards Optimization of building energy.

The risk, innovation and data management plan is a document that shall provide a set of guidelines and best practices for the management and implementation of the project concerning project risks, innovations and results, as well as data used and generated during the project.

The document focuses on the underlying approaches for risk, innovation and data management used in SATO and defines a set of templates and methodologies to monitor the project's activities according to these domains. The document is the first version of D9.8 which will be updated in Month 24 of the project.

1. Introduction

1.1. Objectives and scope

The current deliverable D9.8 – Risk, Innovation and Data Management Plans – constitutes a set of guidelines and best practices for risk, innovation, and data management. A detailed risk management plan is outlined specifying SATO's risk management strategy, the main project risks and defining a system failure management plan.

Besides, a plan for effective and structured innovation management is presented including the description of SATO's innovation potential as well as assessment framework to monitor and verify the degree of innovation for the results generated within SATO.

A data management plan is presented that defines a strict guideline to comply with European and national legislation on the acquiring, handling, processing, and archiving of data generated during SATO project and beyond the project's end, being updated by Month 24 (M24).

In terms of data management, D9.8 allows for a consortium-wide alignment around the project's data management processes. The objective is to promote the principles of:

a. the recently published General Data Protection Regulation (GDPR) (Regulation (EU) 2016/679);

b. the Universal Declaration of Human Rights and the Convention 108 for the Protection of Individuals according to Automatic Processing of Personal Data; and

c. the national laws applying its provisions.

1.2. Relation to other activities

Task T9.3, and, subsequently, its respective deliverables, have a transversal impact throughout SATO, providing a set of guidelines on (i) the definition, assessment, prioritization, mitigation and monitoring of the general and specific project risk, (ii) the effective and structured management, monitoring and improvement of project results according to SATO's anticipated innovation potential, and (iii) generation, acquiring, handling, sharing and curation of research data during all activities carried out within and beyond SATO project, especially important for the demonstration and replication-related Work Package 6 (WP6).

1.3. Structure of the deliverable

Deliverable D9.8 is structured as follows:

- Chapter 2 – Risk Management: Within the first chapter, the risk management plan for SATO project is presented detailing the overall risk management strategy, the rating and assessment framework to score the risk according to likelihood and impact on the successful implementation of SATO, a preliminary list of risks identified until M6 and an introduction to the approach used to treat and mitigate system failures during the demonstration phase of the project in WP6.
- Chapter 3 – Innovation Management: Chapter 3 presents the innovation management process followed during the implementation of SATO to ensure the envisaged innovation potential and the technological as well as commercial readiness of the project results.
- Chapter 4 – Data Management: In Chapter 4 the overall procedures to handle data generated during the project are detailed. Additionally, templates for the storage, processing and sharing of data are presented that will be updated during the turn of the project and the updated version of D9.8 (M24).

2. Risk Management

Since SATO will impact the very homes of users and adopters and thus directly influence their personal and private surroundings, it is crucial that adequate risk management is ensured. The focus must be on guaranteeing the integrity of people's personal environment and of the appliances therein, which needs to be addressed already in the prototype phase. The risk management strategy for the SATO project is based on an early identification of all relevant risks, assessment of their impact level, allocation of their ownership, resolution or mitigation by the respective owners, follow-up, and report.

The responsibility of risk management relies with the Project Coordinator (PC). Identified risks are dealt with and alerts are raised in case any of the identified risks increase its priority. All risk management activities are monitored by the PC in collaboration with each WP leader.

2.1. Risk management strategy and implementation

The risk management process is composed of five stages as shown in Figure 1: identify risks; assess risk impact and likelihood; prioritize risks; mitigate risks; and monitor project implementation. For each risk that enters the risk management process, these stages are executed in sequence. Implementation of the risk management will include the following steps:

1 At SATO project kick-off, the risks associated with each WP were revisited to detail the information about risk identification, assessment, mitigation actions, ownership, and monitoring processes.

2 Create a risk register as described below to track and report risk management progress. This will be maintained throughout the project life.

3 Based on the risk register, establish the adequate risk management control mechanisms and communication to guarantee the adequate project development and share of positive outcomes it generates.

4 Develop the risk related plans: Data Management Plan, Stakeholder Management Plan and System Failure Management Plan.

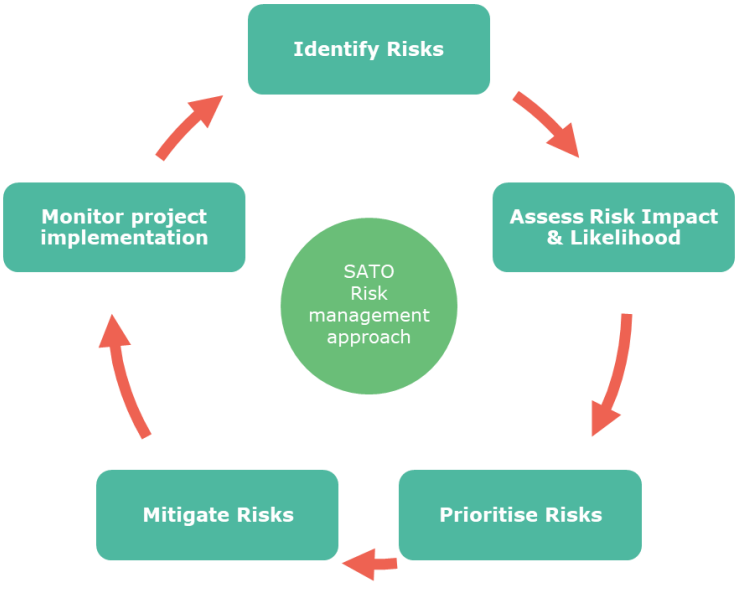

Figure 1 SATO risk management process

The project risk register will be maintained by the PC and stored in a dedicated folder of the project repository. Each of the identified project risks (R) will be scored using the product of probability (L) and impact (I) as depicted in below.

Risk (R)		Likelihood (L)		
		Low	Medium	High
Impact (I)	High	3	6	9
	Medium	2	4	6
	Low	1	2	3

Figure 2 Risk register scores

- Green indicates that the project is on track. The risks already identified are not expected to impact the other project metrics or overall business outcomes.
- Yellow indicates the necessity of some corrective action. At least one identified risk may impact negatively on some project metric, outcome, or stakeholder. There might be needed to implement some corrective actions.
- Red indicates that significant corrective actions are required. One or more identified risks may impact the project. All Partners must place their best efforts to bring risks to acceptable levels by implementing the necessary actions.

The risk register will be updated during project execution to add new risks found and to update the status of identified risks.

2.2. Main project risks

SATO risk register will be stored in a dedicated folder of the workspace. Each of the identified project risks (R) will be categorised as a general risk (GR) or specific risk (SR) and scored using the product of probability (Likelihood Score - LS) and impact (Impact Score - IS).

The likelihood is the estimated probability that the risk will materialise even after taking account of the mitigating measures put in place.

The impact is the estimated damage (cost, safety, environment, image, etc.) that the risk will cause if materialised as shown in Table 1.

Table 1 List of SATO project risks (L: likelihood; I: impact; R: risk; H: high; M: medium; Lo: low)

Risk ID	Risk description	Proposed risk-mitigation measures
General risks		
GR1	Partners run out of budget due to internal changes, over expenditure, etc. (**L=M, I=Lo, R=2, WP9**)	All partners will review expenditures/ budgeted amounts on a six-monthly basis. This will help the identification of potential deviations. The PC (FC.ID) will support partners with modifications if necessary.
GR2	A partner or key staff leaves the project. (**L=M, I=Lo, R=2, WP9**)	PC and WP leader for key staff will analyse two options: (i) the substitution of the partner by another one of similar characteristics and/ or (ii) the redistribution of tasks among the partners of the project. The project management handbook (D9.1, FC.ID) establishes mechanisms to react against possible delays. Moreover, regular WP and technical

		meetings will be held to ensure that activities are aligned, controlled and that learnt lessons shared.
GR3	Delays on deliverables and results not meeting project objectives. (**L=M, I=M, R=4**)	The project management handbook (D9.1, FC.ID) establishes mechanisms to react against possible delays. Moreover, regular WP and technical meetings will be held to ensure that activities are aligned, controlled and that learnt lessons shared.
GR4	Partners not agreeing on the Intellectual Property Rights (IPRs) of the project developments and results. (**L=Lo, I=M, R=2, WP9**)	The Consortium Agreement (CA) will establish basic rules for IPR. The Plan for the Exploitation and Dissemination of Results (PEDR) will further identify the generated results (foreground) and ownership.
GR5	Unbalanced workload distribution (time, consortium members, staff, tasks). (**L=M, I=Lo, R=2, WP9**)	During the proposal phase, there will be detailed project planning, clear assignment of responsibilities and negotiation to guarantee a clear definition and acknowledgement of the work plan and activities. During the project, there will be periodic review meetings.
GR6	Not able to go beyond the state-of-the-art. (**L=Lo, I=H, R=3, WP2-WP5**)	In the proposal and at the beginning of the project, there will be detailed reviews of the state-of-the-art entailing innovative concept developments. The quality and complementary expertise of the consortium partners will ensure that the developed concept and extensions of the two commercially available platforms goes beyond the state-of-the-art.
GR7	Difficulty to further increase the TRL of the existing platforms. (**L=Lo, I=H, R=3, WP2-WP5 & WP7**)	The project platforms are based on already existing and economically viable platforms. The developments will involve developers who already participated in the earlier platform developments. Moreover, certification and compliance plans of the developments ensure to target a broader market.
GR8	Incompatible requirements between parts of the system and lack of interoperability obstructs the integration of the modules into a holistic overall concept. (**L=M, I=H, R=6, WP1-5**)	The technical specification of compatibility requirements between parts of the system will be defined at the beginning of the project. Moreover, WP1 is carried out during the entire development process of WP2-WP5 to ensure adjustments. Regular project meetings and constant communication between the work package leaders ensure standardized interfaces, both technically and cross-sectoral. Interoperability tests at early stages of the development process will also ensure that misguided development paths are not followed for long.
GR9	Disagreement between Consortium partners about quality of procedures and overall objectives. (**L=M, I=M, R=4, WP9**)	The clear definition of the governing board structure will contribute to an efficient resolution of disagreements. The PC will be responsible for it, and if required the PMB will assist to follow appropriately the procedure stated in GA and CA.

GR10	Cybersecurity risk and data privacy concerns. (**L=M, I=H, R=6, WP3,6,9**)	The data related risks will be mitigated through the actions and procedures established in the Data Management Plan and Risk Management Plan following the guidelines stated in the GDPR. The Data Protection Officer (DPO) will involve experts during the project to ensure that the developed services are GDPR-compliant. If, inadvertently, a data leak and/ or failure is detected, the activities and procedures outlined in the System Failure Management Plan will ensure the protection of equipment and sensitive data. Cybersecurity risk management procedures will be included in the Data Management Plan and Risk Management Plan implementing the cybersecurity triad (confidentiality, integrity and availability).
GR11	COVID-19 pandemic restrictions cause delays in tasks which require direct contact with involved users, specifically for the pilot sites. (**L=M, I=M, R=4, WP1,6**)	Efficient communication and dissemination action plans are described in T8.1 (CORE) with users and stakeholders even if face to face meetings are not possible. Desk based studies and technical characterization will be accelerated and completed to a high-level to make up for possible delays and restrictions in on-site activities.
Specific risks		
SR1	In an early stage, irrevocably defined specifications limit the later developments. (**L=M, I=Lo, R=3, WP1**)	The specifications are based on a thorough analysis of the literature, other best practices and the consortium's significant experience. Moreover, the continuous structure of WP1 (EDP CNET) will ensure that alternative development paths are acknowledged if the consortium recognises that the plans will need to be modified based on experience gained during the project.
SR2	Compatibility of the various IoT devices and APIs communication protocols with the common platform. (**L=M, I=H, R=6, WP3**)	In WP2, the SATO platform will be developed, that shall serve as a middleware (software that acts as a bridge between distinct data sources, control devices, and platforms, and the SATO platform streaming components) to integrate the heterogeneous IoT devices and their APIs, existing building equipment and appliances in one common cloud-based platform. This platform will embed a multi-protocol message broker as well as unified open and standardised communication protocols (e.g., EEBUS technology) and various APIs to communicate and integrate the heterogenous building energy system.
SR3	Lack of consideration of the GDPR compliance prevents the deployment of the platform, services, or assessments. (**L=M, I=H, R=6, WP1-WP9**)	A Data Protection Officer (DPO) will be announced before any operational actions are carried out. The DPO will involve experts during the implementation of the project to ensure that the services are GDPR compliant. The data related risks will be mitigated through the actions and procedures established in the Data Management Plan and Risk

		Management Plan following the guidelines stated in the GDPR.
SR4	Clients/ Users do not engage in the prototype and clients/ users abandon the demonstration phase before the project's end. (**L=Lo, I=H, R=3, WP6,8**)	The Stakeholder Management Plan and Communication Plan will establish guidelines and activities to ensure the engagement of the clients/users throughout the entire project. The user-centred design framework will continuously ensure that the developments of the project and deployment of the pilots are aimed at the needs of users.
SR5	Underestimation of possible implementation costs concerning the installation of monitoring and automation equipment. (**L=M, I=M, R=4, WP1,6**)	Solid characterization of the pilots scope, with a clear definition of the requirements for each of the pilot buildings will be respected throughout testing activities and early identification of the data that will be needed to input the models, enabling the partners to estimate, if it is the case, which equipment should be bought.
SR6	Systems failure during or after the demonstration phase. (**L=Lo, I=M, R=2, WP9**)	At first, the Risk Management and compliance with the procedures within will lower the likelihood and impact of potential system failures. Moreover, System Failure Management Plan will establish a solid guideline of procedures and activities to ensure the appropriate management of potential system failures including technical and emergency support throughout the entire project. This plan will further detail clear responsibilities among the partners.
SR7	Lack of certification strategies for the developed technologies limits market penetration. (**L=M, I=M, R=4, WP7**)	In T7.1, a detailed certification plan for each individual technology and application is developed and implemented during the project. The participation of the executing partners in the technical work packages as well as a continuous dialogue will support the certification processes.

2.3. System failure management

A system failure management plan (SFMP) aims at the prevention of hazardous and abnormal events that could affect or perturb a system. Due to the importance of the plan, it is relevant to implement a rigorous and methodological approach to detect failures and mitigate these through effective recovery procedures.

The SATO system failure management plan will ensure the continuation of the vital project processes during the demonstration phase in case of an emergency or system failure. Implementing this methodology will not stop eventual system failures but will prevent them and enable their recovery in a more effective manner.

The SFMP will detail and document all activities to be executed in case of an unforeseen emergency, which will be used as a guideline and continuously updated document to collect all necessary information of such an event (e.g. failure name, failure type, cause, impact, likelihood, mitigation measure etc.). The following template shall serve as a base to cluster potentially emerging system failures.

The **1st column** indicates the 'Failure name' of the failure.

The **2nd column** indicates the 'Failure type' to classify the failure according to common failure domains.

The **3rd column** indicates the 'Cause' that led to the failure.

The **4th column** indicates the 'Impact' the failure has on the project implementation based on a scale from 1-5.

The **5th column** indicates the 'Likelihood' of the failure to appear during the project based on a scale from 1-5.

The **6th column** indicates the 'Mitigation measure' applied to successfully mitigate the failure.

Table 2 SATO system failure catalogue

Failure name	Failure type	Cause	Impact	Likelihood	Mitigation measure

Figure 3 SATO system failure management approach

The SFMP is composed of four distinct stages as follows:

1. **Failure identification** denotes the stage in which the first observation of the failure is detected for further development in the next stages. This step includes to collect all the information

necessary to allow a detailed analysis of the failure situation (e.g., failure time, affected device, system, component, location, impact etc.).

2. **Failure classification** after carefully and clearly identifying what happened and collecting the corresponding information, the failure will be classified by type (e.g. electrical, social etc.). If the failure is already known, corresponding mitigation measures can be realized in an effective manner. In cases of a yet unknown failure type, this step will help to extend and complement the failure database to ensure a faster recovery procedure in the future.
3. **Failure mitigation** is the most relevant one, because it is associated with the mitigation plan which incorporates different strategies that will prevent any major hazard to the system and ensure the efficient and effective resumption of vital business functions in the event of an unscheduled interruption.
4. **System recovery** encloses all operational, administrative, and strategic activities to put the associated mitigation plan into practice until the system is working under normal conditions. The restored operational reliability will be tested and ensure that the appropriate mitigation plan is implemented.

The corresponding responsible entity to coordinate all activities associated with the SFMP and ensure the adherence to the outlined procedure is represented by the PC. In case the emergency or failure is detected during the demonstration phase in one of the pilots, the corresponding pilot leader oversees the execution of the SFMP.

In any case, all consortium partners as well as clients/users will be informed about potential emergency incidents and each partner will assure its consent to support the responsible entity to carry out all necessary activities to achieve the system recovery in the most cost effective and user-friendly manner.

3. Innovation Management

3.1. Innovation management process

This section describes how innovation management (IM) will be carried out during the project. Effective IM encompasses the entire innovation value chain of a project, from the inception of the idea at the proposal stage through the innovation process up to the innovation result originating from the execution of the project.

By following a standardized IM process, the SATO project will ensure that the developments and results of the project are released in a coordinated manner and business models are designed for the changing market trends and needs ensuring the satisfaction of the target stakeholders and clients of the project.

The IM process within the SATO project shall facilitate all involved partners to realise opportunities and use these to create and introduce new ideas, processes, or products industriously. According to the European Commission (EC) IM is defined as follows:

"Overall management of all activities related to understanding needs, with the objective of successfully identifying new ideas, and managing them, in order to develop new products and services which satisfy these needs."

Based on this definition, SATO IM shall support the project consortium to accomplish the following five objectives:

- Understanding of the building energy and construction market needs, trends and opportunities, key stakeholders and technologies;
- Being responsible for the overall strategic approach for the SATO project;
- Continuous monitoring of the building energy and construction market, IP, and technology landscapes;
- Steering of the technology development plan to meet the project objectives and market needs as well as to take corrective measures if necessary;
- Ensuring that the project's innovation governance and management processes and structures are sound, updated regularly and work effectively.

The derived IM process and the relationships between IM, the Exploitation Strategy to be detailed in D7.4 as well as IPR management and strategy for the SATO project are illustrated in Figure 4.

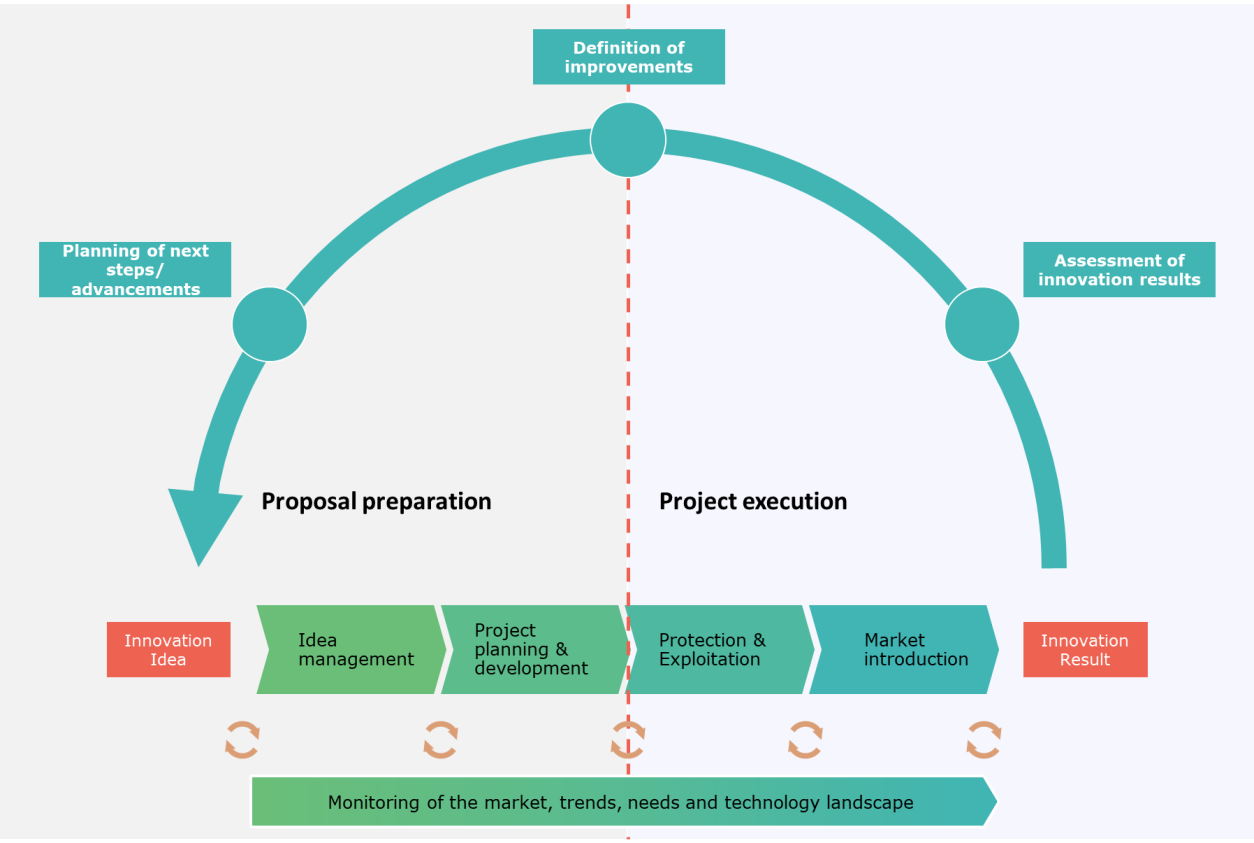

Figure 4 SATO innovation management process

According to Figure 4, SATO IM is commenced with the point of capturing the creative works (*Innovation Idea*) and finishes when a novel product/service/knowledge emanates from the innovation process (*Innovation Result*).

The innovation process itself comprises four consecutive steps that compose a streamlined methodology to manage, develop and refine the *Innovation Idea* according to close monitoring of external factors, such as the trends and needs of the building energy and construction market as well as the technology

landscape, through all stages of the process. This will ensure that changing market conditions and other external trends (e.g. COVID-19 crisis, economic crisis, availability of novel IoT and ICT technology, etc.) are acknowledged which enables the SATO's consortium to refine and adapt the *Idea Management & Strategy* accordingly.

Thereupon, the *Innovation Idea* is matured to a technological concept and prototype during the development stage of the SATO Project (**WP2 – WP5**). The progress of the developments will be tracked based on the deliverables associated to each of the development streams whereas the WP leader is responsible for the timely delivery and adequacy to meet the overall innovation objectives of the deliverable.

Subsequently to the *Idea Development & Project Execution* stage, the *IPR Management & Exploitation Strategy* are developed and defined for each of the innovative concepts and results in the present report as part of the Exploitation Plans (within Task T7.3 Exploitation Plans). This will ensure that the IPRs associated with SATO results are sufficiently protected and defined whilst the exploitation strategy aims at maximizing the impact of the results of being successful in the market.

After *Market Introduction*, the IM will further ensure that the performance on the innovation result in the market is assessed according to preliminary defined key performance indicators (see subsection 3.2) to derive future improvements to increase the technological readiness level (TRL) and commercial readiness index (CRI) of the SATO technology. Based on the identified improvements, the *Planning of next steps/advancements* will conceptualize the necessary steps and technological advancements to yield higher TRLs and CRIs.

The milestones and key steps that are incorporated in the IM process will then set the foundation for future Innovation Ideas within the SATO technology development program.

3.2. Innovation management roles

To ensure an efficient and structured IM process, the project assigned specific roles and responsibilities to monitor and track the IM process throughout the project's implementation. In Table 3, the key roles of the SATO IM process are outlined.

The **1st column** indicates the 'Role' of the different actors of the SATO IM process.

The **2nd column** indicates the 'Entity' appointed/assigned to assume the 'Role' throughout the project.

The **3rd column** indicates 'Responsibilities' that are assigned to each role and entity.

Table 3 SATO IM process roles

Role	Entity	Responsibilities
WP leader	EDP CNET, FC.ID, AAU, CYPE, CORE, POLIMI	• Register/update project results in the catalogues (see Table 2); • Ensure that the information is complete and updated; • Ensure that data for dissemination and exploitation plans are prepared for WP7 (by result main responsible).

Main responsible for project result	All partners indicated in Table 2 and Table 3	• Register information on project result in the catalogue (see Table 2), including data preparation for exploitation and dissemination plans in WP7; • Deliver project results on time, budget and according to the requirements defined in WP1.
Innovation manager	EDP CNET	• Validates the list of key results; • Monitoring of innovation metrics and suggestion of strategies to raise degree of innovation; • Liaising with WP leaders to ensure completeness of information.
WP7 team	CORE	• Ensure that dissemination and exploitation plans are defined (by result main responsible); • Validate dissemination and exploitation plan; • Advise on the best approach to protect Intellectual Properties (IPs) produced during the project.
IM Risk manager	EDP CNET	• Review of exploitation risks and updates the project's risk table.
Advisory board	Definition undergoing	• Provide advisory for the development of the project results according to changing market trends; • Ensure project results are appropriate for the needs of the building energy sector and centrally for the user; • Support dissemination and exploitation activities of individual partners.
Authors of deliverables/milestones	All partners	• Define a dissemination and exploitation plan for every project result in scope.

3.3. Innovation management procedure

In this subsection, the key procedure to capture and review project results as part of the IM process detailed in section 3.1 are defined in a stepwise approach.

Step #	Responsible	Action/Activity	Prerequisites, if any
1	Author of deliverables or milestones	Creates/Updates entries in Catalogue (see Table 2) of Project Results. If support or clarification are needed, she/he can contact the Innovation Manager via email.	Project deliverable milestone concluded.
2	Author of deliverables or milestones	Informs Innovation Manager that entries have been filled in and can be reviewed.	Entries in the Catalogue have been created/updated

3	Innovation Manager and WP7 members	Reviews the information provided in the catalogues and approves the entries, notifying this in the related Deliverable (or Milestone).	Authors of deliverables and milestones have completed the entries in the related Deliverable (or Milestone) page
4	Innovation Manager and WP3 members	In case the information provided in the entries is insufficient, the Innovation Manager will request further updates to the authors of the deliverables (or milestones) before approval.	Incomplete/Insufficient information provided in Catalogues of results pages.
5	WP leader	In case conflicts emerge concerning the documentation of the project results (e.g. may arise when results are created by more than one partner), the WP leader shall discuss with the concerned partners and schedule a review meeting in presence of the Innovation Manager to solve potential conflicts. If the conflict is not resolved, the common conflict resolution procedure of SATO shall apply.	Irregularities or emergence of conflicts regarding the ownership/ quality/ degree of innovation of the result.

3.4. Innovation potential and key innovative elements of the project

3.4.1. Innovation potential

SATO project is characterized by a unique interplay of human-centric automation, cloud-based IoT platforms and adaptive computational control techniques tailored toward the building energy context. The industrial and commercial arm of the SATO consortium will generate high innovation potentials by supporting the academic partners in transforming the technology into an operational TRL8 system and exploiting the knowledge for new business cases.

The main innovative potentials of project are presented in the following:

Innovation potential 1: A BIM based input and output system

The SATO concept is built on the capabilities of Building Integrated Modelling (BIM) to locate energy consuming devices in residential (e.g. multi-apartment buildings, single family buildings), commercial/service (e.g. retail stores, offices) and public (e.g. universities, library) buildings as well as to visualize building energy performance and occupancy indicators in the different assessment scales.

The introduction of a parametric geometry containing information about the sensors will enable the SATO stakeholders (e.g., facility/building managers, building owners, occupants, appliance manufacturers and distribution system operators) to check and keep track of the whole building energy system in an Open BIM 3D environment accessible from any device (computers, tablets, and smartphones) with an internet connection. In addition, this layer will be able to interact with other Open BIM software connected to the SATO platform, exchanging information and requirements through BCF files.

In this way, building designers and engineers in charge of specific disciplines will be able to take this new layer into consideration. This interoperability includes the display of the sensors in Open BIM AR and VR viewers that have been already developed for Android and iOS with real-time updates and

notifications. This will support workflows with any BIM tool (Revit, Archicad, Allplan, IFCBuilder, etc), using the International Foundation Class (IFC) as the main bridge between products of different developers. New BIM layers will allow a disaggregated view of the energy assessments, for instance by showing the assessment of different areas of the building (e.g. floors, rooms), or of different equipment/appliances or groups thereof, thus benefitting users or building managers in their analysis.

Innovation potential 2: Integrated cloud-based data management and computing platform to monitor and control IoT devices at the building level

Although companies and researchers claim to optimize energy efficiency and flexibility in buildings using advanced adaptive techniques and control approaches such as Model Predictive Control (MPC), truly holistic control is not yet commercially available. Often, users are overwhelmed by a multitude of complex solutions and tools, particularly in mobile applications.

SATO's innovation potential delineates an optimized holistic control approach for simultaneous management of energy efficiency, flexibility, and user satisfaction, available to any residential or commercial/service or public building, requiring minimal interaction and human intervention.

This is a clear innovation benefiting the various stakeholders: energy providers and aggregators with improved flexibility potential, residential and service building users with improved energy efficiency and comfort, and building managers with a truly integrated approach.

Innovation potential 3: An artificial intelligence system to perform self-assessment and optimization (SA&O) of a building and its energy consuming equipment, including appliances

SATO will continuously generate and stream building, energy, and user data to the cloud during system operation. Clearly, data availability, diversity, volume, and richness are essential to the discovery of actionable insights useful for impactful SA&O. Yet, the rapid increase in the volume of data does not automatically guarantee new insights and advances in the understanding of the data[1]. Instead, a continuous flow of the right data to the right analytical mechanisms and actors, in the right format is needed. Simplified models running in the cloud can be used to assess this data and identify effective optimization actions. Assessing this data requires a combination of powerful statistical and symbolic Artificial Intelligence (AI) approaches[2] such as machine learning[3], semantic queries and inference machines[4].

To this end, a first-of-a-kind self-assessment framework will be developed within SATO which will use data analysis and machine learning to report energy performance, building behaviour, occupancy and equipment faults in several scales: space (S), time (T), occupancy (O) and autonomy (A).

The spatial scale of assessment and optimization ranges from a single room/equipment to a whole building. The time scale ranges from an instant to a whole year. The autonomy scale refers to the type of control of a given energy consuming device, ranging from fully automated to manual control. There are four main assessments that will be performed by the SATO system, that will be implemented in this task: Energy (in the scales: S,T,O,A), Usage (in the scales: S,T), Functionality (in the scales: T,A), and Faults (in the scales: S,T).

This self-assessment framework will be further aligned with the principles recently introduced in the Smart Readiness Indicator (SRI)[5], while extending these principles with the goal of allowing for dynamic

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[4] Petrova, E., Pauwels, P., Svidt, K., & Jensen, R.L. (2018). Towards Data-Driven Sustainable Design: Decision Support based on Knowledge Discovery in Disparate Building Data. Architectural Engineering and Design Management, Special Issue on Intelligent Building Paradigms and Data-Driven Models of Innovation, 1-23. https://doi.org/10.1080/17452007.2018.1530092
[5] Verbeke S., Aerts D., Rynders G., Ma Y., Waide P.; "Interim Report July 2019 of the 2nd Technical Support Study on the Smart Readiness Indicator for Buildings"; July 2019; Brussels

performance assessments to engage users in improving their building and its contribution to energy efficiency and flexibility.

Innovation potential 4: A SATO supplemental service for new energy consuming devices

SATO will develop and test a service to be provided by appliance manufacturers and retailers that use existing and additional sensors placed in devices or building appliances that are ready for connection to the SATO platform and are automatically monitored and optimized.

The service is deployed as a use case in the Worten retail store pilots of the SATO project. Through this innovation, appliance users will benefit from post-sales energy assessment of the appliance since the purchasing moment. Appliance manufacturers gain a new feature that may increase sales and consumer trust.

Collectively, the energy system gains another contribution from a smart-ready device to the whole flexibility potential.

Innovation potential 5: Automatic parameter and system identification

A library for automatic parameter and system identification will be developed and implemented in the cloud-based SATO platform to allow adaptive management and control of building energy performance. This library will gain accurate knowledge and a digital representation of the building, its behaviour, installed systems as well as appliances, and characteristics of the building users to make accurate assessments and optimal decisions regarding the improvement of the buildings' actual real-life performance. Therefore, a prerequisite for the SA&O of building and appliance performances is the identification of key parameters and system characteristics under real-life conditions.

Different approaches are required for parameter and system identification. Identification of some parameters and systems can be carried out under normal operating conditions, while others require specific operating conditions and specific control strategies of systems and appliances. There will be several identification approaches:

Type 1: Identification is based on measured data time series (for SFP, Heat Recovery Efficiency, COP);

Type 2: Identification is based on measured data time series filtered according to specific time periods, specific conditions (weather, occupied/unoccupied);

Type 3: Identification is based on dynamic in-situ testing and data analysis carried out during specific limited time periods and under specific conditions by modifying system control and operation;

Type 4: Identification is based on grey-box modelling and dynamic data analysis using advanced statistical methods.

Innovation potential 6: A service of performance assessment and optimization with minimum requirements to data and monitoring points

A key challenge in performance assessment and optimization under actual real-life conditions is the need for data, sensors, and monitoring points to collect building and user data with the necessary granularity.

To respond to this challenge, this innovation will be developed to establish well-defined relations between minimum requirements to data sources and different levels of opportunity for SA&O of building performance. This will allow the development of different energy management and assessment services with distinct levels of quality of service, enabling an informed decision on the new possibilities for services and levels of service, when installing new sensors and equipment/appliances.

Innovation potential 7: Smart Self-assessment Services and user engagement

The Smart Self-Assessment Services will provide building users (occupants, facility managers, etc.) with data-driven assessments on building energy systems. These insights are intended to raise awareness and nudge occupants towards energy efficient behaviour, and to drive self-optimization actions for increased energy-efficiency. SATO's smartness assessment will be aligned with the SRI and build upon

the self-assessment framework. It will target building owners/occupants, building managers, and the population in general.

Two Smart Performance Assessment Services will be provided:

(1) A real-time performance assessment displaying information on building and energy consuming equipment performance. The monitoring and self-reporting tool will consider impact categories related to energy efficiency, energy flexibility, comfort, health and wellbeing. This service will be fully compatible with the SRI, whilst adding the ability to move from a theoretical to a real and dynamic building performance assessment.

(2) An automated self-reporting of inputs for a number of smart ready services.

These inputs can be later used for the (potentially automated) SRI assessment of the building.

The self -energy assessment will be based on close to real-time energy and historical data, "expected consumption" from the EPC and the respective Ecodesign and Energy Labelling legal provisions. The coherence of the effective performances of the building and of the appliances with the expected design assumptions will allow the consortium to provide guidelines on how to update the EPBD/EPC calculation approaches while similarly updating the respective Energy Labelling/Ecodesign measurement methods and performance thresholds, as well as providing the data (formatted) to the European Commission for further analysis.

Innovation potential 8: Innovative occupancy detection enables non-intrusive building performance diagnosis

SATO will combine occupancy detection with an advanced building assessment approach during unoccupied times.

Based on the user preference, SATO can deploy innovative non-intrusive user detection, based on personal cell phones and sensor data mining. User presence can be detected through Bluetooth and Wi-Fi beacons that explore low-level network protocols to infer only the existence and approximate location of smartphones and other wearables, without identifying their users or collecting any other personal or identification information. This robust occupancy detection enables non-intrusive building performance diagnosis.

This feature uses the SATO control capabilities to perform self-exploring experiments, i.e., testing operation of building equipment (enabling fault detection), measuring Building as a Battery (BaB) capabilities and ramp-up rates of heating and cooling systems (these are highly dependent on building characteristics), all in periods of no occupation. This diagnostics feature can detect and report equipment performance degradation and failure to the user and the SATO platform.

Innovation potential 9: Optimised BaB and electric vehicle charging for low-cost storage and energy flexibility

Many studies have shown the importance of energy storage for future energy systems. The `building as battery' concept (BaB) consists in the use of the structural thermal capacity of floors, ceilings, walls and building furniture as an energy (heat) storage medium. This low-cost energy storage system relies on heat pumps to insure the electrical energy-to-heat conversion.

BaB in residential buildings: the building internal mass is preheated during solar daytime hours (using renewable energy) and cooled by discharge into the room air after sunset, for space heating. For

apartments with high thermal mass, thermal insulation is the key driver of BaB thermal efficiency, with highly insulated apartments reaching BaB efficiencies of 60 to 80%[6].

BaB in non-residential buildings: the BaB storage potential can be used to anticipate or delay the HVAC system start-up time. Recent research results show that even in low thermal mass offices, BaB storage can be used to turn HVAC off for up to two hours. The control and monitoring capabilities of SATO will be used for self-assessment of BaB response and use this low-cost storage resource.

SATO contributes to the provision of energy storage by optimising the combined operation of building thermal inertia and bi-directional electric vehicle charging. In times of high electricity prices or high CO2 emissions, vehicle batteries can be partially discharged and thus provide energy to the connected household or to the distribution grid. Conversely, in low-cost times, such as the middle of sunny cold days, heat pumps can be used to charge the BaB with heat that will be released in the afternoon, eliminating demand during those hours.

Currently there are no commercial solutions that combine these two capabilities.

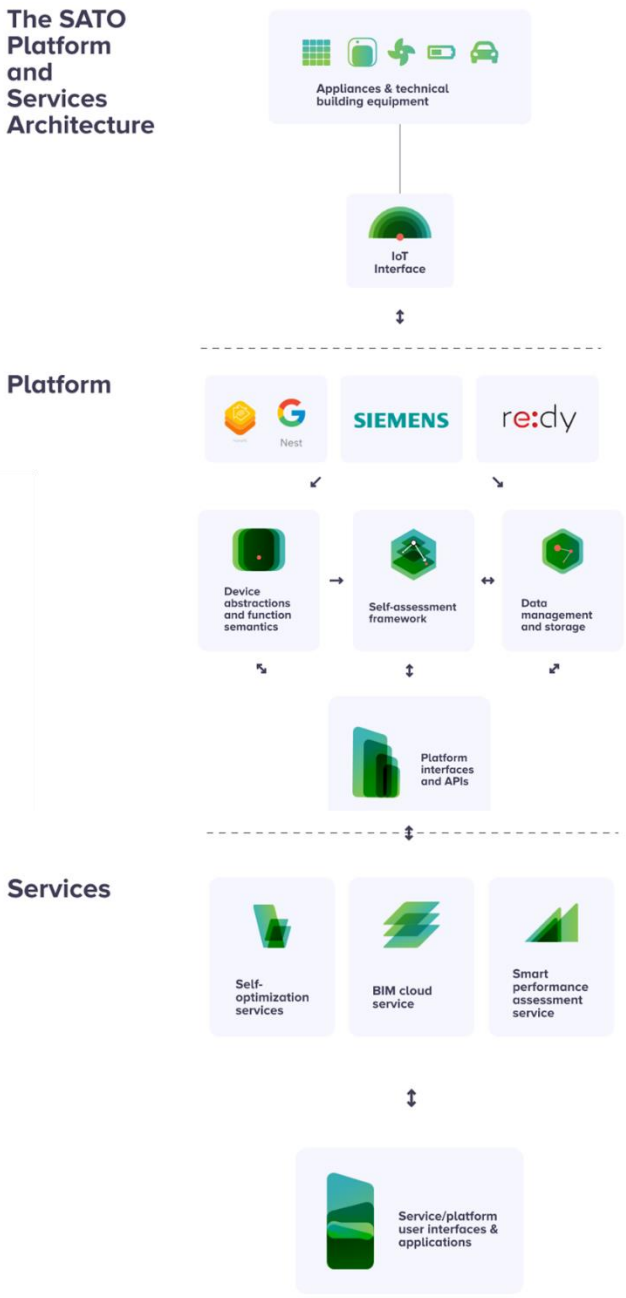

Figure 5 SATO innovative concept in a nutshell

3.4.2. Key innovative elements

The SATO project will envisage the development of a unified cloud-based software/hardware platform – the SATO platform – for enabling buildings to self-assess and self-optimise their energy performance (see Figure 5).

The SATO platform will serve as a middleware to integrate all energy consuming equipment, appliances and devices of different building typologies in an open and homogeneous platform (e.g., residential, commercial/service, public) through novel IoT interfaces enabling 2-way communication between the cloud-based SATO platform and the local devices at the building level. The SATO platform will collect monitored/controlled building and user data, as well as external data useful for the optimal management of the building-as-a-whole (e.g., weather data, dynamic market prices).

On top of the SATO platform, a self-assessment framework with automated SRI capabilities will be implemented to report building energy performance and to engage users in improving their behaviour to improve the buildings' energy efficiency and flexibility.

SATO project will also develop novel energy management services – the SATO services – that use the SATO platform and show how the SA&O

[6] Panão, Marta JN Oliveira, Nuno M. Mateus, and G. Carrilho da Graça. "Measured and modeled performance of internal mass as a thermal energy battery for energy flexible residential buildings." *Applied energy* 239 (2019): 252-267.

functionality may contribute to lower energy consumption, increase energy flexibility and efficiency of the building and enhance user satisfaction.

To engage different types of stakeholders of the SATO concept, the project will develop novel building interfaces tailored towards the individual user segments. A mobile and web-based application will be implemented, allowing: (i.) building users to monitor and manage the buildings' energy performance remotely, and (ii.) building managers/owners to receive user feedback and preferences to adjust the building environment accordingly. Moreover, a novel BIM interface will be implemented to visualise the results of the SA&O in different scales and aggregation levels.

This overall innovative SATO concept is consequently broken down in individual Key Innovative Elements (KIE) that are enumerated in the table below according to the following categories:

The **1st column** indicates the 'KIE ID' which labels each KIE with an individual identifier to allow for a proper management and cataloguing of the KIE throughout the project.

The **2nd column** indicates the 'KIE description' which describes each KIE in a short and comprehensible manner.

The **3rd column** defines the 'KIE responsible' which indicates the responsible entity to develop and generate the KIE.

The **4th column** indicates the 'Associated WPs' in which KIE is developed and generated.

Table 4 List of KIEs in SATO

KIE ID	KIE description	KIE responsible	Contributors	Associated WPs
KIE1	BIM based input and output system	CYPE	FC.ID, AAU, XTEL	WP3
KIE2	Integrated cloud-based data management and computing platform to control IoT devices at the building level	FC.ID	CYPE, XTEL, EDP CNET, SAGOE, EKAG	WP2
KIE3	Artificial intelligence systems to perform SA&O of a building and its energy consuming equipment	FC.ID	AAU, POLIMI, CYPE, XTEL, VL, EDP CNET, SONAE, AMES, SIP, KI IT, EKAG, SAGOE	WP3
KIE4	SATO supplemental service for new energy consuming devices	SAGOE		WP4
KIE5	Automatic parameter and system identification	AAU	FC.ID KI IT	WP3
KIE6	Energy and thermal efficiency management services	AAU	FC.ID, POLIMI, CYPE, XTEL, MIL, EKAG	WP4
KIE7	Coordinated flexibility management services tool	POLIMI	FC.ID, AAU, EDP CNET, MIL	WP4

KIE8	Aggregated optimal control services tool	FC.ID	AAU, POLIMI, EDP CNET, EKAG	WP4
KIE9	Smart self-assessment services tool	SAGOE	AAU, FC.ID, CORE, VL, SONAE, CYPE, EKAG	WP4
KIE10	Mobile & web-based application for client engagement	FC.ID	EDP CNET, SONAE, FB, AAU, CYPE	WP5
KIE11	Non-intrusive building performance diagnosis	AAU	FC.ID, XTEL, VL, SONAE, SAGOE	WP2
KIE12	Optimised BaB and electric vehicle charging for low cost storage and energy flexibility	EKAG	FC.ID, AAU, CYPE, XTEL, EDP CNET, AMES, SAGOE, SIP	WP6

As none of the KIEs enumerated in the table above have been generated yet, the final catalogue indicated above may differ in the final version of the project in M24 and M36.

3.4.3. Deliverables with high innovation potential

Aside from the KIEs identified in the previous section, the SATO project will generate a significant number of deliverables that are anticipated to have a high innovation potential and are listed in Table 2. These deliverables will be monitored with particular attention being paid at all stages of their development by the Innovation Manager, to ensure that a high degree of innovation is achieved.

The deliverables with high innovation potential within SATO are structured as follows:

The **1st column** indicates the 'Category (CAT)' under which the deliverable can be assigned to. The categories are aligned with the main SATO project pillars including SATO specifications, SATO platform, SATO self-assessment framework, SATO service toolbox, SATO user interfaces as well as the SATO demo and impacts.

The **2nd column** indicates the 'ID' of the deliverable.

The **3rd column** defines the 'Title' of the deliverable.

The **4th column** indicates the 'Due date' of the deliverable until when the deliverable will be generated.

The **5th column** indicates the 'Related Tasks' of the deliverable.

The **6th column** indicates the 'Responsible' entity who will be in charge of the main developments associated to the deliverable.

The **7th column** indicates the 'Type' of the deliverable. Following types of deliverables are foreseen: reports, other (e.g., software/hardware prototypes).

Table 5 List of Deliverables with high innovation potential in SATO

CAT	ID	Title	Due date	Related Tasks	Responsible	Type
SATO specifications	D1.2	Requirements of the self-assessment framework	M7	T1.2	AAU	Report
	D1.4	Description of the system architecture of the SATO platform	M9	T1.3	FC.ID	Report
	D1.7	Business Case, Business Model and Financing	M14	T1.6	CORE	Report
SATO platform	D2.1	Concept of the SRI enabled SATO platform	M7	T2.1	FC.ID	Report
	D2.2	Interfaces between platform, services and stakeholders	M12	T2.2	AAU	Report/Other
	D2.3	Upgrade and firmware modifications to IoT infrastructure	M14	T2.2	AAU	Report/Other
	D2.4	Interoperability between proprietary platforms and SATO platform	M13	T2.3	EDP CNET	Report/Other
	D2.5	SATO platform prototype	M16	T2.4	FC.ID	Report/Other
SATO self-assessment framework	D3.1	Parameter and system identification toolbox for SATO assessments	M17	T3.1	AAU	Report/Other
	D3.2	Data quality and device failure assessments	M12	T3.2	FC.ID	Report/Other
	D3.3	BIM-based sensor location and placement assessments	M15	T3.3	CYPE	Report/Other
	D3.4	Reference energy consumption/ performance database	M12	T3.4	CORE	Report/Other
	D3.5	Equipment/appliances energy performance assessments	M12	T3.5	SAGOE	Report/Other
	D3.6	Building energy performance assessments	M12	T3.6	POLIMI	Report/Other
	D3.7	User and occupancy behaviour assessments	M12	T3.7	AAU	Report/Other

	D3.8	Integrated self-assessment framework prototype	M10	T3.8	FC.ID	Report/Other
SATO service toolbox	D4.1	Energy and thermal efficiency management services tool	M18	T4.1	AAU	Report/Other
	D4.2	Coordinated flexibility management services tool	M18	T4.2	POLIMI	Report/Other
	D4.3	Aggregated optimal control services tool	M20	T4.3	FC.ID	Report/Other
	D4.4	Energy performance self-assessment services tool	M21	T4.4	SAGOE	Report/Other
	D4.5	Integrated SATO services tool set	M15	T4.5	FC.ID	Report/Other
SATO user interfaces	D5.1	BIM-based Interactive Application Design	M15	T5.1	CYPE	Report
	D5.2	WEB-based Interactive Application Design	M15	T5.1	FC.ID	Report
	D5.3	BIM-based Interactive Applications	M20	T5.1	CYPE	Report/Other
	D5.4	WEB-based Interactive Applications	M20	T5.3, T5.4	FC.ID	Report/Other
SATO demo & impact	D6.6	Monitoring and Validation Report of the Pilots	M36	T6.2, T6.3, T6.4, T6.5, T6.6	EDP CNET	Report
	D8.6	SATO inputs to EU policy (EPBD, Ecodesign Directive and Energy Labelling Regulation)	M36	T8.3	POLIMI	Report

3.5. Innovation management framework

3.5.1. Assessment framework

SATO IM assessment framework shall serve as a means of verification to assess the degree of innovation for each of the project results throughout the lifetime of the project while ensuring that the generated results are addressing the evolving needs of the building energy sector and industry landscape. By closely monitoring the release of the project results according to a set of innovation metrics (see subsection 3.5.2), the assessment framework may also lead to the identification of corrective measures in case of deviations from the strategic objectives.

The overall scheme of SATO's IM assessment framework is illustrated in Figure 6.

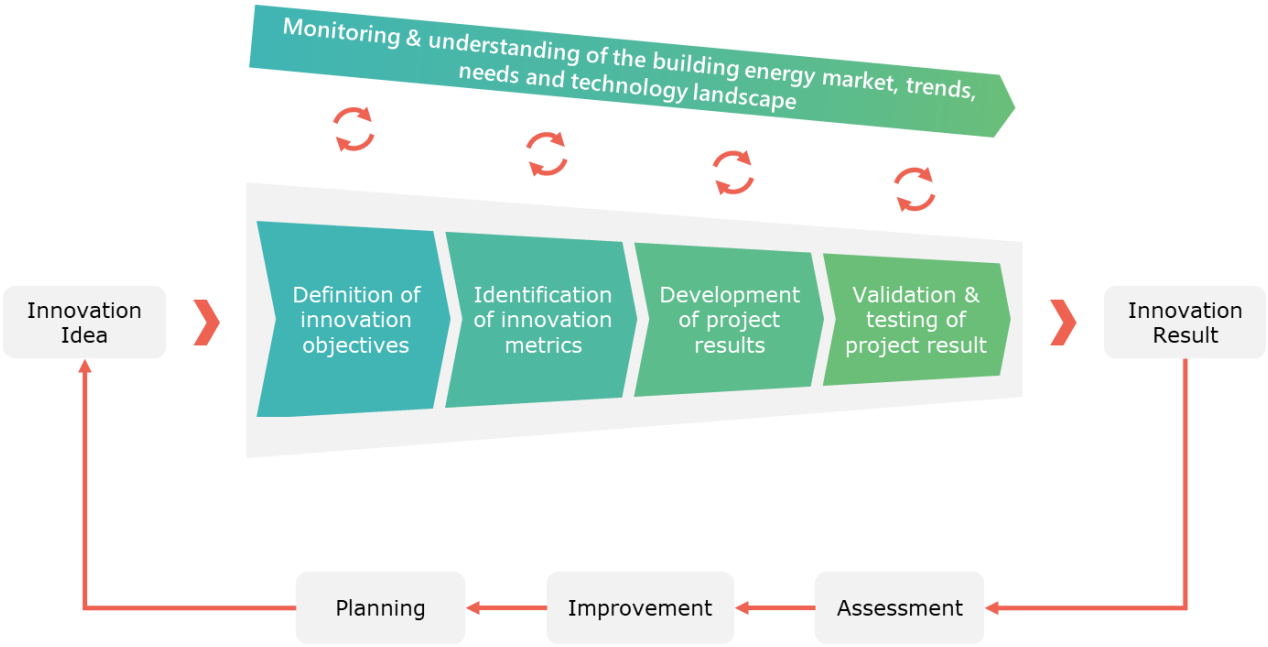

Figure 6 Scheme of SATO IM assessment framework

Each project partner who will generate results with innovation potential (see Table 4 and Table 5) shall define a set of innovation objectives that can be measured and verified by quantifiable innovation metrics to be identified subsequently. According to these initial steps, the project partners shall then develop the project result and they will be tested and validated against the set of innovation metrics defined during the demonstration activities in WP6 of SATO.

During the demonstration activities and before the project's end, each partner shall assess if the expected degree of innovation is met. In case project results do not achieve the expected degree of innovation, the responsible to generate the result with strong support of the Innovation Manager and WP leader shall suggest and plan corrective measures to improve the degree of innovation until the innovation metrics are reached.

The Innovation Manager shall continuously liaise with WP leaders to assess the degree of innovation of the activities executed therein against the Innovation management plan (present report). This will be done also collectively for all WPs, due to the high degree of interconnectivity and interdependency of the SATO activities. Thereby, the Innovation Manager with the support of the Advisory Board members shall monitor and understand the evolving market, trends, needs and landscape of the building energy sector and ensure that the information gathered is reverted to the project result responsible.

3.5.2. Key performance indicators and innovation metrics

A preliminary set of innovation metrics that shall serve as a means of verification of the innovation objectives for each of the KIEs and project results has been defined. In the second version of the Risk, Innovation and Data Management Plans (M24), the list of innovation metrics will be completed. The preliminary set of metrics is listed in Table 6.

The **1st column** indicates the 'ID' of the innovation metric (IME).

The **2nd column** indicates the 'Description' of the IME.

The **3rd column** indicates the 'Category' of the IME.

The **4th column** indicates the 'Target value' of the IME against which the project result will be validated.

Table 6 List of SATO innovation metrics

IME ID	Description	Category	Target value
IME1	Technological readiness of the project result	Technology	7-8
IME2	Commercial readiness index of the project result	Market	1-3
IME3	Number of patent applications triggered	Technology	TBD
IME4	Number of new ideas for follow up developments triggered	Technology	TBD
IME5	Number of scientific publications and conference/congress presentations triggered	Science	TBD
IME6	Number of new products/services released as a direct consequence of the project result	Business	TBD
IME7	Number of clients using the product/services/software/hardware	Market	TBD
IME8	User satisfaction level	Market	TBD
IME9	Number of contributions to building standards and EU policy (EPBD, Ecodesign Directive and Energy Labelling Regulation)	Policy	TBD

4. Data Management Plan

4.1. Data set description methodology

Within this subsection, the methodology to define and collect the data sets to be generated or acquired, the origin, nature, and scale, and to whom it could be useful, and whether it underpins a scientific publication or not, is described. In addition, information and guidelines on the reuse of the data are detailed.

As the SATO project is still in the initial phase of its implementation, it is not possible to list the data that will be generated/acquired in the project, since relevant activities towards data sets' identification are still being carried out in WP1 – Specifications and Requirements for SATO, WP2 – Development of integrated technical Platform for SATO, WP3 – Development of SATO Self-Assessment Framework, WP4 - Development of SATO SA&O Services Toolbox, WP5 – Development of SATO User Interaction and Interfaces and WP6 – Pilot Deployment and Evaluation of SATO.

A first comprehensive list of the data sets to be generated/acquired within SATO will be identified in D1.2 - Requirements of the self-assessment framework. Thereupon, a set of use cases (D1.4) will be detailed

for each of the SATO pilots according to which the data sets to be collected during the demonstration phase can be specified (D1.5) to allow for the validation and evaluation of the SATO use cases. The final description of the data sets to be generated/acquired will be included in the updated version of the D9.8 in M24. The next version of D9.8 will, as well, characterize the identified data sets as defined in the subsection 4.3 on "Data Management, Sharing & Open Access".

Table 7 defines the tool that will be used to characterize and describe the data sets that are expected to be generated/acquired by the project. The table includes standardized items under which every data set will be classified.

The **1st column** indicates the 'Data set ID'. The ID of the data set shall be a unique identifier of the individual data set and shall ensure proper cataloguing of the data set.

The **2nd column** indicates the 'Title of the data set'. The title of the data set shall be self-explanatory regarding the nature and purpose of the data set.

In the **3rd column**, the 'Filename' under which the data set will be stored/archived/curated is specified.

The **4th column** specifies the WPs for which the data set is generated or acquired.

In the **5th column**, the Pilot name corresponding to the data set is specified. Here, it shall be distinguished between residential, commercial/service, and public buildings.

The **6th column** indicates the consortium partner(s) and/or contact person(s) responsible for the data set.

In the **7th column**, the 'Relation to the project objective' is detailed. The relation adheres to the subordinate 4 specific objectives of SATO Project:

- Objective 1: Implement and test a cost-effective solution to assess the real-life energy performance of a building and its energy consuming equipment.;
- Objective 2: Development of user-centred self-optimized energy management services (SATO services). The proposed SATO services use the SATO platform and the self-assessment framework (SAF) to efficiently control building equipment for simultaneous optimization of energy efficiency, flexibility and user satisfaction;
- Objective 3: Develop BIM and WEB-based interfaces for the SATO platform. A 3D CAD tool BIM interface will be used for large buildings. Small buildings/fractions or apartments will rely on a WEB-based interface;
- Objective 4: Implement a set of diverse building pilots to test and demonstrate the SATO platform, SAF and services. The SATO project includes eight pilots in three different climate regions. Pilots involve control, assessment, and optimization of systems with long lifecycles (SATO-BMS) and shorter lifecycles (SATO-APL), and an AI powered comparative assessment tool (SATO Compare).

In the **8th column**, the 'Data type' of the data set is indicated. The expected data types include but are not limited to:

- Integers;
- Booleans;

- Characters;
- Floating-point numbers;
- Alphanumeric strings;
- Other (to be specified).

The **9th column** specifies the 'Data format' of the data set. The expected data formats include but are not limited to:

- ASCII text-formatted data (TXT);
- CAD data (DWG);
- Comma-separated values (CSV);
- dBase (DBF);
- eXtensible Mark-up Language (XML);
- Tab-delimited file (TAB);
- JavaScript Object Notation (JSON);
- Geospatial open data based upon JSON (GeoJSON);
- Geo-referenced TIFF (TIF, TFW);
- Hypertext Markup Language (HTML);
- Keyhole Markup Language (KML);
- MS Word (DOC/DOCX);
- MS Excel (XLS/XLSX);
- MS Access (MDB/ACCDB);
- OpenDocument Spreadsheet (ODS);
- Open Document Text (ODT);
- Rich Text Format (RTF);
- SPSS portable format (POR);
- Other (to be specified).

The **10th column** details the 'Description of the data set'. The description of the data set shall be clear and precise so that each data set can be distinguished from the others by the information enclosed[7].

The **11th column** indicates the 'Origin of the data'. The origin of the data set shall indicate how the data was collected and what kind of equipment was used to obtain the data set.

In the **12th column**, it is specified whether the data is personal (traced back to an individual entity) or not. This characteristic shall help to identify sensitive data in terms of GDPR as well as requirements emanating from ethical, data privacy and security considerations at the point where it is generated/acquired.

[7] NOTE: It may be sufficient to introduce keywords in context with the data set description. The keywords used shall still allow to identify each data set individually. The characterisation of the data sets based on keywords may allow the use of database tools, such as SQL to organise, maintain and access the data sets during SATO project.

Table 7 Template for characterization and description of the data sets

Data set ID	Title of data set	Filename	WPs included	Pilot name	Responsible Partner	Relation to project objective	Data type	Data format	Description of data set	Origin of the data	Personal data
DS_1											
DS_2											
…											
DS_{n-1}											
DS_n											

This project receives funding in the European Commission's Horizon 2020 Research Programme under Grant Agreement Number 957128.

Complementing Table 7 on the characterization of the data sets, a second table will be used (Table 8) to specify the physical instances of the data set (building, origin equipment/tool, repository equipment/tool as well as communication between origin, repository and access rights).

The **1st column** indicates the 'Data set ID'. The ID of the data set shall be a unique identifier of the individual data set and shall ensure proper cataloguing of the data set. It must be one of the entries in Table 7.

In the **2nd column**, the 'Building' shall specify the building type where the data set was collected from.

The **3rd column** specifies the 'Origin equipment/tool' from which the data set is collected, generated, or acquired.

In the **4th column**, the 'Repository equipment/tool' shall specify the devices used to receive, store, and process the data.

The **5th column** indicates the 'Communication between origin and repository' used to send/receive the data from the origin to the repository.

The **6th column** indicates the 'Access level' to specify whether the data set is confidential or public.

Table 8 Template to specify the physical instances of the data set

Data set ID	Building	Origin equipment/tool	Repository equipment/tool	Communication between origin and repository	Access level
DS_1					
DS_2					
…					
DS_{n-1}					
DS_n					

This table will further contextualise data sets within SATO project, directly linking them with demo sites and hardware and software.

4.2. Ethics, Privacy and Security considerations

The SATO project involves carrying out data collection (in the context of the piloting and validation phase in WP6) and a set of large-scale validation tests to assess the technology and effectiveness of the proposed building energy management solutions in real life conditions. Hereby, the data management plan specifies ethics, privacy, and security considerations to comply with all European and national legislation and directives relevant to the country where the data collections are taking place and, moreover, where the data set is curated and preserved.

This project receives funding in the European Commission's Horizon 2020 Research Programme under Grant Agreement Number 957128.

As SATO project includes multiple building typologies (residential, commercial/service, public) with diverse characteristics and specific objectives, the nature of the collected and processed data is heterogenous. To cope with the different nature of the data sets, methodologies to address ethical requirements as well as data privacy and security are of utmost importance to establish a general framework in this heterogenous data environment.

The following three subsections will detail the different methodologies and principles used to address privacy and data protection issues raised by the project's activities.

4.2.1. Ethics requirements

The internal ethical agenda of SATO follows the guidelines of various expert communities in the field of data ethics (e.g. the European group on ethics in science and new technologies to the European Commission). The ethical agenda includes a code of conduct to specify correct behaviour and corresponding principles in relation to data collection and processing. The following six principles are contemplated and addressed within SATO ethical code of conduct:

1 **Ownership** – Who is the owner of the data (e.g. individuals own their own data)?

2 **Transaction transparency** – What access is given to the owner and how transparent is the access? A transparent access for the use of the individual's personal data must be established. The individuals should have full and transparent access to the data sets.

3 **Consent** – Which individuals or other entities need to give consent to use the data? Individuals or other entities shall be explicitly informed of what personal data is being provided by the owner of the data, to whom it is being provided, when, and for what purpose.

4 **Privacy** – What efforts and measures are in place to ensure data privacy? In terms of data processing, the project partners are obliged to invest all reasonable effort to preserve the privacy of the individual.

5 **Currency** – If applicable, what is the financial value of the personal data and how is that communicated with the owner of the data? Individuals shall be explicitly informed of any financial transactions resulting from their data.

6 **Openness** – How much of the aggregated data sets are freely available? If applicable, under adherence to point 1. to 5., aggregate data should be freely available for the owner of the data.

Adherence to these principles will ensure the responsible and sustainable use of the data generated and processed in SATO. The ethical code of conduct shall further serve as a complement to the mere compliance with data protection laws and current regulations (specified in the next section). In fact, the code of conduct of SATO shall reflect a principle that promotes honesty and genuine transparency in data management.

Besides the six principles, any data generation/acquiring activity involving humans will be strictly held confidential at any time of the research. This entails the following practical actions each project partner shall obey while interacting with volunteers/individual stakeholders:

1. Volunteer participants recruitment: research participants will be recruited for the residential pilots and, eventually, for office building pilots when/if building zones with permanent single occupants or permanent small groups of occupants are considered. The recruitment will be carried out by the pilot owners, based on the participants free and voluntary willingness to participate in the project pilot. All potential participants will be provided with clear information

on the project and will be asked to give consent in writing. To this end, an informed consent procedure will be adopted, in accordance with EU and relevant national regulations.

2. Informed consent procedure: informed consent forms will be employed in the language of the potential participants and in terms easily understandable. An information sheet will accompany the consent form to convey relevant information on the project and on the participant involvement. It will explicitly inform all participants about the first six principles of the code of conduct and give them the opportunity to provide their consent to the data management process by informing all participants about the following set of questions: Why the data is being collected? How is it going to be used? How long it will be stored? How it can be amended by the individual concerned? Additionally, it will inform volunteers on the personal data protection mechanisms in place and on the right to refuse to participate and to withdraw the participation and data;
3. Ensure volunteers that no personal or sensitive data will be centrally stored without appropriate anonymization and encryption mechanisms. In addition, the volunteers shall be informed about the data security measures in place (see subsection 4.2.3 Data Security) to avoid potential identification of individuals.

The briefing and information provided shall be conducted in the volunteers' native language. Additional information provided shall include a (i) written description of the project and its goals, (ii) the project's progress and the related testing, evaluation, and validation procedures (respecting SATO confidential information), and (iii) information on unrestricted disclaimer rights on their agreement.

To oversee the adherence of the SATO consortium to the ethical code of conduct and to establish an entity communicating with the European Commission, an Ethics Manager shall be appointed as part of the Project Management Support Team. The Ethics Manager will be responsible to check that all activities follow the ethics, privacy and security considerations detailed in this chapter.

4.2.2. Data privacy and personal data

SATO project will engage different building typologies collecting multiple sets of data and carrying out various measurements of data per building. Hence, the project stakeholders (internal and external) as well as the occupants affected by the data collection will vary from building to building.

The collection, processing and transmission of personal data will be analysed under principles of:

a. The recently published GDPR (Regulation (EU) 2016/679);
b. The Universal Declaration of Human Rights and the Convention 108 for the Protection of Individuals with regard to Automatic Processing of Personal Data; and
c. the applicable national laws.

Any additional regulations at national level that do not fall under the GDPR and apply to data protection or any other sensitive information will also be considered.

The project will respect the privacy of all stakeholders and citizens and follow a stakeholder management procedure assuring that stakeholders and citizens are fully informed about their rights, the objective and handling of their data. The stakeholder management procedure obliges the project partners to obtain consents where personally identifiable data is collected and processed as described above, implementing suitable data handling procedures and protocols to avoid potential identification of individuals. This will include participants' data sets in activities that use techniques such as interviews, questionnaires, workshops, or mailing lists as well as building, energy, and mobility data collection.

Data managed during the project will be processed only under the following preconditions which need to be met:

1. When the data subject has given her/his consent;
2. When the processing is necessary for the performance of or the entering into a contract;
3. When processing is necessary for compliance with a legal obligation; and
4. When processing is necessary in order to protect the vital interests of the data subject.

To this end, personal data managed within SATO will be anonymised and stored in a form which, when desired, does not permit identification of users, buildings, or devices. SATO will establish a data management framework that guarantees the security of collected personal data from potential abuse, theft, or loss. Privacy and security mechanisms will be embedded in the SATO platform design and configured appropriately for the specific privacy requirements of distinct data sources.

This framework will establish the guidelines that the project partners shall obey when data is generated/acquired, transferred and stored, as well as preserved and curated.

The SATO Ethics Manager and Data Protection Officer will be responsible to ensure the consortium's compliance with the laid-out data protection and privacy measures. The Ethics Manager will be assisted by one partner representative per beneficiary (if necessary). The Ethics Manager and Data Protection Officer will further support the consortium partners in the process of generating/acquiring data and consult both the internal and external stakeholders of SATO during any activity related to the generation/acquisition, handling, sharing and curation of data.

4.2.3. Data security

A fundamental task is to manage the data in a secure way. Besides using anonymisation techniques to anonymise identifiers of buildings, persons, or devices, SATO will promote data encryption and backup distribution dealing with sensitive data of individual stakeholders. Moreover, the goal of these measures will be to ensure that data remains consistent over the lifetime of the project and there exist alternatives to the main files in case they disappear or get corrupted. The encryption component adds an extra layer of security to the data files and information.

For each data set (which will be classified with Table 8 and Table 9, at least), the partners will state the provisions and measures to be implemented to ensure data security, privacy, and ethical requirements.

The secure management of information will adhere to the guidelines of relevant standards (e.g. ISO/IEC 27001 and 27002; Code of practice for information security management) to ensure the triad of cyber security:

- **Confidentiality** – Preventing unauthorised disclosure of information;
- **Integrity** – Assuring that data cannot be modified in an unauthorised manner;
- **Availability** – Making information available for authorised users.

The information security management will further contain the Directive on security of network and information systems ('Cybersecurity directive', NIS-Directive 2016/1148) on the security of critical infrastructures and the ePrivacy Directive 2002/58, as well as European Union Agency for Network and Information Security (ENISA) guidance. Storage of information will fully comply with the national and EU legal and regulatory requirements.

The processes on privacy and security applying to the building sector already established as well as data security measures and engineering best practices considered will be encapsulated in the first update of the data management plan by M24.

4.3. Data management, sharing and open access

SATO will implement a comprehensive data management system complying to the ethics, privacy and security considerations mentioned above, facilitating a swift processing between the project participants.

After the data sets have been generated/acquired, the procedures on how the data is managed shall ensure trackability, transparency and usability among the consortium partners.

In general, SATO data management plan details four different categories of data generated or acquired in the project:

Research data – all the data necessary to evaluate the quantitative or qualitative KPIs of the project and data necessary to validate the results presented in public deliverables or scientific publications. The consortium strongly believes in and applies the concepts of open science, and benefits arising from the European innovation ecosystem and economy by facilitating the reuse of data at a larger scale. The data management plan covers the entire research data life cycle and must be consistent with exploitation and IPR requirements. Hence, research data linked to exploitable results will not be put into the open domain if they compromise its commercialization prospects or have inadequate protection, which is also a H2020 obligation. The Project Coordinator will be responsible to ensure that provisions on Scientific publications and guidelines on Data Management in H2020 are adhered to. As indicated, scientific research data should be findable, accessible interoperable and reusable (FAIR) to ensure it is soundly managed beyond the original purpose for which it was collected.

Operational and observational data – all the data, raw data generated/acquired as well as curated data during the implementation, testing and operation of the demonstration activities (operational data), and data from qualitative activities including surveys, interviews, fieldwork data or, engagement activities (observational data, such as the one that will be collected under WP1 and WP5 including activities on user engagement). Particularly, sensitive data provided by consortium partners for the demonstration scenarios and personal data of individual stakeholders will be kept strictly confidential to protect their competitive advantage and in terms of personal data anonymized and secured to maintain compliance to GDPR.

Monitoring and evaluation data – all the data related to the monitoring of project specific KPIs to track the performance of the project (WP6). This data will be regularly reported and published in relevant repositories in an open way for the project partners and in a restricted way as part of a report (D6.6) accessible for the public.

Documentation, instruments, and reusable knowledge – all the data and documentation produced by SATO consortia, including specific documentation of the project and demonstration and implementation activities, such as tools, equipment, instruments, software, and underlying source code. The data management plan covers the entire research data life cycle and must be consistent with exploitation and IPR requirements. In terms of public results, sufficient and consistent documentation and publication will support the project's dissemination activities. All public Deliverables will be published on the project website in Open Access.

4.3.1. Data handling and management

SATO will ensure that all the research data generated is findable, accessible, interoperable, and reusable (FAIR) complying with the H2020 Guidelines on FAIR Data Management. To implement FAIR Data Management, SATO will facilitate the use of a data handling system following the template presented in Table 9.

In the **1st row,** the 'Data set ID' shall be indicated.

In the **2nd row,** a 'Short description' of the data set shall be provided.

The **3rd row** indicates the 'Purpose and relevance of data collection and relation to objectives' to ensure that the data set is required for the implementation of the project.

The **4th row** specifies the 'Methodology' used to collect the data set, how it will be handled and managed.

In the **5th row**, the 'Data source, data ownership' shall be specified including the origin of the data set according to Table 8 and Table 9 as well as the ownership of the data.

The **6th row** shall specify any relevant standards and privacy considerations associated to the data set.

The **7th row** 'Storage' shall indicate how the data is stored, for how long and who will have access to the stored data.

The **8th row** shall specify whether the data set is related to any partner's 'Exploitation/Dissemination' activities.

The **9th row** shall specify the 'Dissemination level, Limitations, Approach, Justification' of the data set.

The **10th row** shall specify the 'Stakeholders' associated to the data set besides the owners of the data.

Table 9 Template for data handling and management summary

Data handling and management	
Data set ID	
Short description	
Purpose and relevance of data collection and relation to objectives	
Methodology	
Data source, data ownership	
Standards, data formats, vocabularies	
Storage	
Security and privacy considerations	
Exploitation/Dissemination	

Dissemination level, Limitations, Approach, Justification	
Stakeholders	

The template will serve as a guideline to detail the description, purpose, and relevance of the data sets as well as the methodology and collection procedure used to obtain them. Furthermore, this data management system allows to complement the general information enclosed in Table 8 and Table 9, by addressing the question of ownership, which standards are applicable, how the information is stored and what data security and privacy considerations shall be considered and/or applied.

For data sets that are further used in publications and/or deliverables because of SATO, the deliverable, corresponding dissemination level and the stakeholders involved shall be detailed. In case the assessment changes, of whether a data set will be published as part of a deliverable or not, the responsible consortium partner shall update the status of each data set as soon this can be foreseen.

To assure the trackability and transparency of responsibilities for each data set, the concept of a Responsibility Assignment Matrix is incorporated, in an adapted way towards the data management topic. In Figure 7, the basic concept of this approach is illustrated.

	Partner 1	Partner 2	...	Partner n-1	Partner n
DS1		R,C,G			
DS2	R	C		G	
...				C	
DSn-1	C	G		R	
DSn	R				G

R Responsible

G Gatherer

C Curator

Figure 7 SATO data handling and management approach

In the rows of the Responsibility Assignment Matrix all the data sets generated/acquired are listed, whilst the columns are assigned to individual project partners. The matrix itself abstracts three different forms of data responsibility: the Responsible (R), the Gatherer (G) and the Curator (C). One partner could potentially cover all the responsibility layers vertically (see Partner 2 for Data set 1 in Figure 2).

The specific tasks corresponding to each responsibility level include but are not limited to:

I. **Responsible** - responsible to track the data set through its entire life cycle during SATO project and beyond. The data set Responsible shall further liaise with the Gatherer and Curator to ensure transparency and compliance of tall activities concerning the data set.

II. **Gatherer** - including all the tasks related to the collection or generation/acquisition of the data set. The Gatherer shall assure that the data is collected in an appropriate way and complying to the general procedures stated in the data management plan.

III. **Curator** - responsible to archive and, if applicable, preserve the data set during the project and 5 years after the project's completion. The Curator is further responsible to ensure that the guidelines on data curation and preservation detailed in the following section are implemented (e.g., appropriate storage of data set in repository, costs in relation to data curation, etc.).

IV. Both guidelines, the Data Handling System and the Responsibility Assignment Matrix, will ensure that the data sets are clearly documented, and responsibilities are well defined within the life cycle of SATO project.

All information and data gathered and elaborated will be appropriately described in the respective deliverables. All public deliverables will be made available and archived on the project website and through the EU Community Research and Development Information Service (CORDIS) for the project. The project aims to make research data and publications that comply with the ethics, privacy, and security considerations freely available through *Open Access* and suitable repositories.

4.3.2. Sharing and open access

The activities within SATO will include several public deliverables as well as scientific and other publications. The consortium will provide timely open access to research data in project-independent repositories and provide the link to the respective publications, to allow the scientific community to examine and validate the results based on the underlying data.

The policy for open access to research data and publications follows the H2020 Guidelines to Open Access. It is the will and commitment of the partners to share non-commercially sensitive knowledge and experience with the building sector to ensure learning is transferred and errors are not repeated. The consortium members have committed to allocate specific budget to ensure and encourage the academic partners to publish research results as Gold Open Access. The policy for open access to research data (technical platform, energy services, non-personal data, knowledge, etc.) arising from this project is illustrated in Figure 8.

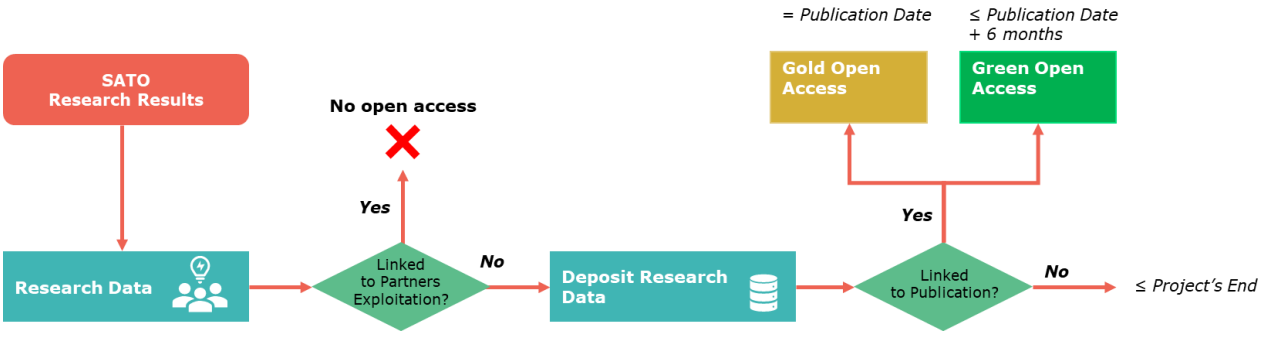

Figure 8 SATO research data sharing process

In case *Gold Open Access* in peer-reviewed repositories cannot be achieved, the consortium will resort to *Green Open Access* strategy.

4.3.3. Document management

All documents and files generated within the SATO are handled in a project specific cloud platform set up by the Project Coordinator to ease the collaboration and increase transparency among the various consortium partners to locate and access the project documentation. The naming and terminology of the files and documents follows a rigid structure agreed on by all consortium partners, addressed in D9.2 – Project Management Plan.

The partners are responsible that the documents and files they upload are complying to the overall guidelines laid-out in this data management plan. The partners are advised to coordinate the sharing of sensitive documents with the SATO Ethics Manager and Data Protection Officer.

4.3.4. Data curation and preservation

This subsection describes the procedures for the long-term curation and preservation of the data. The procedures included will indicate how long the data shall be stored, where it will be stored and what costs are associated with it.

Public deliverables will be published and curated on the project website while internal data sets will be backed up to allow recovery for re-use and/or verification. Primary data will be archived for a minimum of years, to be determined still, by the data responsible/partner generating the data.

The classification system presented in Table 10 shall facilitate appropriate measure for the data curation and preservation procedures.

The **1st column** indicates the 'Data set ID'. The ID of the data set shall be a unique identifier of the individual data set and shall ensure proper cataloguing of the data set.

The **2nd column** indicates the 'Storage location' where the data set is stored during the project.

In the **3rd column**, the 'Type of repository' where the data set will be stored/archived/curated is specified.

The **4th column** specifies the 'Time period' for how long the data set will be preserved after the project's end.

In the **5th column**, the 'Approximated volume' of the data set shall be detailed to anticipate a reasonable size and associated costs of the preservation repository.

The **6th column** specifies the 'Storage repository' where the data set will be preserved after the project's end.

The **7th column** specifies the 'Associated costs for preservation' of the data set according to the approximated storage/repository volume.

Table 10 Template for data curation and preservation

Data set ID	Repository		Long-term preservation plan			
	Storage location	Type of repository	Time period	Approximated volume	Storage repository	Associated costs for preservation
DS_1						
DS_2						
…						
DS_n						

5. Conclusion

The present deliverable constitutes the first version of the D9.8 – Risk, Innovation and Data Management Plans for SATO project at the time of delivery: March 2021. This document presents overlying guidelines and best practices used concerning all activities related to the management of risks, innovation, and data throughout the project.

More detailed procedures, descriptions, forms, etc. will be added as they become available through the ongoing work in the respective WPs whilst existing templates will be verified, complemented, and maintained. The next update (due to Month 24) will include detailed data set descriptions for the activities within that period.