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Executive summary

The SWICE consortium aims to identify and quantify the energy saving potential and opportunities for increased quality of life that can emerge from future urban scenarios involving new modalities of living and working, changes in leisure and mobility behaviours. Besides aiming to propose environmental and technological solutions, this research project builds upon the premise that energy demand is, first and foremost, an outcome of social dynamics, involving complex patterns of energy usage and requiring creative approaches in material flows. As a result, it considers the focus on the wellbeing of people, seen both as individuals and as a collectivity, as a crucial component of the energy transition, which, to be successful, must be socially embraced and implemented in the physical spaces we inhabit. Aligned with Switzerland's Energy Strategy 2050 and net-zero targets, SWICE aims therefore to integrate sufficiency, well-being, and low-carbon strategies into renovation practices and neighborhood development, while maintaining a strong focus on social inclusion and resilience.

The consortium brings together a range of different disciplines spanning across Geography, Sociology, Social-Psychology, Transportation, Engineering, Economics and Architecture, allowing to create research synergies on multiple levels and tackle the project's objectives with a holistic approach. Transdisciplinarity is equally central, with more than 20 cooperation partners and more than 30 other local stakeholders actively involved in designing and implementing solutions, ensuring that scientific advances are rooted in real-world applicability.

The SWICE project incorporates six Living Labs across Switzerland accounting for a participative involvement of stakeholders at different levels (residents and employees, property managers, businesses and communes/cities). Living Labs serve as the core observation platforms for research activities as well as for implementation projects where the sufficiency and wellbeing challenges addressed by SWICE are translated into action.

Since its launch, SWICE has advanced theoretical frameworks, practical tools, and real-world applications. Year 4 marked a consolidation and expansion of implementation, with a stronger emphasis on co-designed interventions, cross-work package integration, and translation toward policy and practice. Living Labs matured into active experimentation environments, where multi-stakeholder processes were used to co-create and test neighborhood-scale transformation scenarios, governance models, and targeted behavioral interventions. Advanced analytical and digital tools were further developed and deployed, including AI-powered knowledge platforms, human-centered digital twins of the Swiss building stock, decision-support systems, and participatory simulation tools. Integrated modelling frameworks linking energy performance, indoor and urban environmental quality, and health outcomes were operationalized, alongside spatial planning algorithms for resilient neighborhood transformation.

Zusammenfassung

Das SWICE-Konsortium zielt darauf ab, das Energieeinsparpotenzial sowie die Chancen zur Steigerung der Lebensqualität zu identifizieren und zu quantifizieren, die sich aus zukünftigen urbanen Szenarien ergeben können – darunter neue Wohn- und Arbeitsformen sowie Veränderungen im Freizeit- und Mobilitätsverhalten. Neben der Entwicklung umweltfreundlicher und technologischer Lösungen beruht das Projekt auf der Annahme, dass Energiebedarf in erster Linie das Ergebnis sozialer Dynamiken ist. Diese beinhalten komplexe Nutzungsmuster und erfordern kreative Ansätze im Umgang mit Stoffflüssen. Im Zentrum steht dabei das Wohlbefinden der Menschen – sowohl individuell als auch kollektiv –, das als entscheidender Bestandteil der Energiewende verstanden wird. Eine erfolgreiche Transformation muss gesellschaftlich getragen werden und sich in den physischen Räumen manifestieren, in denen wir leben. Im Einklang mit der Energiestrategie 2050 und den Netto-Null-Zielen der Schweiz will SWICE daher Strategien der Genügsamkeit, des Wohlbefindens und der CO₂-Reduktion in Renovierungspraktiken und Quartiersentwicklungen integrieren – stets mit Fokus auf soziale Inklusion und Resilienz.

Das Projekt Konsortium zahlreiche Disziplinen, darunter Geografie, Soziologie, Sozialpsychologie, Verkehrswesen, Ingenieurwesen, Wirtschaft und Architektur. Dadurch entstehen interdisziplinäre



Forschungssynergien, die eine ganzheitliche Herangehensweise an die Projektziele ermöglichen. Transdisziplinarität ist ebenfalls zentral: Über 20 Kooperationspartner und mehr als 30 lokale Akteure sind aktiv an der Entwicklung und Umsetzung von Lösungen beteiligt, um sicherzustellen, dass wissenschaftliche Erkenntnisse praxisnah angewendet werden.

SWICE umfasst sechs Living Labs in der ganzen Schweiz, die eine partizipative Einbindung verschiedenster Interessengruppen (Bewohner*innen, Angestellte, Immobilienverwalter, Unternehmen und Gemeinden/Städte) ermöglichen. Diese Living Labs dienen als zentrale Beobachtungsplattformen für Forschungsaktivitäten und als Räume für konkrete Umsetzungsprojekte, in denen die Herausforderungen von Genügsamkeit und Wohlbefinden praktisch angegangen werden.

Seit dem Projektstart hat SWICE theoretische Rahmenwerke, praxisorientierte Instrumente und reale Anwendungen entwickelt. Jahr 4 war geprägt von einer Konsolidierung und Ausweitung der Umsetzungsphase, mit einem stärkeren Fokus auf ko-kreierte Interventionen, die Integration zwischen den Arbeitspaketen sowie die Überführung der Ergebnisse in Politik und Praxis. Die Living Labs entwickelten sich zu aktiven Experimentierungsumgebungen, in denen Multi-Stakeholder-Prozesse genutzt wurden, um Transformationsszenarien auf Quartiersebene, Governance-Modelle und gezielte Verhaltensinterventionen gemeinsam zu entwickeln und zu testen. Fortschrittliche Analyse- und Digitalwerkzeuge wurden weiterentwickelt und eingesetzt, darunter KI-gestützte Wissensplattformen, menschenzentrierte digitale Zwillinge des Schweizer Gebäudebestands, Entscheidungsunterstützungssysteme sowie partizipative Simulationsinstrumente. Integrierte Modellierungsansätze, die Energieperformance mit Innen- und Außenraumqualität sowie gesundheitlichen Auswirkungen verknüpfen, wurden operationalisiert, ebenso wie räumliche Planungsalgorithmen für resiliente Quartiersentwicklung.

Résumé

Le consortium SWICE vise à identifier et quantifier le potentiel d'économie d'énergie et d'amélioration de la qualité de vie qui peuvent émaner de futurs scénarios urbains impliquant de nouvelles modalités de vie et de travail, ainsi que des changements dans les comportements de loisirs et de mobilité. En plus de proposer des solutions environnementales et technologiques, ce projet repose sur le postulat que la demande énergétique est avant tout le résultat de dynamiques sociales, impliquant des schémas complexes d'utilisation de l'énergie et nécessitant des approches créatives dans les flux de matériaux. En conséquence, il considère que le bien-être des personnes, vues à la fois comme individus et comme collectivité, constitue un élément essentiel de la transition énergétique, laquelle, pour réussir, doit être socialement acceptée et mise en œuvre dans les espaces physiques que nous habitons. Aligné avec la Stratégie énergétique 2050 de la Suisse et les objectifs de neutralité carbone, SWICE vise ainsi à intégrer la sobriété, le bien-être et les stratégies bas carbone dans les pratiques de rénovation et le développement des quartiers, tout en maintenant un fort accent sur l'inclusion sociale et la résilience.

Le consortium SWICE réunit un large éventail de disciplines, y compris la géographie, la sociologie, la psychologie sociale, le transport, l'ingénierie, l'économie et l'architecture, permettant de créer des synergies de recherche à plusieurs niveaux et de répondre aux objectifs du projet avec une approche holistique. La transdisciplinarité est également centrale, avec plus de 20 partenaires de coopération et plus de 30 autres parties prenantes locales activement impliquées dans la conception et la mise en œuvre des solutions, garantissant ainsi que les avancées scientifiques soient ancrées dans la réalité.

Le projet SWICE comprend six laboratoires vivants ("Living Labs") répartis en Suisse, assurant la participation active de parties prenantes à différents niveaux (résidents et employés, gestionnaires immobiliers, entreprises et communes/villes). Ces laboratoires vivants servent de plateformes d'observation pour la recherche ainsi que de terrains d'expérimentation pour des projets concrets, où les défis liés à la sobriété et au bien-être sont traduits en actions concrètes.

Depuis son lancement, SWICE a développé des cadres théoriques, des outils pratiques et des applications concrètes. La quatrième année a marqué une consolidation et une extension de la



phase de mise en œuvre, avec un accent renforcé sur les interventions co-conçues, l'intégration entre les work packages, et la traduction vers les politiques publiques et la pratique. Les Living Labs ont évolué en environnements d'expérimentation active, où des processus multi-acteurs ont permis de co-concevoir et de tester des scénarios de transformation à l'échelle des quartiers, des modèles de gouvernance et des interventions comportementales ciblées. Des outils analytiques et numériques avancés ont été développés et déployés, notamment des plateformes de connaissance basées sur l'IA, des jumeaux numériques centrés sur l'humain du parc bâti suisse, des systèmes d'aide à la décision et des outils de simulation participatifs. Des cadres de modélisation intégrés reliant performance énergétique, qualité environnementale intérieure et urbaine, et impacts sur la santé ont été opérationnalisés, ainsi que des algorithmes de planification spatiale pour des quartiers résilients.

Riassunto

Il consorzio SWICE ha come obiettivo l'identificazione e la quantificazione del potenziale di risparmio energetico e delle opportunità per una migliore qualità della vita che possono emergere da futuri scenari urbani caratterizzati da nuove abitudini legate alla vita privata e professionale, allo svago e alla mobilità e a modelli di business alternativi. Oltre a proporre nuove soluzioni ambientali e tecnologiche, il progetto parte dalla premessa che la domanda di energia è, prima di tutto, un risultato di dinamiche sociali, che coinvolgono complessi modelli di consumo di energia e richiedono approcci creativi in termini di flusso di risorse. Di conseguenza il progetto considera il benessere delle persone, viste nella loro dimensione individuale e collettiva, come una componente cruciale della transizione energetica che, per avere successo, deve essere socialmente accettata e implementata negli spazi fisici che abitiamo. In linea con la Strategia energetica 2050 della Svizzera e gli obiettivi di neutralità climatica, SWICE mira a integrare strategie di sobrietà energetica, benessere e basse emissioni di CO2 nelle pratiche di riqualificazione e nuovo sviluppo di quartieri, mantenendo un forte focus sull'inclusione sociale e sulla resilienza.

Il consorzio SWICE riunisce un'ampia gamma di discipline – geografia, sociologia, psicologia sociale, trasporti, ingegneria, economia e architettura – creando sinergie di ricerca su più livelli e affrontando gli obiettivi del progetto con un approccio olistico. La transdisciplinarietà è centrale: più di 20 partner di cooperazione e oltre 30 attori locali sono attivamente coinvolti nella progettazione e nell'attuazione delle soluzioni, garantendo che i progressi scientifici siano radicati nella realtà applicativa.

Il progetto SWICE comprende sei Living Lab distribuiti in tutta la Svizzera, che prevedono il coinvolgimento partecipativo di diversi stakeholder (residenti, lavoratori, amministratori immobiliari, imprese e comuni/città). I Living Lab fungono da piattaforme centrali per l'osservazione e la sperimentazione, dove le sfide legate alla sufficienza e al benessere vengono tradotte in azioni concrete.

A partire dal suo avvio, SWICE ha sviluppato quadri teorici, strumenti pratici e applicazioni reali. Il quarto anno ha segnato una fase di consolidamento ed espansione delle attività di implementazione, con una maggiore enfasi su interventi co-progettati, sull'integrazione tra i work package e sulla traduzione dei risultati di ricerca in possibili raccomandazioni strategiche per la politica e la pratica professionale. I Living Labs si sono evoluti in ambienti di sperimentazione attiva, in cui processi multi-attore sono stati utilizzati per co-progettare e testare scenari di trasformazione a scala di quartiere, modelli di governance e interventi comportamentali mirati. Strumenti analitici e digitali avanzati sono stati ulteriormente sviluppati e implementati, tra cui piattaforme di conoscenza basate sull'IA, digital twins human-centered del building stock svizzero, decision-support systems e strumenti di simulazione partecipativa. Sono stati operazionalizzati framework di modellazione integrata che collegano performance energetiche, comfort indoor e outdoor e impatto sulla salute, insieme ad algoritmi di spatial planning per quartieri resilienti.



1. Work programme overview

The research questions that drive SWICE revolve around how sufficiency practices can be mainstreamed across different domains of everyday life, how behavior change can be effectively promoted to support the energy transition, and how urban spaces and infrastructures can be reimagined to simultaneously enhance energy efficiency and human well-being.

While people and their socio-material dynamics are considered the primary “agents of change” in the energy transition, three main “sectors of change” are identified in terms of their influence on energy demand and supply management: the **built environment**, **open spaces**, and **mobility**.

To address these interdependent pillars, SWICE is structured into eight research work packages (WPs), designed to provide systemic, participative, and evidence-based solutions that respond to the tension between increasing demand for space, comfort, and mobility and the urgent need for decarbonization and circularity—without compromising on well-being.

The **Built Environment** pillar is addressed through **WP3** and **WP4**, which focus on reorienting renovation and planning practices toward sufficiency, low carbon, and quality of life.

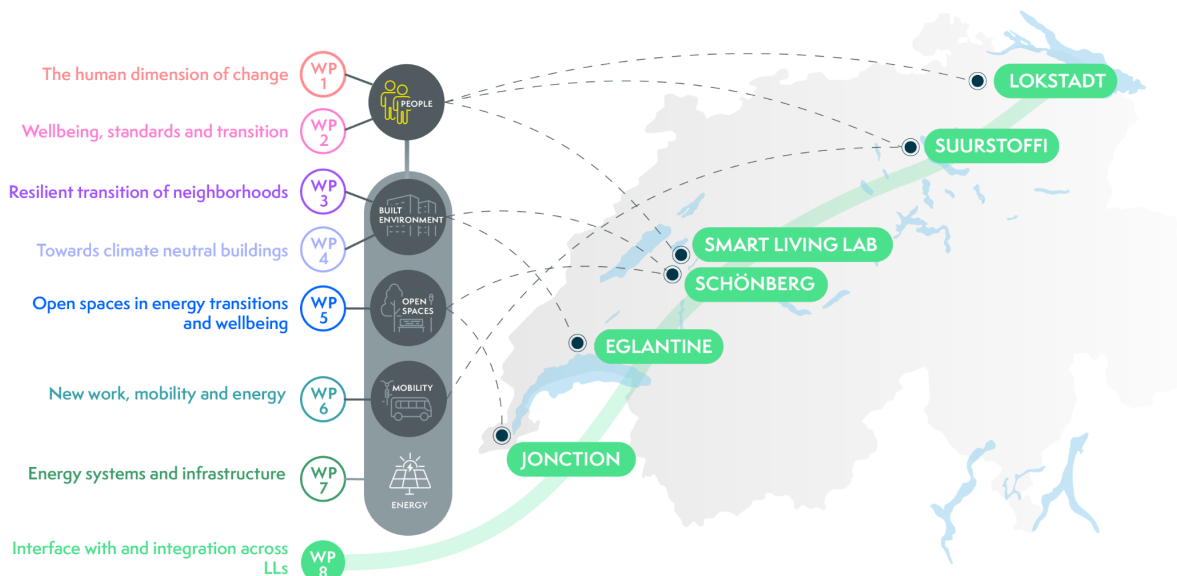
The **Open Spaces** pillar is developed in **WP5**, which investigates how public and semi-public outdoor spaces can support sustainable behaviors and enhance social inclusion.

The **Mobility** pillar is the focus of **WP6**, which explores new models of work and daily travel that reduce emissions while aligning with well-being.

All three pillars are informed by behavioral and societal insights developed in **WP1** and **WP2**, which provide theoretical and normative foundations for sufficiency-oriented lifestyles across all domains.

Transversal integration is supported by **WP7**, which develops a multi-scalar digital twin of the energy system to model the impacts of urban and architectural actions on sustainability and economic performance.

All SWICE research WPs contribute to building robust scientific frameworks, identifying interventions that integrate technical, social, and policy dimensions, and testing these in **real-world Living Labs**. These Living Labs, whose methodological approach is coordinated through **WP8**, are central to the project's **transdisciplinary methodology**, involving residents, municipalities, researchers, and private actors in co-creation processes to ensure relevance, feasibility, and long-term impact.





2. Progress of activities

Throughout the fourth reporting period (April 2025–March 2026), activities across the consortium have further consolidated and matured, with increasing convergence around implementation, cross-work package integration, and the translation of results into policy and practice.

At the scientific level, SWICE further operationalized key frameworks that inform intervention design and policy guidance. Building on previous efforts, the Sustainability Lifestyle Typology developed by WP1 was applied across several Living Labs and integrated into energy and behavioral models, enabling more targeted and realistic representations of energy demand. In parallel, WP2 made significant progress in linking sufficiency, environmental quality, and health through integrated modeling frameworks that connect building performance, indoor and urban environmental quality, and health outcomes. These developments were complemented by new spatial planning tools and algorithms supporting the transformation toward resilient “8-minute neighborhoods,” as well as the elaboration of a transition roadmap for the construction sector. Together, these advances contribute to making sufficiency more actionable across scales and sectors.

In parallel, technical innovations were further developed and tested. WP4 significantly expanded its AI-powered sufficiency knowledge platform and advanced human-centered approaches to building design and operation, including personalized sensing, comfort-driven control algorithms, and a digital twin of the Swiss residential building stock. New decision-support tools were developed to assess sufficiency scenarios at the municipal level, while analytical frameworks across work packages enabled the assessment of behavioral patterns and energy consumption across spatial scales. These developments strengthen SWICE’s capacity to link behavioral insights, technical systems, and environmental performance.

Interface of Chat Sufficiency

Living Labs have become fully operational and central to SWICE activities. In Fribourg (Schönberg Living Lab) and Geneva (Jonction Living Lab), WP5 and its partners implemented participatory processes and pilot interventions addressing urban heat, outdoor comfort, and social vulnerability. These included co-designed shading installations, cooling strategies, and community-based activities, supported by extensive data collection campaigns. In Winterthur (Lokstadt Living Lab), behavioral interventions related to mobility, local services, and energy consumption were



implemented and expanded, supported by digital tools and strong engagement with residents. In Églantine, WP3 advanced governance models for energy communities and co-created interventions aimed at reducing energy consumption while improving well-being.



Living Lab interventions in Geneva (left) and Fribourg (right) during summer 2025

Stakeholder engagement and co-creation processes were further strengthened across the consortium. Participatory workshops, co-design processes, and new tools such as simulation games enabled stakeholders—including residents, planners (ex. Urbaplan), public authorities (ex. Cities of Fribourg, Geneva and Winthertur), and private actors (ex. SIG, Implenia, Groupe E, Losinger Marazzi)—to actively contribute to transformation pathways. WP6 continued to explore the links between mobility, work practices, and energy use, while contributing to the integration of SWICE findings into existing standards and regulatory frameworks.

In terms of integration, WP8 played a key role in supporting cross-work package collaboration, aligning methodologies across Living Labs, and fostering reflection on impact assessment and upscaling. At the same time, WP7 advanced the integration of behavioral and flexibility data into energy system models, strengthening the link between user practices (ex. flexibility in the residential and mobility sectors, working and consumption habits) and system-level dynamics (grid reinforcement and renewable energy adoption). Overall, Year 4 reflects a clear maturation of SWICE, with stronger alignment between scientific research, Living Lab implementation, and policy-oriented outcomes.



Example of workshops provided by WP8 workshop, on the topic of barriers, enablers and good practices for Living Labs



3. Highlights of outputs

During the fourth reporting year, SWICE delivered a broad range of outputs spanning scientific advances, technical tools, Living Lab experimentation, and knowledge transfer activities, further strengthening its contribution to the energy transition debate in Switzerland and beyond.

Scientific contributions and knowledge transfer

Over the past year, SWICE has continued to advance knowledge across key domains related to sufficiency, well-being, and sustainable urban transitions, while significantly expanding its knowledge transfer and outreach activities.

A first body of work focused on the integration of environmental quality, health, and energy performance. WP2 developed a multi-scale modeling framework linking indoor and urban environmental conditions with health outcomes, combining simulation, environmental exposure data, and statistical methods. This work provides new insights into trade-offs between energy efficiency and indoor environmental quality, as well as the influence of urban form on health risks.

A second research stream addressed behavioral dynamics and energy demand. WP1 generated new empirical insights from mobility tracking and lifestyle data collected across Living Labs, enabling a deeper understanding of behavioral patterns and their variability. These insights were increasingly integrated into energy models and decision-support tools, contributing to more realistic and human-centered analyses of energy consumption and intervention impacts.

A third area of work focused on sufficiency and transformation in the built environment. WP3 and WP4 developed new methodologies and tools to assess transformation scenarios at multiple scales, combining simulation, life-cycle assessment, and participatory approaches. These contributions emphasize the importance of co-design, governance, and stakeholder engagement in enabling sustainable neighborhood and building transformations.

In parallel, SWICE significantly expanded its knowledge transfer (KTT) activities. A targeted effort was made to engage professional audiences through expert publications, resulting in six articles published in sector-specific outlets, including contributions to flagship publications such as *Espazium* and *EspaceSuisse*. Workshops with non-academic actors increased substantially, with 15 events organized to engage industry professionals, public authorities, and the wider public, including dedicated workshops at EPFL to co-develop a roadmap for housing transformation. Collaboration was also established with the Centre de Compétences pour la Durabilité dans la Construction (CCDC), creating new opportunities to disseminate SWICE findings within professional networks. In addition, SWICE results were presented at public events such as the *Journées de la Durabilité* at EPFL, and new communication formats were developed, including a video series showcasing Living Lab activities, with a first video focusing on Lokstadt.

Policy impact

In Year 4, SWICE further strengthened its contribution to policy and standard-setting processes. WP6 continued to engage with existing frameworks such as SIA 2039, Minergie, and SNBS, supporting the integration of mobility and behavioral aspects into building standards. WP2 advanced the development of a transition roadmap for the construction sector, supported by stakeholder engagement and participatory processes. Across the consortium, increasing efforts were made to translate research findings into concrete policy recommendations, including on housing transformation, urban heat mitigation, and mobility regulation.

Decision-support tools and databases

SWICE continued to deliver a series of technical and methodological tools to support decision-making and practical implementation:

- **SWICE App:** further developed to collect behavioral data and support Living Lab interventions.



- **LifeStyler and Sustainability Lifestyle Typology tools**: applied across multiple contexts to enable tailored interventions.
- **AI-powered sufficiency knowledge platform (ChatSufficiency)**: significantly expanded to provide accessible, evidence-based insights.
- **Building Energy Sufficiency Explorer**: enabling the exploration of energy demand scenarios across Swiss municipalities.
- **Digital tools for Living Lab monitoring and management**: supporting stakeholders in tracking transformation processes.
- **PowerHood serious game**: further developed as a participatory tool to explore trade-offs in energy transitions.

These tools are increasingly being applied in Living Labs and planning contexts, strengthening the practical relevance of SWICE outputs.

Living Lab interventions

SWICE Living Labs served as fully operational testbeds for co-created interventions.

In **Églantine**, WP3 advanced the implementation of governance models for energy communities and initiated interventions linking energy reduction and well-being.

In **Lokstadt**, multiple behavioral interventions were implemented, including mobility campaigns, local service promotion, and upcoming energy feedback initiatives.

In **Schönberg**, participatory construction processes led to the implementation of urban heat mitigation measures, while in **Geneva**, extensive data collection and stakeholder engagement informed the design of interventions addressing thermal comfort and social vulnerability.

At **Suurstoffi**, the project advanced from pilot testing to applied interventions on coworking practices, assessing their impact on space use, mobility patterns, and energy demand, with a stronger focus on long-term behavioral change.

At the **Smart Living Lab**, activities progressed from experimental setups to operational monitoring and demonstration, including real-time data collection through dense sensor networks and the use of the STEP pavilion as a testbed for circular construction, façade systems, and digital twin applications.

Across all sites, Living Labs increasingly function as integrated environments combining experimentation, data collection, stakeholder engagement, and policy learning, demonstrating both the potential and the challenges of implementing sufficiency-oriented strategies in real-world contexts.



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