AMBIENT-6G

TOWARDS STANDARDIZED 6G CONNECTIVITY FOR AMBIENTLY-POWERED ENERGY NEUTRAL IOT DEVICES

Deliverable D6.2

Initial dissemination, exploitation and standardization plan

Co-funded by the European Union

6GSNS

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Abstract:

This deliverable provides the AMBIENT-6G initial planning for the activities on dissemination, communication, standardization, exploitation, and innovation. This plan will be regularly reviewed and updated by the consortium during the project lifetime. The deliverable also presents the activities executed in the first five months of the AMBIENT-6G project with regards to dissemination, communication, standardization, exploitation, and innovation.

Keywords:

AMBIENT-6G, Dissemination, Communication, Standardization, Regulation, Exploitation, Innovation

Disclaimer:

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Executive summary

AMBIENT-6G targets the development and validation of **internet of things (IoT) energy-neutral devices (ENDs)** capable of operating for extended lifetimes without battery replacement or manual recharging, addressing critical sustainability and scalability challenges for future IoT and 6G networks.

This document outlines the project's strategic approach to **dissemination**, **communication**, **standardization**, and **exploitation**. During the first months of the project, partners successfully initiated activities across multiple fronts:

- **Dissemination & Communication:** The consortium established a structured three-step dissemination approach, initiated targeted awareness campaigns via dedicated website, social media presence, press releases, and participation in conferences. Multiple scientific papers were submitted or accepted in prominent venues, and several workshops and sessions have been organized or planned to engage the broader scientific, industrial, and public communities.
- **Standardization & Regulation:** AMBIENT-6G partners have actively engaged with key international standardization bodies such as the 3rd Generation Partnership Project (3GPP), Institute of Electrical and Electronics Engineers (IEEE), European telecommunications standards institute (ETSI), and Wireless Power Consortium (WPC). A concrete procedure has been set to ensure that the technical developments of the project are closely aligned with ongoing and emerging standardization efforts, including the close monitoring of evolving 5G and 6G standardization activities. Initial contributions were submitted, particularly in the domains of 3GPP Ambient IoT specifications and IEEE 802.11.
- **Exploitation & Innovation:** Early-stage partner-specific exploitation strategies have been refined, considering each partner’s individual commercial objectives and market positioning. Multiple complementary proof of concepts are under development, aiming to validate project innovations and prepare for industrial adoption across a variety of IoT verticals. The consortium has also initiated value proposition analysis to support future business models for END deployment.

The presented plan will serve as a living document throughout AMBIENT-6G lifecycle, continuously updated as project results mature, ensuring alignment with both project objectives and wider 6G research and industrial priorities.

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1 Introduction

The AMBIENT-6G project aims to develop and validate a new class of internet of things (IoT) energy-neutral devices (ENDs) that are capable of operating for decades without battery replacement or manual recharging, tackling one of the most pressing sustainability and scalability challenges in the future of IoT. By delivering lab-validated hardware, software, and network protocols, AMBIENT-6G targets to shape the design of future ultra-low-power 6G connectivity solutions and contribute directly to the evolution of 6G standards for Ambient IoT (AIoT). The innovations developed in AMBIENT-6G are expected to influence 6G deployments, helping to enable a sustainable, intelligent, and maintenance-free IoT ecosystem during the early 2030s.

AMBIENT-6G does not address this challenge in isolation. The project takes a comprehensive approach, combining deep technological innovation with a strategic push toward standardization, open science, and real-world validation. The technical advancements (including active and passive communication protocols, backscatter techniques, predictive energy-aware algorithms, etc.) will be integrated into realistic lab-scale and industrially relevant proof of concept demonstrators. These will showcase AMBIENT-6G's contributions to a spectrum of IoT applications, ranging from infrastructure monitoring to wearable technologies and smart manufacturing. Importantly, AMBIENT-6G aligns closely with Europe's 6G research agenda. The project will be close to ongoing END-related standardization and regulation in the 3rd Generation Partnership Project (3GPP), Institute of Electrical and Electronics Engineers (IEEE), European telecommunications standards institute (ETSI), Wireless Power Consortium (WPC), and other bodies, while investigating the concept of ENDs beyond current specifications to include broader device classes and deployment scenarios, targeting solutions that are well positioned for long-term adoption in global wireless ecosystems.

The expected impact of the project spans multiple dimensions:

- From a **scientific perspective**, AMBIENT-6G targets, among others, novel circuit designs, energy harvesting techniques, backscatter and Wireless Power Transfer (WPT) solutions, ultra-low-power communication protocols, and energy-aware machine learning (ML) approaches.
- In terms of **environmental value**, ENDs will reduce toxic battery use and disposal, support carbon-neutral digital transformation, and enable sustainable monitoring in hard-to-reach or sensitive environments.
- **Economically**, AMBIENT-6G targets to unlock new business models and deployment strategies by lowering operational overhead and extending device lifetimes, especially in sectors where battery maintenance is prohibitive.

To maximise the expected impact, AMBIENT-6G has defined a coordinated framework for dissemination, communication, standardization, exploitation, and stakeholder engagement, built around several objectives:

- Increase project visibility within the wireless research and industrial IoT communities through early communication and user-friendly, robust demonstrators.
- Accelerate scientific knowledge exchange and enable sustainability of results via open-access publications, datasets, and tools (e.g., open hardware/software components releases where feasible, access to validated testbeds for future experimentation).

- Establish strong synergies with SNS JU projects and working groups to drive alignment and amplify pre-standardization efforts.
- Foster adoption by key stakeholders as well as early and targeted engagement with regulators, industry, and standardization bodies to ensure that AMBIENT-6G's contributions are aligned with specification activities, disseminated broadly and positioned for maximum uptake.

The work package (WP) of AMBIENT-6G that will drive these efforts is WP6, and the aforementioned objectives are driven by the following project specific objectives (SO) that are relevant to WP6 work:

- **SO5**: *Actively support, contribute to, and steer 6G standardization efforts for ambient power enabled IoT, such as Ambient IoT in 3GPP Release 19 and beyond, driven by evidence-based scientific results.*
- **SO6**: *Provide industry with insights into viable use cases, and business models for ENDs and Ambient IoT, providing a solid foundation for further exploitation of the project outcomes.*

This document outlines the initial plans and strategic vision for achieving these objectives, promoting the results and positioning the technologies developed within AMBIENT-6G. It will serve as a roadmap reference for dissemination and impact activities throughout the lifetime of the project, with updates provided in follow-up deliverables.

The rest of the document is organised as follows. **Chapter 2** describes the project's dissemination and communication plan, the overall methodology set, and the relevant activities within the first six months of the project's lifetime. **Chapter 3** details AMBIENT-6G plans on standardization and regulation, the overall approach considered, and the activities and knowledge acquired during the project's starting period. **Chapter 4** outlines the exploitation stakeholders and plans as well as the project's general procedure considered for business modelling and innovation management. Finally, we conclude the document.

2 Dissemination and Communication

Dissemination, communication and exploitation activities are a key enabler for the success of the AMBIENT-6G project. The goal of dissemination and communication is to maximise the research impact and to reach a large and diverse user group, enabling exploitation in different domains, creating competitive advantages and new business opportunities.

2.1 Objectives and methodology

A key objective of WP6, to be carried mainly by T6.1 with focus on dissemination and communication, is **WP06.1**: "*Help the technical work packages to demonstrate their solutions to communities and disseminate the project results to key stakeholders*"**.**

AMBIENT-6G labels 4 target groups (T):

- **T1: Industry and innovators:** comprises technology houses and solution providers in different sectors. These small, medium or large companies strive for further business development and have a large valorisation potential within AMBIENT-6G.
- **T2: (European) Society:** this is in a broader sense considered to be the general public and organisations that pursue non-state, non-profit, non-partisan and non–violent goals performing on a local, national, regional and international level.
- **T3: Academic Research:** this includes universities, research institutes and scientific platforms where basic or applied research is performed, and knowledge is transferred.
- **T4: Policy makers and regulatory authorities:** focuses on EU's policy makers (e.g., Next-Generation IoT) and regulatory bodies (e.g., related to Waste from Electrical and Electronic Equipment (WEEE)), as well as END-related standardization bodies (e.g., 3GPP, ITU, IEEE).

The dissemination plan of AMBIENT-6G to the potential users involves a three-step approach, ensuring the widest adoption possible. Figure 1 provides a graphical overview of this approach.

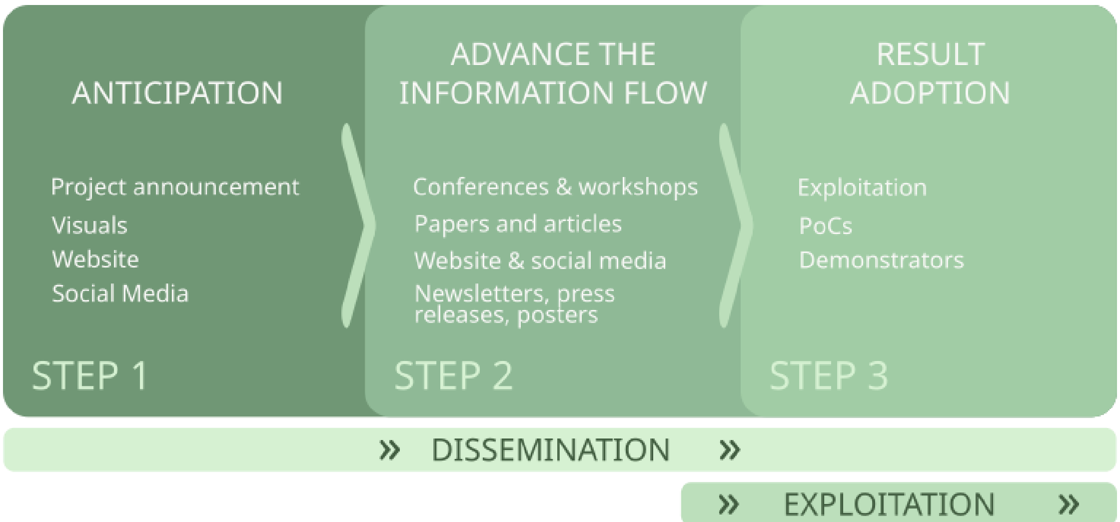

Figure 1: Dissemination three-step approach.

Step 1: Anticipation

In this first step, awareness around the AMBIENT-6G consortium and its goals has been created in the first term of the project. Within the first two months, **announcement messages** have been sent out to the stakeholders already in the portfolio of the current consortium members. Since **visuals** (logo, colour palette, fonts, etc.) are central to the project's branding and identity, the current **logo design** has been slightly adapted in the first month. The third anticipation goal is the creation of a **consortium website (ambient-6g.eu[1])** where the ambition, the general information (such as stakeholders and public events), and in a later phase the results of this project are demonstrated and where a **blog post newsletter**[2] takes its origin. Further online dissemination will be achieved by using the accounts that are created on appropriate **social media platforms**[3]. Figure 2 depicts the project's website and social media platforms set.

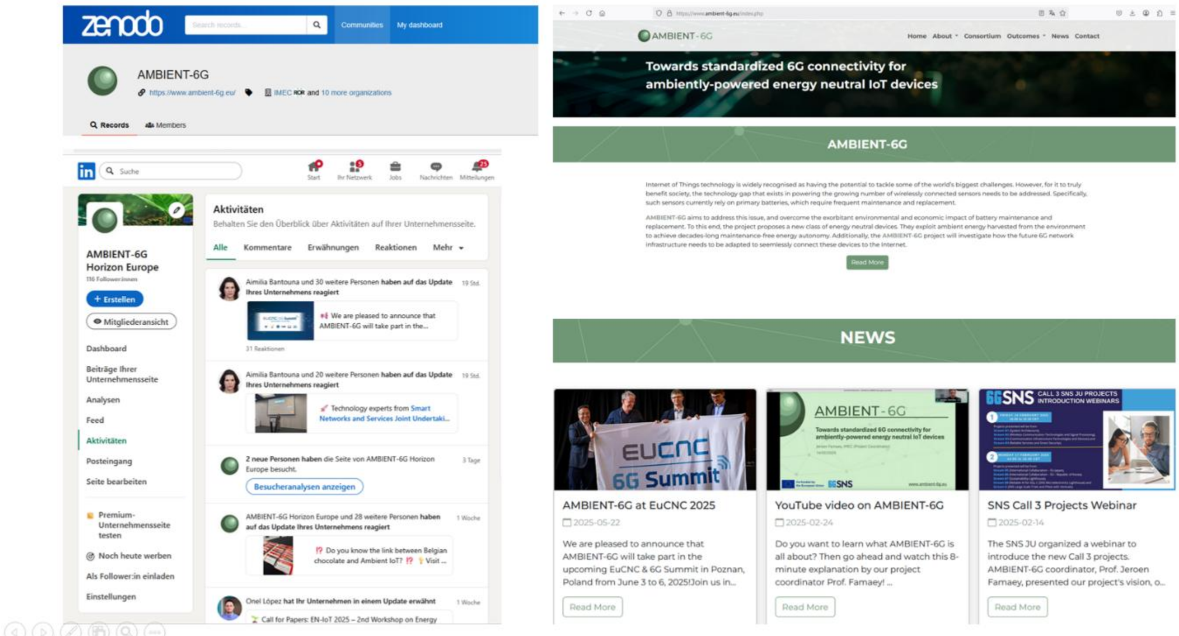

Figure 2: AMBIENT-6G website and social media.

Step 2: Advance the information flow

As the project continues, scientific and technological outcomes are generated. During this second phase, these results will be published in **scientific papers** submitted to journals and conferences. During the correlated **conferences**, the scientific results can be lively debated, and the gathered insights and feedback can positively contribute to the project's progress. For the technological results, we will organise or contribute to existing **workshops**, targeting industry and innovators and opening the opportunity for further research activities and valorisation. Results, whether scientific or technological, will be published as soon as possible if there are no

[1] https://www.ambient-6g.eu/

[2] https://www.ambient-6g.eu/news.php

[3] http://linkedin.com/company/ambient-6g-horizon-europe

legitimate objections from academic or industry partners. **Dedicated Proof of Concepts (PoCs)** will be developed to showcase the preliminary research outcomes to the four target groups.

The **website** is updated throughout the project and research outcomes will be shared through different social media platforms, maintaining the information flow to the different target groups. In addition, newsletters, press releases, posters, and information about workshops and conferences play a crucial role in this dissemination phase, facilitating interactive communication both within and beyond the consortium.

Step 3: Result adoption

In the last step of this plan, the sharing of research results (dissemination) explored in the previous two steps evolves into exploitation, where the results are adopted by industry and innovators. To further promote the results, **integrated PoCs** showcase the symbiotic relation of the different specific research outcomes. Both dedicated and integrated PoCs can further result in a robust, stable, and refined **demonstrator.**

Collaboration with targeted stakeholders and engagement with key industry players are vital for identifying dissemination activities, assessing associated business opportunities, and establishing initial contacts with potential partners and clients. This dissemination plan is closely coordinated with standardization and exploitation plans to amplify their impact and align efforts.

2.2 Dissemination and communication plans

To maximise the project impact, the dissemination and communication approach will be refined throughout the project's lifetime, according to each partner's AMBIENT-6G dissemination plans envisaged at the proposal stage. The dissemination and communication plan will be further refined during the project's lifetime and will be a living document.

Table 1 includes the first refined version of the individual partners' plans.

Table 1: Individual partners' dissemination and communication plans

Individual dissemination and communication plans	
IMEC	• **Online presence:** IMEC contributes towards content published on the project website, newsletter and share project announcements on LinkedIn reaching our network of industrial and academic partners. IMEC communication department assists with the dissemination of major milestones to specialised technical magazines as press releases among IMEC's broad national and international scientific/technological press network. Furthermore, hardware schematics and source code developed during this project will be contributed to GitHub. Open datasets and open access publications will be published on Zenodo. As project coordinator of AMBIENT-6G, IMEC will actively participate in online SNS-JU events to encourage collaborations and disseminate project updates amongst the SNS community. • **In-person events:** IMEC submits papers (full, demo abstract, poster abstracts) to leading EU and International conferences, such as European Conference on Networks and Communications (EuCNC), IEEE International Conference on

	Communications (ICC), IEEE Global Communications Conference (Globecom), IEEE Conference on Vehicular Technology (VTC), International Conference on Computing, Networking and Communications (ICNC), Wireless Communications and Networking Conference (WCNC), Embedded Wireless Systems and Networks (EWSN), and SenSys. In addition to advertising the project via various international/national events such as IMEC ITF World and IMEC Wireless community, IMEC will co-organise and contribute towards workshops for both academia and industry. Moreover, IMEC will partake in workshops and SNS-JU meetings for project promotion and to present research outcomes. • **Scientific presence:** IMEC will submit scientific articles to high-impact peer-reviewed journals and magazines such as IEEE Internet of Things Journal, IEEE Sensors Journal, and IEEE Communications Magazine. IMEC will also participate in editing of a special issue on the AMBIENT-6G topic in one of these journals.
OUL	• **Online presence:** OUL contributes to promoting AMBIENT-6G progress via the University of Oulu and 6G Flagship social media channels, including LinkedIn and X, and direct channels with the vast industrial partners. The software developed as part of the project will be made available as open source via Github, while the collected data will be published as open datasets on Zenodo and other similar platforms. • **In-person events:** OUL will discuss research findings associated with AMBIENT-6G in prominent international IEEE conferences and European forums, including EuCNC, International Conference on Communications (ICC), Globecom, WCNC, and VTC. OUL will co-organise and convey active contributions to the dedicated workshops for both technological innovators and academic community. • **Scientific presence:** OUL will submit scientific articles to high-impact journals and magazines such as IEEE Transactions on Wireless Communications, IEEE Transactions on Industrial Informatics, IEEE Internet of Things Journal, and IEEE Communications Magazine. OUL will target open access publishing to help raise the visibility and impart of the research. OUL will also participate in editing of a special issue on the AMBIENT-6G topic in one of these journals.
AAU	• **Online Presence:** Aalto University will utilise its established social media channels to actively promote the AMBIENT-6G project's progress, ensuring ongoing engagement with both academic and industrial communities. Additionally, Aalto plans to contribute open-source resources on GitHub and publish datasets on platforms like Zenodo. • **In-Person Events:** Aalto University aims to showcase its research findings and conduct demonstrations at prominent international IEEE conferences and relevant European forums, including EuCNC. • **Scientific Presence:** Aalto University is committed to submitting research articles to high-impact, peer-reviewed journals within the IEEE and ACM families, highlighting its contributions to the field.

LMF	• **Online Presence**: LMF will promote AMBIENT-6G progress via Ericsson social media such as LinkedIn and relevant results such as publications on our corporate webpage. • **In-Person Events**: LMF will participate in jointly organising workshops, conferences, or in SNS-JU meetings to present research findings and attained knowledge, e.g., from standardization activities. • **Scientific Presence**: LMF will contribute to research publications in well-known peer-reviewed conferences and journals
SEQ	• **Online Presence**: SEQ will actively contribute to promote AMBIENT-6G progress via Sequans website or social media such as LinkedIn. • **In-Person Events**: SEQ can participate in jointly organising workshops, conferences, or in SNS-JU meetings to present research findings and attained knowledge, e.g., from standardization activities. • **Scientific Presence**: SEQ will contribute to articles in the form of whitepapers or joint papers, supporting the promotion of project's key topics and lessons learned and will pursue publication of scientific results in well-known peer-reviewed journals and magazines.
WIN	• **Online presence:** WIN communicates the company outcomes from R&D and sales activities through the company website at the news section and the company social media accounts including LinkedIn, Twitter, YouTube channel and Facebook. • **In-person events** WIN disseminates the company's research outcomes through i) presentations and demos at conferences such as European EuCNC, Globecom, ICC, Indoor and Mobile Radio Communications (PIMRC), VTC, etc.; ii) participation in workshops within such conferences. • **Scientific presence:** scientific papers in renowned journals / magazines such as IEEE Wireless Communications Magazine, Springer Computer Networks, IEEE Transactions on Cognitive Communications and Networking, Elsevier Engineering Applications of Artificial Intelligence, etc.; and iv) patents.
KUL	• **Online presence:** KUL will actively share the content created on the AMBIENT-6G platform via LinkedIn. The project announcements will be shared with our vast industrial partners. We will make contributions to the website including videos of the integrated PoCs and demonstrators KU Leuven intends to develop. Data sets and hardware generated through the course of this project will be actively committed to GitHub. • **In-person events:** KU Leuven will submit papers to European and international, high-level conferences such as EuCNC, where one poster has been accepted for EuCNC 2025, Global IoT Summit, ICC, WPTCE and GLOBECOM. We will co-organise and convey active contributions to the dedicated workshops for both technological innovators and academic community. DRAMCO may attend some SNS-JU meetings in person and actively report our progress whilst seeking for potential synergies and cooperations.

	• **Scientific presence:** We will submit scientific articles to high-impact journals and magazines such as IEEE IoT magazine (one paper under revision in April 2025), IEEE Sensors Letters, IEEE Wireless Communication Magazine.
QKS	• **Online Presence**: QKS promotes AMBIENT-6G progress via the Quicksand website and social media platforms such as LinkedIn. • **In-Person Events**: QKS participates in jointly organising demo & platform sessions, workshops, conferences, or in SNS JU meetings to present project & research findings • **Scientific presence:** QKS will contribute to whitepaper articles supporting the promotion of project's key topics.
NXP	• **Online Presence**: NXP supports dissemination of project results and achievements to the scientific community and industry through Social Media Channels (e.g., LinkedIn) and website. • **In-Person Events**: To showcase project results to the public and stakeholders with potential interest in new market opportunities, we will organise roadshow-style exhibitions. In addition, dissemination of results will be fostered in events (e.g., 6G summit), meetings and workshops of platforms like RAIN RFID. Furthermore, we will participate in demonstration sessions, workshops, conferences or in SNS JU meetings where project findings will be brought forward.
TUG	• **Online Presence:** Promotion of results and activities within AMBIENT-6G will be published on TU Graz social media accounts. Additionally, TU Graz plans to publish datasets on the university's open-access repository, website posts, as well as postings, comments and re-posts via personal LinkedIn accounts of researchers and AMBIENT-6G LinkedIn account. • **In-Person Events**: TU Graz will actively submit research results to international conferences such as ICC, ICASSP, EuCNC, EUCAP and aims to present results in the form of oral and poster presentations. Additionally, we regularly participate and disseminate results at COST action CA20120 INTERACT, which seeks to advance 6G networks, making radio communications more intelligent and seamless for enhancing human and machine interactions. TU Graz will also contribute to hosting of a project meeting, and will engage with local stakeholders (industry, scientific community). • **Scientific Presence**: Graz University of Technology will actively pursue publication of scientific results in renowned peer-reviewed journals and magazines and will also target open-access platforms to help raise visibility and impart attained research outcomes. • **Communication to Broader Public**: press release, partner spotlight, SDG contribution post for TU Graz' part of AMBIENT-6G. To be shared as good practise examples for partners to realise their own contributions. • **Task lead T6.1**: TU Graz will drive and monitor dissemination and communication activities of the consortium.
TEL	• **Online presence:** Communication strategy will involve experts in the company with experience in social channels, press releases and blogs, and the internal

	dissemination channels, such as the Telefónica Excellence School, Workplace and the ThinkBig blog. • **In-person events:** TEL will contribute towards industrial and scientific dissemination as an essential task, taking advantage of the company's position in the industrial ecosystem, with strong presence in relevant telecommunications industry fora and professional events worldwide (such as Global Workshop on Energy and Climate Change 11/2025).

Focused joint dissemination and communication plans

The know-how and innovation related to END is not widespread. In particular, the holistic view on the multiple facets that will be present in AMBIENT-6G is rather unique, ranging from wireless transmission to energy management, electronics, embedded intelligence, and security. To spread this know-how and reinforce the impact of the project, we intend to jointly organise special dissemination activities, including: (i) editing of special journal issues, (ii) preparation of topical educational material (possibly for blended courses); and (iii) organisation of a focused summer/seasonal school on the interaction with END, including a hands-on component.

KU Leuven will take the ownership for the hosting and organisation of the summer school. We anticipate that the AMBIENT-6G results ranging from end-node innovation to protocols will make up an interesting base for this summer school. Moreover, industry talks covering diverse use cases will be planned. PhD students will be invited to present their related R&D findings in a poster session. The tentative plan is to organise it in Gent, Belgium, in the summer of 2027.

2.3 Dissemination activities

Journal / conference publications

Table 2: AMBIENT-6G journal and conference publications

Title	Authors	Venue	Type	Partner(s)	Status
Experimental Study on the Effect of Synchronization Accuracy for Near-Field RF Wireless Power Transfer in Multi-Antenna Systems	Gilles Callebaut, Jarne Van Mulders and Bert Cox (KU Leuven, Belgium); Benjamin J. B. Deutschmann (Graz University of Technology, Austria); Geoffrey Ottoy (KU Leuven & Technology Campus Ghent, Belgium); Lieven De Strycker and Liesbet Van der Perre (KU Leuven, Belgium)	EuCAP 2025	Conference	KUL	Published
AmbAu: Accurate and Robust Physical Layer Authentication for Ambient Backscatter Devices	Yifan Zhang, Yongchao Dang, Masoud Kaveh, Zheng Yan, Riku Jantti	IEEE ICC 2025	Conference	AAU	Accepted
Designing RF-Powered Battery-Less Electronic Shelf Labels with COTS Components	Jarne Van Mulders, Gilles Callebaut	IEEE WPTCE 2025	Conference	KUL	Published
Li2BC: From Visible Light Communication to Ambient RF Backscatter	Kalle Koskinen, Boxuan Xie, Kalle Ruttik, Riku Jäntti	IEEE GeMiC 2025	Conference	AAU	Accepted
RIS-Aided Backscattering Tag-to-Tag Networks: Performance Analysis	Masoud Kaveh, Farshad Rostami Ghadi, Zheng Yan, Riku Jäntti	IEEE MeditCom 2025	Conference	AAU	Accepted

Artificial Noise Management for Securing Backscatter Communication Networks: Current Advances, Open Challenges, and Future Directions	Yifan Zhang, Zheng Yan, Jie Wang, Yishan Yang, Zhao Li, Riku Jäntti	IEEE Network Magazine	Journal	AAU	Accepted
Integration of Backscatter-based Ambient Internet of Things to Cellular Communication Systems	Riku Jäntti, Jingyi Liao, Tianshu Zhang, Boxuan Xie, Muhammad Usman Sheikh, Kalle Ruttik, Giang Phan, Dinh-Thuy Phan-Huy, and Ayman Hassan	IEEE Communication Standard Magazine	Journal	AAU	Accepted
IoT on the Road to Sustainability: Vehicle or Bandit?	Jona Cappelle, Liesbet Van der Perre, Emma Fitzgerald, Simon Ravyts, Weronika Gajda, Valentijn De Smedt, Bert Cox, Gilles Callebaut	IoT Magazine	Journal	KUL	Submitted
Physically Large Apertures for Wireless Power Transfer: Performance and Regulatory Aspects	Benjamin Deutschmann, Ulrich Mühlmann, Ahmet Kaplan, Gilles Callebaut, Thomas Wilding, Bert Cox, Liesbet Van der Perre, Fredrik Tufvesson, Erik G. Larsson, Klaus Witrisal	IEEE Wireless Communications Magazine	Journal	TUG, NXP, KUL	Accepted
Geometry-Based Channel Estimation, Prediction, and Fusion	Benjamin Deutschmann, Erik Leitinger, Klaus Witrisal	IEEE Open Journal of Signal Processing	Journal	TUG	Rejected
Spatiotemporal Synchronization of Distributed Arrays using Particle-Based Loopy Belief Propagation	Benjamin Deuschmann, Peter Vouras	2025 IEEE Conference on Computational Imaging Using Synthetic Apertures (CISA)	Conference	TUG	Accepted
Secure Backscatter Communications Through RIS: Modeling and Performance	Masoud Kaveh, Farshad Rostami Ghadi, Zhao Li, Zheng Yan, Riku Jäntti	IEEE Transactions on Vehicular Technology	Journal	AAU	Submitted
Sense-then-Charge: Wireless Power Transfer to Unresponsive Devices with Unknown Location	Amirhossein Azarbahram, Onel L. A. López, Richard D. Souza, Petar Popovski, Matti Latva-aho	IEEE GLOBECOM 2025	Conference	OULU	Submitted
Data Assisted Backscatter Communications using DECT-2020 NR+ as Ambient Signal	Jingyi Liao, Kalle Ruttik Riku Jäntti, and Zhu Han	IEEE SPAWC 2025	Conference	AAU	Submitted
Starlink Ku-Band Downlink Based Ambient Backscatter Communication	Jingyi Liao, Kalle Ruttik Riku Jäntti, and Zhu Han	IEEE SPAWC 2025	Conference	AAU	Submitted
Wireless Energy Transfer Beamforming Optimization for Intelligent Transmitting Surface	Osmel Martinez Rosabal, Onel Alcaraz López, Victoria Dala Pegorara Souto, Richard Demo Souza, Samuel Montejo-Sánchez, Robert Schober, Hirely Alves	IEEE Transactions on Wireless Communications	Journal	OULU	Submitted
Dual-Hop Joint Visible Light and Backscatter Communication Relaying under Finite Blocklength	Boxuan Xie, Lauri Mela, Alexis A. Dowhuszko, Kalle Ruttik, Riku Jäntti	IEEE GLOBECOM 2025	Conference	AAU	Submitted
Joint Visible Light and Backscatter Communications for Proximity-Based Indoor Asset Tracking	Boxuan Xie, Alexis A. Dowhuszko, Lauri Mela, Zehui Xiong, Riku Jäntti, Dusit Niyato	IEEE GLOBECOM 2025	Conference	AAU	Submitted

Voltage Profile-Driven Physical Layer Authentication for RIS-aided Backscattering Tag-to-Tag Networks	Masoud Kaveh, Farshad Rostami Ghadi, Yifan Zhang, Zheng Yan, Riku Jäntti	IEEE Internet of Things Journal	Journal	AAU	Submitted

Software

Table 3: AMBIENT-6G software and data

Software name	Description	Partners involved	Link to activity
DECT-NR-Matlab-Toolbox	DECT NR Matlab Toolbox for PHY and MAC layer	IMEC	https://smart-networks.europa.eu/event/sns-ju-call-3-projects-introduction-webinars

Talks / Presentations / Posters / Panels / Demos

Table 4: AMBIENT-6G talks, presentations, and panels

Activity name	Type	Target Audience	Date	Venue	Partners involved	Link to activity
Project presentation at SNS JU Call 3 Projects Introduction Webinars	Clustering activity	Research community	14/02/2025	SNS-JU Webinar	IMEC	https://smart-networks.europa.eu/event/sns-ju-call-3-projects-introduction-webinars
Energy-aware operation protocols for energy-harvesting IoT	Clustering activity Talk	Research community	5/06/2025	EuCNC & 6G Summit, Poznan	OUL	https://www.eucnc.eu/wp-content/uploads/2025/06/EuCNC-6G-SummiT_Final-Programme.pdf
3GPP Ambient-IoT standardization in Rel. 19 and beyond	Clustering activity Talk	Research community	5/06/2025	EuCNC & 6G Summit, Poznan	LMF	https://www.eucnc.eu/wp-content/uploads/2025/06/EuCNC-6G-SummiT_Final-Programme.pdf
Advances in Wireless Power Transfer using Large Arrays	Clustering activity Talk	Research community	5/06/2025	EuCNC & 6G Summit, Poznan	KUL	https://www.eucnc.eu/wp-content/uploads/2025/06/EuCNC-6G-SummiT_Final-Programme.pdf
Wireless plant sensor demo and study: Attributional Life-Cycle Assessment of Wireless Plant Sensing Module	Poster and Demo	Research community	3/06/2025-5/06/205	EuCNC & 6G Summit, Poznan	KUL	https://www.eucnc.eu/wp-content/uploads/2025/06/EuCNC-6G-SummiT_Final-Programme.pdf

Workshops

Table 5: AMBIENT-6G workshops

Activity name	Type	Target audience	Date	Status	Partners involved	Link to activity
Organising WIC Mid-Winter Meeting 2025: 'Positioning and sensing: where do we stand, go, fly?'	Conference / Workshop	Research community	30/01/2024	Completed	IMEC, KUL, TUG	https://sites.google.com/view/wic-mid-winter-meeting-2025
Workshop on Energy Neutral and Sustainable IoT Devices and Infrastructure (En-IoT) at EWSN 2025	Conference / Workshop	Research community	22/09/2025	Planned	IMEC, OUL	https://superiot.eu/en-iot-2025

6G IA / SNS JU collaboration

Table 6: AMBIENT-6G 6G IA / SNS JU collaboration activities

Activity name	Type	Venue	Date	Status	Partners involved	Link to activity
Special Session "Towards standardized 6G connectivity for ambiently-powered energy-neutral 6G devices"	Conference / Workshop	EuCNC 2025	02/06/2025	Completed	IMEC, OUL, KUL	https://www.eucnc.eu/programme/special-sessions/special-session-8/
Participation to the SNS JU Communication Task Force Meetings	Virtual calls	Online	Monthly calls	Ongoing	TUG	Comms Task Force meeting
Participation to the 6G IA pre-standardization working group calls to collect info on standards proceedings and identify opportunities for collaboration with other projects	Virtual calls	Online	Monthly calls	Ongoing	SEQ	https://6g-ia.eu/6g-ia-working-groups/#pre-standardization
Participation to SNS JU Technology Board .	Face-to-face meetings and virtual calls	Kista & Online	Monthly calls	Ongoing	AAU	

2.4 Communication activities

What has been reached throughout communication activities by end of May 2025 is at a preliminary stage, as the project needs some time to consolidate and produce results to be disseminated. Table 7 lists the AMBIENT-6G communication activities during this starting period.

Table 7: AMBIENT-6G communication activities

Means/location	Which messages/results	Target group(s)	KPI	KPI reached until
Online presence				**1.1.-31.5.2025**
Website	Project objectives and general information Project news Project results: deliverables, papers, videos of demonstrators, SW tools	All	Number of visitors to the website: >2500 per year Views and downloads of specific items: >250 per year	Webiste traffic statistics (4.2.-17.6.2025) Visitors <=1,983 Visits 2,533 Pages 4,909 Hits 25,367 Bandwith 2.72 GB
LinkedIn	Project announcement and news	All	> 36 posts over project duration	14 posts over project duration 5070 impressions

			>30 000 impressions	116 followers 152 reactions 13 items shared
Youtube	Project promo and news	All	n/a	1 item uploaded
Github, Zenodo, etc.	Open data, designs, software tools	Technological innovators and academic community	>200 downloads, forks, or stars	1 upload on GitHub
Press releases	Project announcement, major achievements	General public, all communities	At least 2 releases in min 4 countries over project duration	1 press release (Austria)
Newsletter items	Project announcement, major achievements	General public, all communities	n/a	7 newsletter items posted newsletter subscriptions
SNS-JU online meeting series	SB, TB, WG News and progress on the projects, exploration of potential synergies and cooperation	6G-IA and related EU projects	Attend >80% of the relevant meetings, with at least 3 significant contributions	Attended >80% of relevant meetings 1 SB online meeting attended 3 TB online meeting attended 3 WG online meetings attended
In-person events				
SNS-JU in-person meeting	SB, TB News and progress on the projects, exploration of potential synergies and cooperation	6G-IA and related EU projects	Attend >90% of the relevant meetings, with at least 1 significant contribution	1 SB in person meeting attended (Athens, May 2025) 1 TB F2F in person meeting attended (Kista, Feb 2025)
Dedicated workshops	In-depth scientific and technological results Overview and keynote presentations	Technological innovators and academic community, relevant SNS JU sister projects	(co-) organise at least 3 events	n/a
Leading and focused conference participation	In-depth scientific and technological results	Scientific community (academic and industrial R&D groups)	>24 papers	6 submitted 4 accepted 1 published
Scientific presence				
High-impact scientific journal articles	Major scientific innovative results of the project	Scientific community (academic and R&D groups in companies)	>12 papers	6 submitted 2 accepted
Tutorial style/overview articles	Broad knowledge and lessons learnt of key topics of the project	Scientific community and a broad technical community.	>3 papers	n/a
Editing of special issues in relevant high impact scientific journals	Scientific awareness of the major themes and topics under investigation in the project	Scientific community and a broad technical community.	>3 guest editorials	n/a

Website

A website[4] has been established, and it has a news section[5] that is linked to a newsletter subscription[6] possibility. It links to social media channels, such as LinkedIn[7], YouTube and open repositories such as Zenodo[8] and Github[9].

Social media

Social media posts are mainly posted on the LinkedIn account of AMBIENT-6G. Re-posting and commenting via partner's social media accounts is encouraged. Of course, the news section of the website also features those posts and links closely with SNS JU social media activities.

Table 8 lists the social media communication activities that have been realised so far.

Table 8: AMBIENT-6G communication activities on (social) media

#	M	partner	Content Type	Description	Target group	Channel
1	1	IMEC	Project Kick-off	Project announcement with objectives.	technically interested public, 6G community	LinkedIn, Website
2	1	IMEC	WIC mid-winter meeting	Conference announcement + ambient partner	technically interested public, 6G community	Website
3	2	TUG	6G SNS JU issues	Call 3 Project Introduction webinars	6GSNSJU community	Website
4	2	KUL	6G Series Workshop	presentation of Ambient-6G objectives	6GSNSJU community	LinkedIn, Website
5	2	IMEC	Website Launch	Anticipation of how information will flow	technically interested public, 6G community	LinkedIn, Website
6	3	TUG	LinkedIN Launch	Build a stable community interested in 6G technical apps	technically interested public, 6G community	Website
7	3	TUG	6GSNSJU issues	White Paper on 6G KPIs	6GSNSJU community	LinkedIn
8	4	IMEC	Project presentation	Video on YouTube	6G scientific community	YouTube
9	4	IMEC	Youtube launch	Advertise YouTube channel link	6G scientific community	LinkedIn, Website
10	5	TUG	Result anticipation	How ambient builds on former projects: Reindeer	6G scientific community	LinkedIn, Website

[4] https://www.ambient-6g.eu/

[5] https://www.ambient-6g.eu/news.php

[6] https://www.ambient-6g.eu/contact.php

[7] http://linkedin.com/company/ambient-6g-horizon-europe

[8] https://zenodo.org/communities/ambient-6g

[9] https://github.com/ambient-6g

11	5	TUG	Press Release about project	Press release Ambient-6G	6G scientific community, regional press (Graz, A)	print, TU Graz website
12	5	TUG	Partner spotlight 1 - TU Graz	Helle Köpfe: Stromversorgung ohne Kabel oder Batterie (Bright heads: power supply without cable or battery)	technically interested public, 6G community, regional press (Graz, A)	Print, TU Graz social media
13	5	IMEC	EuCNC & 6G summit participation	AMBIENT-6G will take part in upcoming EuCNC&6G Summit in Poznan in June 2025	6G community	Website LinkedIn
14	6	KUL	EuCNC & 6G summit participation	AMBIENT-6G has taken part in EuCNC&6G Summit in Poznan in June 2025	technically interested public, 6G community	Website LinkedIn

Table 9 outlines the project's tentative plan for social media postings / communication activities for Year 1 (Y1) of the project. This social media plan will be further refined during the project's lifetime and will be a living document.

Table 9: AMBIENT-6G social media posts

Quarter of Y1	Month	Driving partner	Content Type
Q2	Jul	KUL	Research Highlights
Q3	Jul	TBD	Partner spotlight 3
Q3	Jul	TBD	6GSNSJU issues
Q3	Aug	TUG	SDG Contribution Post 1
Q3	Aug	OULU	Research Highlight
Q3	Sep	OULU	Partner spotlight 4
Q3	Sep	TBD	Conference attendance
Q3	Sep	IMEC	Event Highlight (Consortium Meetings)
Q4	Oct	AAU	Research Highlight
Q4	Oct	TBD	Conference attendance
Q4	Nov	KUL	Partner Spotlight 6
Q4	Nov	TBD	6GSNSJU issues
Q4	Nov	NXP	Partner Spotlight 7
Q4	Nov	QKS	Partner Spotlight 8
Q4	Dec	QKS	Research Highlight
Q4	Dec	TBD	SDG Contribution Post 2

Promo

YouTube video: AMBIENT-6G Project Introduction by Jeroen Famaey, IMEC, Project Coordinator[10].

Press releases / News

Power supply without cables or batteries. A research project at Graz University of Technology is looking for ways to supply small electronic devices with energy using radio waves.

An article[11] of a local newspaper featured the scientific goals of AMBIENT-6G for the broad public. It focused on the role of TU Graz researchers and on the societal impact of this EU funded project.

[10] https://www.youtube.com/watch?v=TWOB74H2d5U

[11] https://www.kleinezeitung.at/steiermark/19674047/stromversorgung-ohne-kabel-oder-batterie

3 Standardization and Regulation

A key objective for AMBIENT-6G is to maximise the relevance and impact of the developed technology solutions by following related standardization and regulation activities. To achieve this, several AMBIENT-6G partners actively participate in international entities like 3GPP, IEEE, and ETSI, with target to share research outcomes, innovations, and recommendations that align with the 6G vision, and aiming to augment the END technology specification efforts. This involvement shall ensure that the project's technological advancements are relevant to and considered in the global standardization and regulation process. Overall, AMBIENT-6G targets at least 10 contributions from project research and findings to regulators and standardization bodies. Supporting scientific paper submissions and standards-related intellectual property rights (IPRs) are also expected by-products of these contributions and activities.

3.1 Objectives and methodology

Task T6.3 of AMBIENT-6G has its focus on standardization and regulation, with main objective to align the project’s technical work with the most relevant international standardization efforts on 6G and END technology, as well as to help leave a footprint on respective standards and future products and maximise the technical and commercial impact of the project outputs. Various standardization bodies are currently looking for communication solutions for energy-neutral long-life maintenance-free devices which will provide the basis for addressing IoT with END in 6G systems.

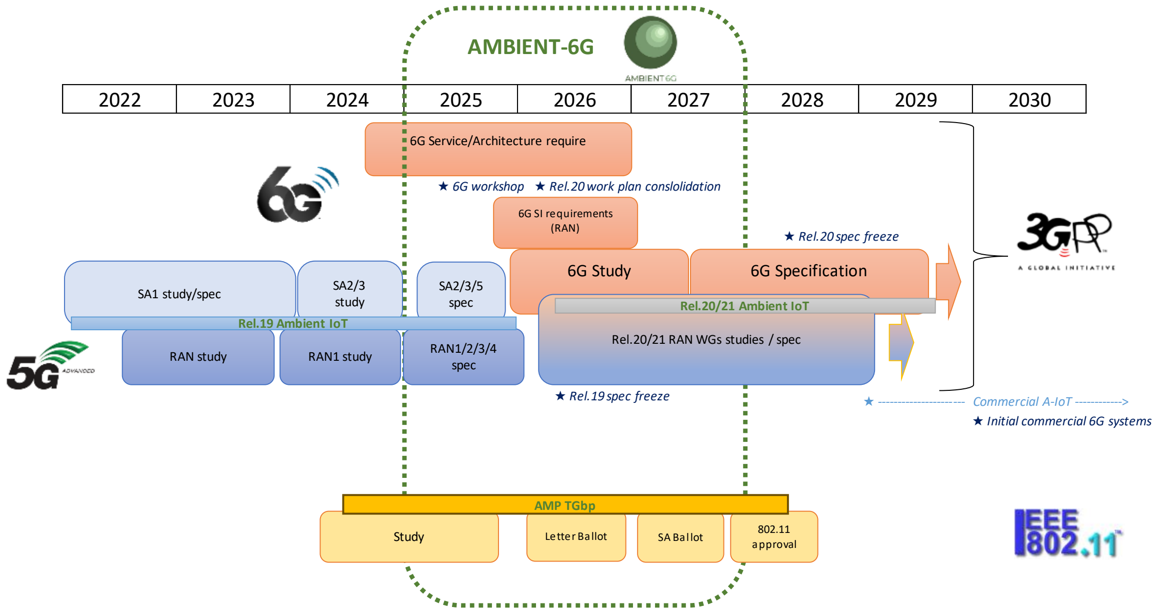

Figure 3: AMBIENT-6G overlap with IEEE 802.11, 3GPP Ambient IoT and 6G tentative timelines

AMBIENT-6G has targeted to monitor and contribute to standards organisations to learn about and influence the development of specifications for END communications. Figure 3 presents the tentative time plans of 3GPP and IEEE standardization for END related devices in conjunction with AMBIENT-6G project lifetime. It is evident that AMBIENT-6G timeline overlaps excellently with the expected studies and specification work as well as with the overall 6G study phase. This will enable AMBIENT-6G to follow closely the respective standardization process and to have direct impact by increasing awareness and facilitating the adoption of our project outcomes. To this end, several AMBIENT-6G partners (LMF, NXP, SEQ, TEL, TUG) have planned - and already started - to follow these international activities, leveraging their expertise in designing, prototyping, and validating low-power communication systems for IoT and edge devices. These partners also leverage their expertise in the standardization processes; how the various standards groups create study and work plans, where and how the collective industry knowledge is captured, and on the development of standardization technical documents and proposals for specification.

To achieve the T6.3 objective described above and the relevant WP6 objective WPO6.3: "*Define input for standardization and regulation and coordinate partners submission of technical results to SDOs for ensuring the adoption of the project's innovations*," the plan is to follow an iterative and evolving procedure:

a) Identify suitable SDOs and AMBIENT-6G T6.3 "followers" to access SDO activity info
    - The AMBIENT-6G consortium members are well represented in standardization bodies and early in the project will identify suitable Standards Development Organisations (SDO) groups working on relevant specification as well as channels to follow and access them.

b) Monitor and record identified SDOs ongoing activities
    - T6.3 SDO followers will monitor selected groups to first bring key knowledge on ongoing activities and understanding of specification aspects for future communication systems based on END technology. SDO monitoring will be an ongoing process during the lifetime of the project and will serve two directions: a) bring knowledge from SDO proceedings to the AMBIENT-6G consortium for feeding and iteratively aligning project technical research and developments, and b) supporting AMBIENT-6G partners' planning for contributions to standards, to utilise the project findings and results for influencing discussions and decisions within SDO groups.

c) Bring knowledge back to AMBIENT-6G consortium
    - Dedicated workshops, calls, or plenary sessions will be organised to share findings with the consortium. For example, in May 2025, virtual Standards Workshop #1 took place where T6.3 followers from NXP, TUG, TEL, LMF and SEQ gave a solid background of studies and specification work from monitored SDOs (3GPP, IEEE, ETSI, WPC) regarding the area of energy-harvesting IoT.

d) Align technical work and contribution plans
    - AMBIENT-6G partners will individually digest the standards knowledge brought, map their technical work to any relevant ongoing or upcoming SDO topics, and adapt accordingly their technical work development, if needed, as well as their planning for SDO contributions.

e) Contribute findings and proposals to SDOs
    - AMBIENT-6G partners will provide contributions to identified SDO topics in-line with their individual organisation strategy. These contributions can be in the form of study findings (e.g., comparison of different approaches from simulation analysis to promote a novel efficient approach), technical proposals for specification (e.g., exact procedure or protocol change to be adopted in AIoT specification), etc. It is noted that contributions to SDOs are commonly an individual partner task, but it is also possible to target joint proposals in some cases (e.g., aligned directions for new study or work scope).

In parallel to the process above, AMBIENT-6G will also strive to increase synergies between the project and other pre-standardization and regulation research initiatives and associations, for increased impact and visibility on the industry and the research community. For this, the plan is to seek close collaboration with pertinent SNS JU projects and 6G-IA pre-standardization working group to foster interactions.

Within the first six months of the project, AMBIENT-6G partners have identified several SDO topics of interest and confirmed their plans to monitoring and contributing to them. The identified relevant SDOs and activities are captured in Table 10.

Table 10: Relevant SDOs and topics of interest

SDO group(s)	Partner(s) & expected activity	Topic of interest
3GPP RAN work groups: RAN1, RAN2 (3GPP SA groups may also be monitored)	Contribute: SEQ, LMF, NXP Monitor: TEL	Rel.19 study and specification work on solutions for Ambient IoT devices in NR. Relevant continuation study/work expected within Rel.20/Rel.21 timeframe for 5G-Advanced and 6G cellular systems.
ETSI TC CYBER: develops standards and guidelines for cyber security across different sectors.	Monitor: NXP	Cybersecurity (secure integration of systems, data protection, privacy safeguarding) considerations on wireless power charging in connected systems/ ICT systems with a view to new IoT-technology.
WPC: develops standards for wireless power charging technology	Monitor: NXP	Insights from compatibility- and safety-focused standardization for wireless charging systems may provide insights for the development of standards applicable to END in 6G systems.
IEEE 802.11 Ambient Power (AMP) TIG/SG	Contribute: NXP	Support of Ambient Power communication in 802.11 network (AMP topic interest group TIG and AMP Study Group SG)
IEEE SA P3343 develops a standard for the spatiotemporal synchronisation of distributed apertures.	Monitor: TUG (possible contributions from 2026)	Synchronising distributed antenna arrays in time and space will form one physically large, jointly coherent synthetic aperture providing outstanding RF-WPT efficiency, small EMF exposure, and accurate sensing capabilities.

3.2 Contributions and monitoring

Within the first six months of the project, AMBIENT-6G partners have already been contributing and monitoring activities in several standardization and regulation topics of interest. The list in Table 11 captures the contributions submitted to 3GPP and IEEE groups up to June 2025.

Table 11: List of AMBIENT-6G partners contributions to SDOs

Partner	Contribution Title	Contribution ID	Topic	SDO, WG Meeting, Date
SEQ	Discussion on aspects for Ambient IoT	R1-2501347	Solutions for Ambient IoT (Internet of Things) in NR, Rel.19	3GPP RAN1#120 Feb-2025
LMF	UL multiple access for Ambient IoT	R2-2500863	Solutions for Ambient IoT (Internet of Things) in NR, Rel.19	3GPP RAN2#129 Feb-2025
NXP	AMP Downlink and Backscattering Carrier Waveform	802.11-25/0305r0	Ambient Power Communication Standard	IEEE 802.11 TGbp Plenary Mar-2025
NXP	AMP Backscattering PPDU and SYNC Design	802.11-25/0306r0	Ambient Power Communication Standard	IEEE 802.11 TGbp Plenary Mar-2025

In the following, resulting from the monitoring activities, we summarise the various identified plans and up-to-date state of activities from the relevant SDOs topics of interest.

3GPP

The 3GPP is a global collaboration between telecommunications standards organisations that develops and maintains technical specifications for mobile communication systems. Its work defines the core and radio access technologies behind major cellular generations, including 3G Universal Mobile Telecommunications Service (UMTS), 4G Long Term Evolution (LTE), 5G New Radio (NR), and the forthcoming 6G. Through its three Technical Specification Groups (TGS): RAN (Radio Access Network), SA (Service and System Aspects) and CT (Core Network and Terminals), 3GPP plays a central role in shaping the evolution of mobile technologies worldwide.

As part of its ongoing efforts, 3GPP has initiated work on Ambient IoT, with SA leading on use cases, traffic models, and performance requirements for low-power, passive IoT devices, and RAN exploring the corresponding radio access implications, including waveform design, device density, topologies, deployment scenarios, etc.

TEL, SEQ, NXP and LMF are actively involved in 3GPP standardization with vast experience on specification (including legacy cellular IoT). They are currently monitoring and already contributing to the Ambient IoT work, and will ensure project's alignment with standardization trends to also facilitate implementation of relevant project results in coming releases.

SA

As part of the Release 19 standardization effort, 3GPP's Service and Systems Aspects Working Group 1 (SA1) launched a study item to analyse Ambient IoT applications. The study focused on documenting use cases, traffic scenarios, and KPIs. Its outcomes were formalised in technical report TR 22.840 "*Study on Ambient power-enabled Internet of Things*"[12].

In parallel, SA2 initiated TR 23.700-13 "*Study on Architecture support of Ambient power-enabled Internet of Things*,"[13] to explore how the 5G Core and Service-Based Architecture can be extended (e.g. via new network functions) and to define procedures for identification, subscription, registration, connection management and transport data for these devices.

Other SA working groups are currently looking into security aspects (SA3) and the charging aspects (SA5) of Ambient IoT devices.

To move toward normative status, TS 22.369 "Service requirements for Ambient power-enabled IoT,"[14] is now under change control. This technical specification captures key functional requirements for ultra-low-power communication procedures, positioning support, power-management schemes, data exposure, and security for battery-less, energy-harvesting devices, as well as performance service requirements for the typical Ambient IoT use cases.

RAN

In Release 18, the study item TR 38.848 "*Study on Ambient IoT (Internet of Things) in RAN*,"[15] defined eight RAN radio use cases (indoor and outdoor variants of inventory tracking, sensing, positioning and command) and evaluated them across four connectivity topologies (direct BS–device, BS–intermediate node–device, BS–assisting node–device–BS, and UE–device) using three device classes (backscatter-only, active-transmission with or without energy storage).It then mapped these combinations to deployment scenarios based on whether the device and reader (base station or UE) are indoors or outdoors, and established a set of RAN design targets derived from TR 22.840's service requirements. From these targets, the study formulated a non-exclusive list of needed RAN functionalities (excluding core-network functions) and concluded with a preliminary feasibility assessment covering device aspects (i.e., power consumption, complexity, mobility and density), coverage, user experience data rate, maximum message size, latency, and positioning accuracy. This study laid the foundation for subsequent Release 19 normative work.

In Release 19, TSG RAN agreed to standardize in RP-250796[16] an Ambient IoT "Device 1" that targets extremely low-power operation (~1 µW peak), includes on-board energy storage and an RF envelope detector for reception, and an initial sampling frequency offset (SFO) of up to 10 ppm. This device performs no active amplification in either reader-to-device (R2D) or device-to-reader (D2R) paths; instead, its uplink (D2R) transmission relies on backscattering a carrier wave supplied externally. For connectivity, the direct link configuration between the Ambient IoT device and the base station "Topology 1" was selected for normative work and regarding deployments scenarios "Deployment Scenario 1" (device indoor / base station indoor) was prioritised in RP-250796.

[12] 3GPP, "Specification # 22.840; Study on Ambient power-enabled Internet of Things; Release 19", 2024.

[13] 3GPP, "Specification # 23.700-13: Study on Architecture support of Ambient power-enabled Internet of Things; Release 19", 2025.

[14] 3GPP, "Specification # 22.369; Service requirements for Ambient power-enabled IoT; Release 19", 2024.

[15] 3GPP, "Specification # 38.848; Study on Ambient IoT (Internet of Things) in RAN; Release 18", 2023.

[16] 3GPP, RP-250796, "New Work Item: Solutions for Ambient IoT (Internet of Things) in NR", 2025.

Very recently (June 2025), for Release 20 of the 5G-Advanced track, there were also important developments at RAN#108 plenary meeting where a new study Item "*Study on solutions for Ambient IoT in NR outdoor for active devices*"[17] and a new work item "*Solutions for Ambient IoT (Internet of Things) in NR Phase 2*"[18] were approved.

RAN1

In Release 19 normative work, RAN1 has been focusing on physical layers specification aspects for Reader-to-Device (R2D) and Device-to-Reader (D2R) directions including modulation and coding design, timing acquisition and synchronisation, multiplexing and multiple access, scheduling information and timing relationships. The work has very recently resulted to the first technical specification for Ambient IoT physical layer (TS 38.291[19]). In the following, we describe some key agreements and open points for this specification as of May 2025.

Regarding modulation aspects, current agreements include using 15 kHz subcarrier spacing and DFT-s-OFDM waveform for R2D transmissions with OOK-4 modulation. The set of supported M values (number of chips per OFDM symbol) is {2, 6, 12, 24}. For cyclic prefix (CP) handling, simple CP insertion method is used for small M, while for larger M values, padding-based options are being considered. In the D2R link, both on-off keying (OOK) and binary phase-shift keying (BPSK) modulations are supported without mandatory symbol boundary alignment. Several items remain open, such as finalising CP handling for large M, padding treatment, and waveform generation details for specification text.

Regarding coding, four key aspects have been of focus: line coding, forward error correction (FEC), cyclic redundancy check (CRC), and repetition. Manchester coding is mandated for R2D and remains under evaluation for D2R. FEC is not supported in R2D due to device complexity constraints, while D2R supports convolutional coding with LTE-style rate-1/3 schemes, with further study on rate-1/2 options. CRC is always included for both directions, with CRC-6 used for short payloads (≤24 bits), although alternate lightweight integrity options (e.g., tail bits) remain under discussion. Block-level repetition is supported for D2R only, enabling soft combining and early decoding at the reader.

On timing acquisition and synchronisation specification aspects, key areas include the start indication part (SIP) of R2D timing acquisition signal (R-TAS), where only ON-OFF transmission is supported, with both single and multi ON-OFF options still under evaluation. For the clock acquisition part (CAP), it was agreed that a minimum of two transition edges is needed, with candidate durations being 1.5–3 OFDM symbols. While R2D transmissions exclude midambles to reduce complexity, D2R transmissions require a preamble and may optionally include midambles or postambles to support robust synchronisation and end-timing. On CP handling, discussions are progressing toward finalising modulation-specific timing structures that balance detection performance with device simplicity.

Additionally, RAN1 has concentrated on multiplexing and multiple access (supporting both TDMA and FDMA for D2R Msg1/Msg3), timing relationships (including X=1 or 2 time slots for Msg1 with configurable offsets), and scheduling information (covering signalling based on physical reader to device channel (PRDCH), payload length indication, and group-based D2R resource

[17] https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_108/Docs/RP-251884.zip

[18] https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_108/Docs/RP-251885.zip

[19] https://ftp.3gpp.org//Specs/archive/38_series/38.291/38291-100.zip

assignment). While many core mechanisms have been agreed, several open points remain, including flexible Msg3 scheduling, and the structure of L1 control information.

RAN2

In Release 19, RAN2 focused on upper layer RAN protocols to support Ambient IoT communication. Unlike typical 5G NR cellular protocols which supports multiple layers, such as MAC, RLC, PDCP, SDAP; Ambient IoT supports only MAC layer due to device and use case limitations. In the normative work phase, 3GPP concentrated in standardizing three major aspects, namely paging, random-access and data transmission aspects.

To trigger a communication in D2R or R2D direction, 3GPP has defined a D2R signaling in the form of paging to trigger communication at device side. The paging provides device or group of devices plurality of information which can include both NAS and AS layer components, such as device ID for masked/filtered device ID (to target group of devices), transaction ID, resource allocation, etc. The allocation can be provided either in CFRA manner (group of devices) or in CFRA manner (single device). To discourage redundant response from device, if the device has responded successfully to paging message and completed the D2R or R2D communication, the paging message carries transaction ID which is associated with a service request/type. If a new paging message comes from same reader or another reader again, the device checks the transaction ID, and if the transaction ID is the same for which device has previously responded successfully, the device will not respond again. Furthermore, the device is expected to handle one service request at a time, in case the reader sends more than one paging request where the communication procedural window of different service requests overlap at least partially at device side. In that case, the device will pick newest paging request and continue with the procedure.

Next, to indicate communication from device side, the 3GPP has defined an elaborated CBRA based mechanism which also acts as a baseline procedure for CFRA. To trigger CBRA or CFRA, a paging message is broadcasted, indicating a number of access occasions. Then, the device selects one of the indicated occasions randomly. Within a selected occasion, the device further selects TDMA and FDMA resource randomly and transmits D2R Msg1 containing a 16-bit random number, RN16, for collision resolution purpose. Consecutively, the reader sends R2D Msg2 addressing one or more devices which have successfully accessed the resources in an occasion by indicating their RN16(s) along with other allocation for successive transmission (D2R Msg3 onwards). Next, in Msg3, upon receiving Msg2, the device responds with device ID which reader communicates to CN in order to carry out communication between CN and the device. If the device does not respond with Msg3 or delivers erroneous Msg3, then reader can retransmit Msg2 again to trigger Msg3 (re)transmission. However, if device fails to deliver Msg3 even after reader's numerous Msg2 retransmissions, the reader can send R2D NACK message indicating the end of device right to access the current occasion or later in this paging round. The devices must wait for new paging request to initiate communication again. In case device responds with Msg3 successfully, the network may continue with successive message transmissions that may correspond to delivering data from CN to device in R2D messages (such as Msg4, Msg6, ...) or from device side to CN in D2R messages (such as Msg5, Msg7, ...). Given that the devices are extremely limited, they cannot identify the occasion using its internal clock, rather rely on reader trigger (known as R2D trigger) which is sent at the beginning of every occasion.

Regarding transmission aspects, 3GPP only standardised optionally three primary use cases until now: read command (reading D2R data from device memory), write command (delivering or writing R2D data to device memory) and permanent disable command on top of base use case of inventory (which requires Msg3 transmission containing device ID). To handle data communication to and from device, the reader can allocate AS ID to device and consecutively, it addresses the device using AS ID. The AS ID can be device's CBRA RN16 ID or allocated during CBRA or CFRA procedure, e.g., during Msg2 transmission. Regarding message format, the messages can have header (which may indicate message type especially for various R2D messages), payload, and padding (e.g., in case the messages are byte aligned). To improve device side transmissions' coverage and reliability, the R2D transmission is further equipped with segmentation feature.

IEEE

The IEEE is a global organisation that develops industry standards, publishes peer-reviewed research, and hosts conferences in electrical engineering, computing, and related technologies to advance innovation and interoperability.

AMP

As part of the standardization efforts, the IEEE 802.11bp amendment introduces enhancements to the IEEE 802.11 standard to enable ambient power (AMP) communication, targeting wireless LAN (WLAN) stations (STAs) that operate on harvested RF energy. The amendment defines modifications to both the MAC and PHY layers to support ultra-low-power communication, facilitating the deployment of battery-less IoT devices. These enhancements are designed to accommodate the stringent energy constraints of energy-harvesting systems, with a focus on backscatter communication, but also implements active transmission, synchronisation protocols, and energy-aware processing.

At the PHY layer, IEEE 802.11bp proposes the adoption of simplified modulation schemes optimised for minimal energy consumption. Candidate schemes include on-off keying (OOK) and variants derived from IEEE 802.11ah and IEEE 802.11ba, selected for their compatibility with energy-harvesting circuitry and low-power operation. The amendment supports operation in both sub-1 GHz (e.g., 868 MHz in Europe - ETSI, 915 MHz in the US - FCC) and 2.4 GHz ISM bands. Two data rates are under consideration: a low data rate (LDR) mode at approximately 250 kbit/s and a high data rate (HDR) mode at 1 Mbit/s. Broadband carrier waveforms, such as OFDM with 20 MHz bandwidth, are proposed for use as carrier signals in mono-static backscatter configurations.

The MAC layer is being adapted to support asynchronous, low-duty-cycle operation. Key features include simplified MAC protocols inspired by IEEE 802.11ah's restricted access window (RAW) and IEEE 802.11ba's wake-up radio (WUR) mechanisms. These adaptations aim to reduce channel spamming and wasting energy during medium access, enabling efficient operation under intermittent power availability. Communication protocols are tailored to operate within a peak power of less than 1 mW, ensuring compatibility with ambient energy harvesting capabilities.

The standardization effort incorporates power budgeting strategies and synchronisation mechanisms to ensure reliable operation under variable energy conditions. NXP has already contributed significantly to the development of PHY waveform analysis, mono-static backscattering techniques, and SYNC signal design, drawing on experience from ETSI RFID standards. These contributions aim to enhance the efficiency and robustness of AMP communication within existing 802.11 networks.

Key industry stakeholders - including NXP, OPPO, Qualcomm, and Huawei - have actively supported the development of IEEE 802.11bp. Their contributions emphasise the importance of ultra-low-power device design, RF front-end optimisation for energy harvesting, and the reuse of existing WLAN infrastructure to accelerate deployment. The collaborative effort reflects a shared vision for enabling energy-neutral networking and maintenance-free IoT systems.

SA P3343

IEEE SA P3343 aims to establish algorithms and performance bounds for spatiotemporal synchronisation, i.e., the joint inference of spatial and temporal states in networks of distributed apertures. The spatial states typically comprise node position, orientation, and velocity in scenarios involving mobility. The temporal states typically comprise clock time offsets (TOs), carrier frequency offsets (CFOs), and carrier phase offsets (CPOs). The term *aperture* here implies that nodes are equipped with sensor (e.g., antenna) arrays, giving them the ability to resolve incident signals in the angular domain, which comes at the cost of the unknown node orientation entering its spatial state.

The most demanding, yet most rewarding aspect of this joint estimation problem is to establish phase-coherent operation of distributed nodes. This implies challenging real-time estimation of unknown clock phases (online phase calibration) but holds large performance gains. If solved successfully, full spatiotemporal synchronisation will transform a network of distributed apertures into a very large jointly coherent synthetic aperture, enabling high-rate communications, precise positioning and sensing, and efficient wireless power transfer.

In the context of wireless power transfer, which is highly related to AMBIENT-6G, enlarging and distributing the edge infrastructure concentrates power on the intended receiving END, aiding radiation safety, regulatory compliance, and improving achievable power budgets. 6G distributed MIMO (D-MIMO) infrastructures such as RadioWeaves or Radio Stripes emerge as attractive solutions to power ENDs in a scalable and flexibly deployable way. In order to leverage the maximum achievable (array) gains with such infrastructures using joint coherent transmission (CJT), it is needed to solve the spatiotemporal synchronisation problem. The algorithms developed in IEEE SA P3343 aim to solve this problem.

ETSI

The ETSI, as a recognised standards development organisation (SDO), is responsible for defining harmonised technical specifications and standards. One such specification is for short-range devices (SRDs, EN 300 220/330/440) across multiple frequency bands, including HF (13.56 MHz), UHF (860–928 MHz), and the 2.45 GHz ISM band. These standards are developed in close coordination with the electronic communications committee (ECC) of CEPT and the international telecommunication union radiocommunication sector (ITU-R), ensuring regulatory coherence and spectrum harmonisation across ITU Region 1, which includes Europe, Africa, and parts of the Middle East.

ETSI's deliverables, such as EN 302 208 for UHF RFID, EN 300 330 for HF RFID and NFC, and EN 300 328 for 2.4 GHz ISM band devices, establish essential guidelines for radio equipment, including emissions, duty cycle constraints, and channel access protocols. EN 302 208 specifies the operational parameters for RFID devices in the 865–868 MHz band, incorporating mechanisms such as Listen-Before-Talk (LBT), adaptive frequency agility, and duty cycle limitations to ensure spectral efficiency and mitigate interference in dense deployment environments, which are very relevant topics for other standards in the domain of ENDs and

Ambient IoT. The regulatory framework underpinning these standards is structured around CEPT/ERC recommendations (e.g., ERC/REC 70-03), EU directives such as the former R&TTE Directive 1999/05/EC and its successor, the radio equipment directive (RED) 2014/53/EU, and national declarations submitted to the European Commission. ETSI has further established a dedicated technical committee (TC CYBER) and a strategic roadmap to address cybersecurity challenges in the era of increasing connected devices. This roadmap outlines key areas where standardization can enhance security and support the development of safer digital ecosystems.

NXP Semiconductors has been a key contributor to ETSI's standardization efforts, particularly in aligning RFID and NFC technologies with regulatory and market requirements, and is now also monitoring new roadmaps such as TC CYBER. Their engagement ensures that standards reflect practical deployment needs and support compliance-driven design strategies. These collaborative efforts exemplify how harmonised standards can facilitate innovation while ensuring interoperability and regulatory compliance.

WPC

The WPC, founded in 2008, is a global standards consortium dedicated to the development of interoperable wireless power transfer (WPT) protocols. Its specifications span low- to high-power applications across consumer electronics, kitchen appliances, and light electric vehicles (LEVs), with a focus on safety, efficiency, and cross-vendor compatibility. The Qi standard, WPC's flagship protocol, operates in the 100–205 kHz band and supports inductive power transfer up to 15 W (up to 50 W, proprietary). It uses amplitude and frequency shift keying (ASK/FSK) for in-band communication, enabling dynamic power negotiation, foreign object detection (FOD), and thermal regulation. Qi v2.0 (Qi2) introduces magnetic alignment between transmitter and receiver, improving coupling efficiency and reducing thermal losses. Qi2 remains backward compatible with Qi v1.x devices. The Ki standard extends WPC's architecture to high-power kitchen applications, supporting 100–2.2 kW inductive transfer at around 125 kHz. Designed for embedded operation through non-metallic surfaces, Ki incorporates thermal cutoffs and active load detection to ensure safety in moisture- and heat-prone environments. The LEV standard, currently under development, targets wireless charging for e-bikes, scooters, and other light electric vehicles. It emphasises ruggedised, weather-resistant interfaces and autonomous alignment mechanisms suitable for public infrastructure.

NXP Semiconductors is a key contributor, providing secure power management integrated circuits (Ics), cryptographic authentication modules, and reference designs. Their solutions integrate secure elements (SE), NFC-based pairing, and compliance with WPC's communication stacks, supporting robust and secure WPT implementations.

4 Exploitation and Innovation

The overall objective of the project is to design, prototype, validate, and standardize hardware and software technology solutions for intelligent AI-enabled ENDs, and the 6G network infrastructure that provides connectivity to these devices. To achieve this objective, the project will focus on technological advancements and innovations in the following areas: (i) END hardware and software components to facilitate energy harvesting and management, as well as passive and active wireless communications; (ii) a new 6G low-power wide-area network (LPWAN) technology that uses substantially less energy than existing LPWAN technologies (e.g., LTE-M, NB-IoT); and (iii) ML both on-device and orchestrated along the Cloud-Edge-Device continuum to support intelligent management of the device and network resources, as well as local application data processing. AMBIENT-6G partners aim to exploit the project results through various pathways, aligned with their commercial objectives and societal priorities.

4.1 Objectives and methodology

Task T6.2 of AMBIENT-6G has its focus on exploitation and innovation, with focus on the strategic development and commercialisation aspects of the technological outcomes from the project. The task will aim to:

- identify viable business models that can be leveraged for the successful deployment and exploitation of the new 6G network protocols, infrastructures, and devices
- work with partners to define innovation opportunities for individual or joint exploitation and maximise IPR generation related to the topics of the project

T6.2 will also be the main carrier of the WP6 objective WPO6.2: "*Define business plan for END enabled machine type communications and work with partners to define innovation and exploitation opportunities related to the technical topics of the project.*"

The methodology considered to achieve these objectives includes multiple mechanisms. First, we utilise business models to derive the value that ENDs bring, which will help the SMEs and other industry partners to take advantage of the END solution. Secondly, we participate in standardization efforts pertaining to the proposed 6G network innovations, which will promote future development and integration of the developed technology in follow-up research and maximise the impact of the innovations through IPR. Lastly, six distinct and three integrated complementary proof of concepts (PoCs) that demonstrate the efficacy of END technology in pertinent environments for representative IoT-supported verticals will serve as a comprehensive validation and demonstration of the project solutions.

4.2 Exploitation stakeholders and plans

To maximise the project impact, the business and exploitation approach will be established according to each partner's objective using market research, and will be refined from the plans captured in the project proposal throughout the project's lifetime. The following list in Table 12, which will be a living document, depicts the first refined version of partners' exploitation plans.

Table 12: AMBIENT-6G partners' exploitation plans

Company	Exploitation plans
IMEC	The development and sharing of scientific information in 6G research and its applications will be the main pillars of IMEC's

	exploitation strategy. To enhance the current in-house research initiatives and higher education programs in partnership with Gent University and the University of Antwerp, research in AMBIENT-6G is expected to expand IMEC's research expertise in the areas of ENDs, ambient energy harvesting methodologies, and ultra-low power 6G network technologies. This expanded research is also expected to produce high-impact publications that contribute to both academic and industrial fields. To further prototyping and expediting the development of next-generation products that meet industry demands, IMEC will leverage intellectual property (IP) through research collaborations with industries along the value chain through bilateral partnerships, IP transfer, and licensing. IPR gained from AMBIENT-6G will also be evaluated to establish possibilities for spin-off companies via IMEC's Incubation & Venture initiatives such as imec.istart, a leading startup accelerator program.
Aalto University	AAU will make use of AMBIENT-6G findings in its research and teaching endeavors. The results will improve understanding of ENDs, and the proofs of concept will provide insight into how to integrate ENDs with the rest of the 6G architecture and identify challenges in the system level. Significant findings from the research will be published as scholarly articles that doctoral candidates can use to support their dissertations. It is possible to document certain issues of suitable scope as master's theses. Utilising research findings for commercialisation is made possible by active collaboration with the involved industry.
Oulu University	OUL's contributions will be integrated into 6G Flagship's ongoing research and implementation initiatives, including teaching PhD students and developing the skills of post-doctoral researchers. It is anticipated that the teaching curriculum will be modified in light of AMBIENT-6G's results. Additionally, spin-off initiatives will be promoted.
Ericsson Finland	LMF will use the findings and knowledge gained from AMBIENT-6G in the development of future IoT products. Standardization initiatives in 3GPP will benefit from the pertinent findings. When creating future energy-efficient solutions for other IoT device classes, it is anticipated that the solutions created and showcased in AMBIENT-6G will be applicable beyond ENDs.
Sequans	SEQ will use the project to increase their awareness and expertise in the AIoT space and speed up the time to market of future related products. To expand its understanding of standard evolutions in the context of 3GPP Rel-19 and beyond for AIoT, Sequans will take advantage of AMBIENT-6G results. The gained expertise will also support internal training and communication regarding this new cellular IoT technology, product definition to

	plan Sequans' transition from 5G to 6G, and internal development to make it easier to integrate cutting-edge 6G technologies into our next-generation device platforms' hardware or software. Furthermore, the knowledge gained from SEQ technical work on device architecture, L1/L2 functionality and protocols, and power consumption analysis can help 3GPP groups build meaningful standards specifications by promoting scientific articles, whitepapers, and an informed activity.
Wings	WIN will integrate cutting-edge energy-aware and AI-driven capabilities into its WINGSChariot logistics solution for Industry 5.0, leveraging AMBIENT-6G findings. These include e.g., enhancing the cobot capabilities (e.g., in manufacturing/warehouse audit contexts) in terms of depending from batteries through the addition of predictive energy harvesting capabilities. Accordingly, the adaptive protocols switching will allow WIN IoT devices to adjust their data collection and transmission services within different connectivity contexts and needs. Additionally, WIN intends to create federated learning protocols and dynamic TinyMLOps pipelines to effectively control energy consumption across devices. The best computation layer (cloud, edge, or device) will also be chosen by orchestration methods. WINGSChariot will gradually include all of these elements to improve its offerings.
KU Leuven	KUL plans to use the results in the following areas: (i) applying scientific knowledge to create impactful publications; (ii) creating educational materials for master's programs and lifelong learning programs; and (iii) improving and growing the body of knowledge for industry partnerships. The KU Leuven-DRAMCO collaboration has a diverse industrial network that includes both small and large businesses operating at various value chain stages. Numerous IoT-based innovation initiatives in the fields of farming, logistics, and health have been completed. It is expected that the project's outcomes will strengthen these alliances and draw more business interest.
Quicksand	QKS will continue to establish an ecosystem for scalable and adaptive energy management using the research findings from the AMBIENT-6G project. QKS anticipates two business cases: (i) a hardware ecosystem for upcoming cleantech product designs and integrations (licensing fee per device or one-time price per product design); (ii) an energy management software/firmware library (license fee per device). The proposed new HW eco-system is an expansion of an already-existing licensable eco-system for "fire-and-forget" devices.
NXP semiconductors	NXP will improve its core business of creating security ICs by utilising new technological developments in IC design for ENDs

	that function in 6G environments. The acquired knowledge will benefit new and current NXP engineering services clients, mostly big industrial enterprises. NXP hopes to improve its competitiveness and solidify its market position by facilitating the development of new products, particularly in the nascent IoT sector. In the context of ETSI IEEE 802.11 Ambient Power and ETSI, NXP will additionally support pre-standardization and standardization operations to capitalise on knowledge and outcomes that have been developed.
Technische Universität Graz	TUG will use the scientific findings and insights to advance research, create and expand educational resources, and publish scholarly works. The AMBIENT-6G project will contribute to the expansion of fundamental and applied research in the areas of wireless communications, WPT, and sophisticated low-energy sensing systems. Current, long-standing partnerships with top semiconductor businesses in and around Graz will be further enhanced and benefited by the project. In addition to assisting and instructing PhD candidates in the relevant disciplines, we will handle minor work package contributions within the context of master thesis projects.
Telefonica	TEL intends to create future network architectures with an emphasis on offering innovative wireless services using the expertise gained during the project. Additionally, it will offer a practical summary of the level of maturity of the various technological components that ought to be accessible, making it easier to find chances for collaboration to expedite their development. Based on the project concepts, Telefonica intends to work with its stakeholders and industrial partners to build commercial products that are both technically practicable and scalable. Future network evolution studies that attempt to improve network robustness and capacity will be clearly impacted by the findings and knowledge gained from the project, which will spur new research and innovation efforts within the company.

4.3 Business models and innovation management

Cellular IoT is envisioned as a significant revenue stream bringing a compound annual growth rate (CAGR) of around 11% through to 2030, surpassing 7 billion connection/devices by that time. The key IoT sectors will be broadband and critical IoT which is forecast to double, reaching 4.3 billion devices by 2030[20]. The widespread use of IoT devices in various verticals has given rise to a new class of low-power, longer-life, and battery-less IoT devices referred to as ENDs. For

[20] Ericsson Mobility Report, November 2024, https://www.ericsson.com/4adb7e/assets/local/reports-papers/mobility-report/documents/2024/ericsson-mobility-report-november-2024.pdf

example, as discussed in Section 3, 3GPP SA studies on Ambient IoT for 5G-Advanced have identified relevant use cases that do not overlap with legacy cellular IoT (TR 22.840). Moreover, low-end IoT device based on 6G RAT can provide an opportunity for ENDs to address some new use cases, e.g., i) "iridescent" reflective tags to enable radar-based orientation estimation, ii) sensor system using a tag antenna as sensing device, iii) Hybrid RF indoor positioning system, iv) passive distributed control for a reconfigurable intelligent surface (RIS), v) standing water monitoring on rooftops to ensure structural integrity, vi) outdoor batteryless tracker, along with some of the use cases traditionally served by low-end legacy IoT (e.g., NB-IoT), with requirements that can be satisfied by lower-capability solutions under 6G RAT.

AMBIENT-6G WP5 is scoped to present a structured analysis of use cases for AIoT technology, showing how ENDs can address real world challenges across multiple domains. Identified relevant use cases will be categorised into principal families (e.g., electronic shelf label, in-body or wearable medical sensors, smart agriculture, etc.) and then examine representative scenarios within each category to highlight specific requirements and considerations. Within the scope of AMBIENT-6G task T6.2, the commercialisation and deployment of ENDs will be investigated, taking as input also the analysis performed in WP5. This section covers the business modelling aspects which will be used for deriving the value that ENDs bring. The general plan is to use the value proposition canvas to determine the value of ENDs. This is built around two foundations (i) the value map and (ii) the customer profile, as shown in Figure 4.

Figure 4: The value proposition canvas

Customer Profile

A customer profile reflects a particular customer segment, as each customer has different 'jobs to be done', pains, and gains.

- Gains – the benefits which the customer expects e.g., improvements in efficiency, cost saving, reliability that may increase the likelihood of adopting a value proposition.
- Pains – the negative experiences, emotions, risks, and obstacles that the customer experiences in order to get the job done.

- Customer jobs – the functional (asset tracking), social (improving industry credentials), and emotional (increasing the peace of mind with automation) tasks customers are trying to perform.

Value Map

A value map reflects how a product or service delivers value by addressing the customer profile.

- Gain creators – how the product or service creates customer gains (enabling new capabilities) and how it offers added value (improves performance, adds functionality) to the customer.
- Pain relievers – a description of exactly how the product or service alleviates customer pains (reducing costs, complexity, time, risk).
- Products and services – the products and services (device, platform, algorithms, infrastructure) which create gain and relieve pain, and which underpin the creation of value for the customer.

In the scope of AMBIENT-6G project, the goal is to design value propositions that match customers' requirements and jobs to be done. The project aims to address several business-related questions, including:

(i) In which use cases END operation can bring benefits in terms of ease of use and maintenance, cost, and ecological footprint?

(ii) What are the implementation challenges associated with the various technology enablers, including END device architectures, harvesting solutions, protocols for energy-neutral operation, backscattering communication, wireless charging, adaptive duty-cycling approaches, energy-aware computing?

(iii) What are the challenges for standardiation in existing 5G and forthcoming 6G systems.

To answer these questions, AMBIENT-6G value proposition is ideally situated at the nexus of IoT intelligence, scalability, and sustainability. Customers looking to enhance their portfolio by adopting new use cases, update their infrastructure while cutting expenses and adhering to environmental and future-oriented regulations will profit greatly from it. Similarly, the challenges associated to devices and communication infrastructure are also addressed in the value proposition.

5 Conclusions

During its initial phase, AMBIENT-6G successfully established the foundation for impactful dissemination, standardization, and exploitation of its novel energy-neutral IoT solutions.

A clear dissemination and communication framework has been defined, successfully launching project visibility within the scientific and industrial communities and preparing for broad public outreach as technical results consolidate. Refined dissemination and communication plans (individual partners' and joint ones) have been arranged, and AMBIENT-6G activities are already rich within the first five months of its lifetime.

In parallel, significant progress has been made in positioning AMBIENT-6G within relevant standardization activities. A concrete procedure set to ensure that the technical innovations of the project are closely aligned with emerging 6G specifications. Close monitoring of relevant activities has been established since the beginning of the project, an intra-project workshop has taken place to bring up-to-date knowledge to the whole consortium, and initial relevant partners' contributions have been already submitted to 3GPP RAN1/RAN2 and IEEE 802.11.

Finally, AMBIENT-6G partners have a refined initial exploitation planning tailored to their specific roles, sectors, and commercialisation pathways. The general methodology for business model and innovation management has been set to further investigate the commercialisation and deployment of ENDs, spanning technology licensing, spin-offs, product enhancements, educational impact, and strengthened industrial partnerships.

As the project advances, these activities will continue to intensify and evolve, ensuring that AMBIENT-6G maximises its scientific, societal, and economic impact while contributing to Europe's leadership in sustainable 6G innovation.