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Advancing Global Interoperability for Vehicle-to-Grid (V2G) Technology: Insights from Task 53

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Executive Summary

Electric vehicles (EVs) equipped for bidirectional charging – allowing energy to flow from vehicle to grid (V2G) – are poised to become critical assets for grid flexibility and renewable energy integration. However, today's V2G implementations remain fragmented by proprietary protocols and region-specific grid requirements, impeding widespread adoption. Task 53 is an international collaborative **initiative under the International Energy Agency's Electric Vehicles Technology Collaboration Programme (IEA EV-TCP)** aimed at achieving **global interoperability** for bidirectional charging across **AC, DC, and wireless** technologies. This paper provides a comprehensive technical overview of Task 53's objectives, structure, and early progress. We discuss the background and motivation for Task 53, including the urgent need for interoperable V2G standards to support grid stability. We outline the **global mission** to create a "golden standard" for V2G, and detail the **technical challenges and standardization gaps** (e.g. ISO 15118-20, grid codes, communication protocols) that the task addresses. The paper describes Task 53's organizational framework with three dedicated working groups (AC-Bidirectional, DC-Bidirectional, and Data), and how they collaborate with world-class laboratories (JRC, Argonne, DEKRA) to perform interoperability testing. **Early results** – including identification of key gaps and bugs in current standards – are presented alongside insights from testing facilities. We further highlight **collaborations with industry stakeholders** (OEMs, utilities/DSOs, CharIN, VGIC, etc.) that expand the reach of Task 53. Finally, we present the **roadmap and next steps** toward global V2G scalability, discuss policy implications of interoperable V2G on grid stability and renewable integration, and conclude with the outlook for this important initiative.

Keywords: Public Policy and Promotion, Charging business models, Standardization, V2H & V2G, Smart grid integration and grid management,

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1. Introduction:

As electric mobility matures, electric vehicles are increasingly seen not just as transportation, but also as distributed energy resources capable of providing power back to the grid. The concept of vehicle-to-grid (V2G) or bidirectional charging enables EVs to return stored energy to the electrical grid or to local loads, offering valuable grid services such as peak shaving, frequency regulation, and emergency backup. **Real-world pilots have demonstrated that V2G is technically feasible – "V2G works" – but they also reveal a critical shortcoming: current implementations are often not interoperable across different vehicles and chargers**. Proprietary protocols and regional standards mean that an EV and charging station from one manufacturer or region may not seamlessly operate in V2G mode with equipment from another. This lack of interoperability is a major barrier to scaling V2G to a mainstream global solution.

To address this challenge, the **International Energy Agency (IEA)** launched **Task 53: "Interoperability of Bidirectional Charging (INBID)"** under its Electric Vehicles Technology Collaboration Programme (EV-TCP) in 2024. Task 53 was proposed by Switzerland and approved by the EV-TCP Executive Committee, uniting a consortium of member countries and industry partners in a **fee-based, non-profit** endeavor. As of early 2025, Task 53 has participation from at least a dozen IEA member countries across Europe, Asia, and North America, including major EV markets (e.g. EU countries, USA, South Korea) and support from global industry stakeholders. This broad backing reflects a recognition that **harmonizing V2G standards is an international priority**, enabling even countries without large domestic EV industries or test labs to contribute to and benefit from the development of common solutions.

The need for interoperable V2G is underscored by the increasing importance of grid flexibility in the energy transition. According to the IEA, short-term power system flexibility requirements (to balance fluctuations in demand and renewable supply) are expected to rise **4.5-fold by 2050** relative to current levels. Batteries – including those in EVs – are projected to provide the bulk of this flexibility increase. In essence, electrified transport can play a pivotal role in supporting the grid, but only if vehicles can universally interface with energy systems.

Task 53 was established against this backdrop to coordinate an **international, pre-competitive effort to unify bidirectional charging standards and practices**. By convening automakers (OEMs), charger manufacturers and grid operators (DSOs), standardization bodies, and researchers, Task 53 serves as a platform to identify and solve the technical gaps that prevent "plug-and-play" V2G across all systems. The task's activities and structure are designed to produce tangible outputs: validated **"golden" interoperability standards.**

2. Objectives of Task 53:

Task 53's **global mission** is to achieve **seamless interoperability for bidirectional EV charging (V2G) across AC, DC, and wireless domains**, thereby enabling V2G to scale up globally. The initiative explicitly covers **all three forms of bidirectional charging**:

- **AC bidirectional charging:** where the power conversion (inversion to AC) happens on-board the vehicle and the vehicle directly connects to the AC grid (common for home or building connections).
- **DC bidirectional charging:** where power is exchanged via off-board DC chargers (with conversion off-board) feeding into the AC grid, also used for higher-power transfer (trucks and buses).
- **Wireless bidirectional charging:** inductive charging systems that can also discharge to the grid; while still nascent, Task 53 includes wireless in its scope to future-proof the interoperability framework.

The **ultimate mission** is to ensure that in all cases, the EV, the EV supply equipment (EVSE), and the grid/energy management systems can communicate and operate in harmony.

3. Technical Challenges: GAPs & BUGs

Developing interoperable bidirectional charging on a global scale presents several **technical challenges and exposes gaps in current standards**. Task 53 began by identifying these pain points, as understanding them is a prerequisite to devising solutions. The key challenges and gaps include:

Incomplete Communication Standards (EV–EVSE): The foremost challenge is that the main and only international communication standard enabling V2G, **ISO 15118-20**, is relatively new (published in 2022) and not yet universally implemented or fully validated. ISO 15118-20 is the second-generation vehicle-to-grid communication interface standard that introduces support for bidirectional power transfer, wireless charging, and enhanced security. While it provides a common protocol for EVs and charging stations to negotiate and execute V2G, **conformance test procedures and interoperability profiles for ISO 15118-20 are still under development**. Early implementations by different manufacturers may interpret certain aspects differently, leading to **bugs and inconsistencies**. Moreover, prior to ISO 15118-20, many V2G pilots used interim or proprietary protocols (e.g. CHAdeMO for DC, or automaker-specific extensions of ISO 15118-2 or DIN 70121). Ensuring backward compatibility or migration from these earlier implementations to the new standard is a challenge. Task 53 is identifying several "**GAPs & BUGs**" in the communication protocols where standards like ISO 15118-20 may have ambiguities or missing features specifically related to bidirectional operations. For example, timing sequences for transitions between charge and discharge, or handling of error states during grid services, might not be uniformly defined, causing interoperability failures. **Gathering and categorizing these protocol gaps is a major initial task**, to inform updates to standards or implementation guidelines.

Divergent Grid Codes and Regulations: Another significant hurdle is the **"hundreds of grid codes"** and regional regulations that govern how distributed energy resources (including EVs) connect to and interact with the grid. Grid codes dictate safety, power quality, and control requirements (such as anti-islanding protection, voltage/frequency trip settings, and ramp rates) which vary by country or utility. An EV operating in V2G mode is effectively a small power plant or storage device, and must comply with these codes. Today, **no single unified grid connection standard exists for V2G**. For instance, California's **Rule 21** specifies requirements for inverters (including potentially EVs as energy resources) in that state, while Europe has EN 50549 and other national codes, and Japan and others have their own. Many current EVs and chargers are not designed with multi-grid-code support – they may only meet the rules of their primary market. **Task 53 identified harmonizing these grid code requirements as a key gap**, since an interoperable V2G solution needs a common set of parameters that satisfy the broadest range of codes. This could involve defining settings or modes that cover, say, both North American IEEE 1547 requirements and European standards. Lack of harmonization means that even if communication is standardized, **a vehicle might still refuse V2G in a different region due to grid protection incompatibilities**. Tackling this involves close work with standards like IEEE 1547, UL 1741 (for inverter/EV grid interface in the US), and international bodies to move towards convergence or mutual recognition of V2G capabilities.

AC vs. DC Bidirectional Differences: The technical behavior of V2G differs between AC and DC systems, which introduces additional complexity. **AC V2G (on-board inverter)** must synchronize with grid frequency/phase and maintain power quality, essentially turning the vehicle's charging inverter into a grid-tied inverter. Challenges here include managing the transition between charging and discharging smoothly, handling unbalanced phase loads (in single-phase vs three-phase connections), and meeting stringent safety standards for anti-islanding and disconnect. **DC V2G (off-board inverter)** shifts those responsibilities to the charging station, which must coordinate with the EV on how much power to draw or feed. While AC and DC V2G both rely on ISO 15118-20 for communication, there are **additional AC-specific data and control needs** (e.g., telling a vehicle the grid frequency or enabling Volt-VAR control from the car) that might not have been fully fleshed out in early standards. Task 53's working groups explicitly separate **AC-bidirectional** and **DC-bidirectional** topics to ensure that the unique technical gaps of each are addressed. For example, one identified gap on the AC side is how to handle a **vehicle's response time and performance for frequency regulation**, which may differ by vehicle and was noted by European automakers as a concern (e.g., via the European Automobile Manufacturers' Association, ACEA).

Communication Beyond the EV-EVSE Interface: While ISO 15118 focuses on the vehicle-to-charger link, full V2G interoperability also involves **communications up the chain to energy market actors**. This includes the protocols between the charging station and a backend system or aggregator (e.g., OCPP 2.1 – Open Charge Point Protocol), and between an aggregator and the grid operator or market (e.g., OpenADR, or other demand response signals). **Standardization gaps exist in linking the EV-EVSE conversation with grid-side communications** – for instance, translating a utility's demand response request to specific EV charging or discharging commands in real-time.

Testing and Certification Lack: In the EV charging industry, interoperability has often been ensured by **"plugfest" style testing events and formal certification programs** (for example, CharIN's CCS certification for charging). For V2G, such coordinated testing and certification frameworks are only beginning to emerge. A challenge identified is the lack of standardized **test procedures or reference implementations** for bidirectional charging features. Without agreed test cases, different manufacturers might test V2G functionality under different conditions, possibly missing edge-case incompatibilities. **Conformance testing standards for ISO 15118-20** are still under development as noted earlier, and similarly, there is no single certification for "V2G-capable" vehicles or chargers yet. Task 53 aims to fill this gap by developing and performing laboratory test procedures (see Section 5) that could later inform official certification programs. This includes defining test scenarios for AC and DC V2G (e.g., grid disconnect events, communication error handling, etc.) and conducting cross-tests between multiple EVs and chargers. Until such testing is widespread, interoperability issues may lurk undiscovered.

In summary, the technical challenges facing Task 53 revolve around aligning and enhancing existing standards to cover **all necessary aspects of bidirectional charging**, and doing so in a way that works across different technologies and regions. The major **standardization gaps – in communication protocols (notably ISO 15118-20), in harmonized grid connection standards, and in end-to-end data integration – have been clearly recognized** by the Task 53 experts. By systematically identifying these gaps (often labeled as "GAPs & BUGs"), Task 53 provides a focus for the working groups and partners to develop solutions or push for updates in the relevant standards bodies (ISO/IEC, SAE, IEEE, etc.). The following sections describe how Task 53 is organized to tackle these issues and what progress has been made to date.

4. Laboratory Testing Procedures and Test Site Collaboration

A cornerstone of Task 53 is its emphasis on **hands-on testing and validation in specialized laboratories**. While identifying gaps and writing specifications are crucial, proving interoperability in practice is the ultimate goal. To that end, Task 53 has partnered with and leveraged **world-class EV interoperability test centers in both Europe, Korea and the United States**. Notably, the **EU Joint Research Centre (JRC)** in Ispra, Italy and the **Argonne National Laboratory** in Illinois, USA serve as primary venues for comprehensive V2G interoperability tests. Additional collaborations include testing organizations like **DEKRA, KERI, Elaad,** as well as industry consortia like **CharIN** (Charging Interface Initiative e.V., known for hosting "Testival" interoperability events), and the **Vehicle Grid Integration Council (VGIC)** in the US. These partnerships create a global network of test sites where Task 53 concepts can be evaluated under real conditions.

Test Scope and Procedures: The laboratory tests under Task 53 are designed to cover all combinations of bidirectional charging modes (AC, DC, potentially wireless) and a variety of brands of EVs and EVSEs. The fundamental approach is to conduct **"cross-tests"** where multiple EV models are paired with multiple charging stations to verify that if both implement the Task 53 "golden standards," they indeed interoperate correctly. The goal is to cross-test among at least 3 OEMs, 3 EVSE-manufacturers and 5 DSOs (for each technology: AC, DC and wireless).

The participating labs (JRC, Argonne, DEKRA) are equipped with advanced tools to monitor and simulate conditions. Grid simulators allow testing EVs in a range of grid frequencies and voltages (useful for trying EU vs US grid conditions, or testing responses to disturbances). Load banks can simulate the grid or building loads so that an EV's power output can be absorbed safely. High-speed data loggers and protocol analyzers (including specialized ISO 15118 sniffers) are planned to be used to capture the communication between vehicle and charger for later analysis – crucial for diagnosing where an interoperability issue arises (e.g., a mismatch in expected message sequence). Additionally, **test software from companies like QualityLogic** may be utilized.

It's important to note that **Task 53's lab tests are cooperative, not competitive**. The goal is not to name-and-shame any manufacturer's product, but rather to collectively learn and improve. Companies participate knowing that any issues found will benefit everyone by contributing to a more robust standard. In many cases, tests are done with engineering prototypes or beta software that can be quickly adjusted in subsequent rounds.

5. Preliminary Findings:

In the initial phase of Task 53, a major emphasis was placed on **collecting and analyzing known issues ("gaps" and "bugs") that hinder bidirectional charging interoperability**. This effort has yielded a valuable knowledge base, guiding the task's priorities and early solutions. Key early findings include:

Catalogue of GAPs & BUGs: By Q1 2025, Task 53 had gathered *57 identified gaps/bugs from 31 experts across industry and academia*. These were contributed via an online enquiry on the Task 53 website and through workshop discussions. Each entry in this catalogue corresponds to a specific interoperability pain point. For example, some reported gaps concern the ISO 15118-20 protocol – e.g., lack of clarity in the standard for handling certain error conditions in V2G mode, which can lead to one implementation aborting a session while another tries to continue. Other gaps pertain to **grid code mismatches**, such as EV inverters not meeting a particular country's anti-islanding detection timing. By inviting broad input, Task 53 ensured it wasn't just theorizing problems – it captured real experiences from those already working on V2G pilots.

Notable Gaps in Standards: From the gap analysis, a few specific standardization gaps stood out early:

- *ISO 15118-20 Implementation Gaps:* Several relate to ISO 15118-20 not having fully defined **conformance test profiles** yet. One gap noted that different vendors had implemented the "Pause charging and resume with discharge" sequence differently, since the standard allowed some leeway – causing mismatches. Another was a lack of explicit guidance in ISO 15118-20 for certain AC V2G behaviors (since the standard is very broad, some specifics like how to handle a grid frequency event were left to implementers).
- *Grid Code and Safety Gaps:* It was observed that **no EV had yet implemented islanding detection** on its own – they relied on the charging station for that in DC case, or assumed an external device in AC case. If an EV is directly grid-tied in AC V2G, this is a gap because grid codes require anti-islanding. Thus, Task 53 marked this as a gap to resolve (potentially by having EVs use standards like IEC 62786 for distributed energy resource interfacing).
- *Communication to Grid Integration Systems:* Another early gap identified was the lack of a standardized **interface between EV aggregators and EVSE networks for V2G**. For example, if a utility wants to send a signal to a fleet of EVs to discharge, there wasn't a uniform format for that message across different charging network providers. This gap falls slightly outside vehicle standards, but Task 53 noted it as an interoperability issue to be tackled via the Data working group.

Initial Bug Fixes and Workarounds: In parallel with identifying issues, Task 53's engaged companies began developing interim fixes for testing purposes. In some cases during Workshop 1, engineers were able to apply software patches on-site to overcome bugs discovered (e.g., relaxing a timing parameter to allow another device to catch up). These quick fixes, while not formal, proved that solutions exist. More formally, some results have already been fed back to standard bodies: for instance, a bug list has been communicated to the ISO/IEC Joint Working Group responsible for 15118 so that future amendments or implementation guidelines can incorporate Task 53's findings.

6. Policy Implications and Impact on Grid Stability and Renewable Integration

The work of Task 53, while technical in nature, has far-reaching **policy implications** and potential impacts on how electric grids operate, especially concerning stability and integration of renewable energy. By breaking down interoperability barriers, Task 53 is effectively enabling policymakers and regulators to incorporate V2G into their plans for a cleaner and more resilient energy system. Key implications include:

Enabling New Energy Policies and Programs: Interoperable V2G paves the way for **scalable demand response and energy storage programs using EVs**. Policymakers can design programs (or mandates) knowing that a broad range of EVs will be able to participate. For example, a city or country could introduce an incentive for EV owners to provide grid services at peak times, confident that any compliant EV/charger will work with the program's infrastructure. We are already seeing early signs: **California's Public Utilities Commission approved the first utility tariff for V2G exports in 2022**, which allows commercial EVs (like school buses) to earn revenue by supplying energy to the grid. However, those programs currently often specify particular technologies or even specific vehicles. With Task 53's outcomes, future programs could be **technology-agnostic**, simply requiring adherence to the standard. This lowers barriers for consumers and fleets to join, since they won't need unique hardware or software depending on their provider. **Policies could also mandate V2G-readiness**: for instance, building codes might require new commercial buildings with EV charging to have V2G-capable equipment (knowing that equipment is universally compatible), or vehicle regulations might require that EV models offering high battery capacities also support V2G functions in accordance with the standard.

Impact on Grid Stability: One of the most promising impacts of widespread V2G is on grid stability. If thousands (eventually millions) of EVs can dynamically charge or discharge in unison, they become a massive, distributed buffering system for the grid. This can help stabilize frequency and voltage. For instance, if a large power plant suddenly trips offline, instead of relying solely on traditional power plants to ramp up, a coordinator could instantly reduce charging or even draw power from EVs across the network to compensate – an ultra-fast response that could arrest frequency decline within seconds. Many grid operators maintain "spinning reserve" or rapid response units for such events; a policy that integrates V2G resources into these reserves could improve stability and reduce costs (as EVs are essentially already paid for by their owners, unlike dedicated grid batteries). Interoperability is key here because the grid operator's signals and the EV responses must be standardized; Task 53's data and communication framework contributes to that. Another aspect is **local grid stability**: as more renewable generation (like rooftop solar) comes online, distribution networks face backfeed and voltage rise issues. V2G-capable EVs parked in neighborhoods can absorb excess solar at midday (preventing feeder over-voltage) and then discharge in the evening (supporting the local grid during high demand). Policymakers and regulators in high-solar regions (such as parts of Europe, California, Australia) are very interested in this concept of using EVs for local balancing. Task 53's work will give them confidence that equipment from different vendors can work together to provide these services reliably.

Accelerating Renewable Energy Integration: The variability of renewable energy sources (wind, solar) requires flexible resources to balance supply and demand. **EV batteries collectively represent a vast flexible resource**. By 2030, global EV battery capacity in vehicles will be many tens of gigawatt-hours – essentially a huge storage reservoir distributed across society. Interoperable V2G means any chunk of that capacity can be tapped when needed. Policy-wise, this means countries can set more ambitious renewable energy targets if they account for V2G as part of the balancing toolkit. For example, a country aiming for 100% renewable electricity could explicitly plan to use EV storage at night when solar is down – drawing on cars charged earlier from the sun. Already, some plans (like in the UK's grid future scenarios or Germany's integration studies) consider V2G, but with uncertainties about interoperability, the projections are cautious. With Task 53 reducing those uncertainties, energy planners can more confidently incorporate V2G. On the regulatory side, ensuring that **market mechanisms allow EVs to participate** (aggregators bidding EV fleets into energy markets, or allowing aggregated EVs to provide frequency regulation, etc.) becomes crucial. Some regions have started this (for instance, **European electricity markets under new directives allow aggregation of consumer batteries including EVs**), and the U.S. FERC 2222 order likewise opens markets to distributed energy resources. Interoperability simplifies the role of aggregators – if every EV speaks the same "language," an aggregator can recruit any EV owner and have their resource integrated, making the market participation frictionless.

Standardization Leading to Regulatory Clarity: Often, policy lags technology due to lack of clear standards. With V2G, there have been regulatory hesitations: e.g., how to treat an EV that also acts as an energy resource – is it subject to generator interconnection rules? Does it need a special permit? Uniform standards help answer these. If Task 53's work results in, say, an agreed safe operating envelope for V2G, regulators can then uniformly exempt or include EVs under certain conditions. For example, California might update Rule 21 to explicitly allow any EV charger that is certified to the Task 53/ISO 15118-20 V2G profile to connect without individual interconnection studies. In Europe, network codes could be amended to include an "EV as DER" section referencing the harmonized specs. This regulatory clarity in turn encourages investment: charging providers and automakers will deploy more V2G once the rules are clear and consistent internationally.

Consumer and Society Benefits: At the policy level, one must also consider consumer impacts and societal benefits. Widespread V2G could **reduce electricity costs** by shaving peaks (thus avoiding expensive peaker plants) and providing services cheaper than traditional sources. These savings could be passed to consumers or used to fund further grid improvements. Moreover, if EV owners are compensated for V2G, the total cost of ownership of EVs improves, effectively incentivizing EV adoption – a virtuous cycle aligning with transport electrification goals. Policymakers are interested in this angle: some governments are exploring subsidies or tax breaks for V2G-capable equipment, recognizing that an investment in V2G is an investment in grid infrastructure. Interoperability is essential to ensure these incentives aren't squandered on siloed tech. Imagine a subsidy program for home V2G chargers – if it inadvertently funded incompatible systems, it would fail to deliver public value. Task 53 helps avoid that by pushing one standard that such programs can mandate.

Grid Resilience and Emergency Management: Another impact area is resilience. In natural disasters or outages, V2G could provide backup power to homes or critical facilities. Policies around resilience (such as California's encouragement of solar+storage for backup) could include EVs. Some early examples: Japan has used Nissan Leafs to power evacuation centers after earthquakes. If every EV can do this reliably, emergency response plans could formally incorporate EV fleets. Municipalities might invest in bidirectional school buses, for instance, that serve as grid assets normally and as mobile generators during crises. Interoperability ensures that in a multi-agency response, any vehicle can plug into any compatible infrastructure on the fly. Thus, Task 53's work also indirectly bolsters disaster preparedness policy options.

In summary, **the policy implications of Task 53's success are substantial**. It gives regulators and lawmakers the confidence to integrate EVs-as-grid-resources into their frameworks, knowing that common standards will ensure safety and compatibility. This can accelerate supportive policies – from market rules to incentives – that unleash the full potential of V2G. The anticipated impact on grid stability is transformative: with tens of thousands of interoperable V2G cars, grids can operate with higher renewable penetration and greater reliability. Policymakers aiming for decarbonization and electrification targets will find in V2G a synergistic tool that addresses the variability of renewables while adding value to electric mobility. Task 53's role is essentially to clear the last technical roadblocks so that **good policy can drive forward, leveraging EVs as a flexible, stable backbone of the future energy system**.

7. Expected Outcomes:

- **Improved Standards:** Recommendations for enhancing the ISO15118-20 standard and related Grid Codes to facilitate global V2G interoperability.

  a) Provide proof of interoperable solutions based on a "consortia agreement" and conformance test reports from partner labs.
  b) Ensure interoperability between bidirectional vehicles and charging equipment, with at least 9 combinations (3 OEMs x 3 EVSEs)
  c) Ensure interoperability between bidirectional charging equipment and DSOs, with at least 15 combinations (3 OEMs or 3 EVSEs x 5 DSOs)

d) Develop technical documentation (including presentations, specifications, and videos) detailing the implementation process for third parties to achieve interoperability.

- **Enhanced Collaboration:** Strengthened partnerships between international stakeholders, leading to more cohesive V2G implementation strategies. As governments worldwide tighten regulations on emissions and promote electric vehicles and even bidirectional charging (see California Senate-Bill 59, Maryland House-Bill 1256 and decision by EC to require ISO15118-20 by 1.1.2027…), being part of Task 53 is helping industrial partners to contribute to the development of standards that support regulatory compliance, instead of suffering them passively.

- **Policy Recommendations:** Guidance for policymakers to support the adoption and integration of V2G technology.

8. Conclusion:

The rise of electric vehicles presents not only a revolution in transportation, but also an unprecedented opportunity for energy systems worldwide. **IEA Task 53 "Interoperability of Bidirectional Charging (INBID)" is a timely and crucial initiative at the nexus of these domains, focused on transforming V2G from a patchwork of isolated successes into a globally scalable, interoperable solution.** This paper has provided a comprehensive overview of Task 53's objectives, approaches, and early progress, painting a picture of how technical collaboration can unlock new value streams in the e-mobility ecosystem.

In summary, **Task 53 was born out of the recognition that V2G technology, while viable, lacked the interoperability and standardization needed for broad adoption.** In the Introduction, we outlined how decades of EV development led to this point – numerous proprietary protocols and regional differences have hindered EVs from seamlessly interacting with the grid at large scale. The background underscored the urgency (with grid flexibility needs surging and EVs poised to help) and set the stage for Task 53's mission.

We then detailed the **global mission** of Task 53: achieving true interoperability across AC, DC, and wireless bidirectional charging, effectively creating a universal "language" for V2G. This mission is ambitious but necessary, and Task 53's international, multi-stakeholder nature uniquely positions it to succeed where unilateral efforts might fail. The **technical challenges and gaps** discussed (from standard issues in ISO 15118-20 to divergent grid codes) illustrate the complexity involved – but also validate Task 53's comprehensive scope in addressing all facets (vehicle, charger, grid, communication, data).

Task 53's **organizational structure**, with its three working groups (AC-Bidi, DC-Bidi, Data), ensures focused problem-solving, while its partnerships with **laboratories and test centers (JRC, Argonne, DEKRA, etc.)** ground the work in reality through rigorous testing. The early testing results have importantly confirmed that V2G interoperability issues, though numerous, are solvable – no fundamental physics or safety barrier prevents success, "only" coordination and refinement of standards. By cataloguing dozens of specific gaps and beginning to close them one by one, Task 53 is steadily "closing the gap" as its motto suggests.

Crucially, Task 53 is not working in isolation. **Collaboration with OEMs, charging industry groups like CharIN, grid integration advocates like VGIC, utilities, and regulators, means the initiative's outcomes are immediately disseminated and adopted by the broader community**. This collaborative fabric is perhaps Task 53's greatest strength – it aligns the incentives of all players towards a common goal of interoperability, turning what could be a competitive stalemate into a cooperative win-win. The paper highlighted how these stakeholders are contributing and why they are motivated to see Task 53 succeed (e.g., OEMs benefiting from larger markets, utilities from reliable resources, consumers from lower costs).

Looking forward, the **roadmap of Task 53** points to an exciting trajectory: by 2027, we can expect a set of validated interoperability guidelines and possibly updates to international standards, thanks in large part to Task 53's work. The path to **global scalability of V2G** will then enter a new phase of implementation, supported by the foundation laid by this task. The policy discussion shows that the implications go well beyond engineering – Task 53 is helping enable a future where EVs stabilize the grid and facilitate massive renewable integration, with positive feedback into accelerating EV adoption. It is a prime example of how smart coordination can amplify the impact of clean technologies.

In conclusion, **Task 53 stands as a pivotal initiative at a pivotal time**. As the EV revolution meets the clean energy transition, ensuring these two sectors speak the same technical language is vital. By addressing interoperability head-on, Task 53 is effectively writing the playbook that will allow millions of EVs to function as one integrated network resource, irrespective of make, model, or locale. The work is challenging and detailed – involving standards minutiae and painstaking tests – but the payoff is a future where vehicle-to-grid services are as ubiquitous and effortless as connecting to Wi-Fi. The early achievements of Task 53 demonstrate the power of international collaboration in tackling such challenges. The continued commitment of its members suggests that by EVS-39 and EVS-40, we will be discussing not the promise of interoperable V2G, but its thriving practice across the globe, enabled by the groundwork being laid today. **V2G's full potential – a more stable grid, deeper renewable penetration, and new value for EV owners – is within reach, and Task 53 is helping to make sure we grasp it together**.

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Presenter Biography

Environmental engineer and political activist with a passion for sustainable energy solutions. Producer of oe.energy talks, a podcast dedicated to Switzerland's energy transition, highlighting the importance of collaboration between politics, industry, and society. Currently pursuing an MSc in Sustainable Business Development while serving as President of the Green Liberal Party in Zollikon, Switzerland. Actively involved in IAE Task 53 for communication purposes.

Patrick Eugster is currently pursuing an MSc in Mechanical Engineering at ETH Zurich (2022–2025), where he is conducting his master thesis with the Swiss Solar Group, analyzing the readiness of the Swiss energy industry for bidirectional charging. Previously Patrick completed a BSc in Mechanical Engineering at ETH Zurich (2019–2022). His professional experience includes working as an Intern in Innovation and Startup Scouting at AMAG Venture LAB (2023) and as a Research Intern at Russell Reynolds Associates (2022–2023). At Task 53 Patrick takes care of the industry partners.

Marco Piffaretti has started his career by building solar cars for the "Tour-de-Sol", 39 years ago. Since then, he has co-founded several companies and projects in the field of e-mobility: among others Protoscar, large-scale test "Mendrisio", ALPIQ-e-Mobility, EVTEC, GOFAST, sun2wheel and most recently the "V2X Suisse" project, where 50 EVs offered aggregated flexibility to the Swiss TSO, several DSOs and ZEVs. Currently Marco leads Task53 as Operating Agent.

Regina Flury von Arx, co-founder of novatlantis, brings a wide range of experience in the implementation of projects in the field of electromobility and bidirectionality. She was involved in the first sector coupling field trial in Erlenmatt Ost in Basel as well as in the largest field trial with mobile car sharing vehicles V2X Suisse and is currently involved in the TEC-OFF project of DPD and in Task 53.

Bjoern is the Managing Director of "Next-Dimension", a California based consultancy company focused on promoting and scaling VGI/V2X. Bjoern served as the head of Siemens Venture Capital and later spent 8 years with Nuvve – a leader in the V2X space. Bjoern has been involved in 14 V2X projects worldwide, spanning the US, Denmark, Japan, Australia, Sweden, India, and even Africa. Currently, Bjoern serves as the North American representative of Task 53.