Good Practice of the Year:
Submission Form for “Technological Innovation & System Integration”

The practice: basic information	
Organisation(s) submitting the practice:	Community of Allensbach, Local Agenda 21 Easy Smart Grid GmbH, Karlsruhe International Solar Research Center ISC Konstanz e.V. European Institute for Energy Research EIfER, Karlsruhe
Name given to the practice:	SoLAR (German abbreviation for “Smart Grid without Load Profile Measurement Allensbach-Radolfzell”) The project SoLAR demonstrates energy system transformation by “intelligent energy sector coupling”, based on a real-time price system on the basis of electric grid state variables. This allows flexible appliances of every type, power and availability to be used as “virtual batteries”, and thus to integrate more renewable generation at lower cost.
Please give a short description of your practice (1000 characters max.[1])	SoLAR is based on a technology, patented by Easy Smart Grid, EP 12743945NWB1. The objective is to coordinate a multitude of flexible devices in an electric grid cell to react to the availability of volatile renewable energy. A “balance indicator” (BI) signal is locally derived out of grid state variables like grid frequency or the power balance at connection points of the cell and indicates the cell’s power balance. Additionally, a “congestion indicator” (CI), derived out of voltage or grid loads, is applicable. The indicators are available in real-time (seconds) to the grid participants and interpreted as price signals. By considering actual as well as forecasted prices and available flexibility, each prosumer decides individually if devices are activated – to buy or not to buy. This way an efficient energy market with dynamic tariffs can be built without the need of negotiation. Price signals of higher-level cells may be incorporated to optimize energy exchange in a multi-cell lay-out.
Main objectives of the practice (2000 characters max.):	SoLAR, funded by the Ministry of Environment, Climate and Energy Economy of Baden-Württemberg, Germany, aims to prove functionality and scalability of intelligent sector coupling in a real-life environment. The project has been implemented in a new residential development with 22 households in 12 semi-detached houses and two apartment buildings connected with an existing building with three households. It includes smart

[1] Refers to characters including spaces

	control of a CHP unit, 12 heat pumps, several dozen household appliances, a number of charging units for electric vehicles and some battery storages. Electricity is produced locally with rooftop-PV and the CHP unit. Objective in the estate is to coordinate all devices to increase the electricity self-consumption rate in the residential complex from about 50 to over 80%, while reducing grid load. It is expected that electricity cost for the inhabitants will be reduced by 4 to 6 cents/kWh. It is demonstrated that the technology is simply scalable for large cells like district grids and distribution grids, embedded in a connected electricity grid and market. By combining a fine grain simulation model with in-situ data, the project proofs that a future energy system, based on 100% renewable energies, can be run safely and cost effective. Investments in energy storage, grid extension as well as transaction cost are minimized. The project also aims to develop proposals how real-time tariffs - dynamic prices and/or grid fees - may be designed to integrate the approach into current and future energy markets and provide system services. The practice demonstrated in SoLAR is fully in confor-mance with the objectives the European Commission defined in its “Clean Energy Package”, including “Local Energy Communities” and “Dynamic Tariffs”. The inhabitants of the estate are empowered to produce their own energy and effectively share it with each other. The method to apply dynamic tariffs can be adapted upwards (distribution, transmission grid level) at unlimited scale.
Activities undertaken as part of the practice (2000 characters max.):	Pre-Phase: • Talks with estate owner and community • Development of project idea • Basic conception, lay-out software for sector coupling (energy balance, economic feasibility) • Partner search and application for funding Phase I (virtual pre-evaluation) • Building of digital twin “Virtual Demonstrator” (VD) with flexible heat appliances • Integration of algorithms • Dynamic simulation and pre-evaluation of stability • Economic pre-evaluation in the context of estate-internal energy supply Phase II (realization) • Contracting and realization of CHP and PV • Extension of VD with flexible household appliances and electric vehicle charging • Realization of private electric grid and smart metering • Implementation of electric vehicle chargers

	• Integration of metronomic, communication and control system • Programming and operation • Extension of dynamic simulation and pre-evaluation of stability, including higher grid levels • Proposals and preparation for dynamic tariffs for local energy communities • Real-life evaluation of the system, boosted with hardware-in-the-loop simulations, to emulate system reaction on higher grid levels • Stakeholder interviews and project inclusion of inhabitants
Timeline of the practice (please distinguish between planning, implementation and evaluation):	February to July 2016: Pre-Phase: Development of project idea and partner search, basic conception July 2016 to April 2018: Application for funding, detailed planning Mai 2018 to April 2019: Phase I: building "Virtual Demonstrator" (VD) model and proof of concept July 2019 to July 2021: Phase II: building of houses, completion of VD and algorithm integration/evaluation July to December 2021: Phase II: integration of ICT, pre-tests, operation Planned January to December 2022: Phase II: one year in-situ evaluation, improvements
Place of implementation/ geographical location:	The residential complex, in which SoLAR is executed, is located in the town of Allensbach at Lake Constance in the South of Germany near to the Swiss border.
Please provide some background information. What was the context that prompted the development of the practice? What challenge is it solving? (2000 characters max.)	SoLAR has been initiated by the Local Agenda 21 in Allensbach, a citizen climate protection initiative. Prior to this project, a climate protection guideline had been passed by the community in 2006, stating the objective of climate neutrality by 2050. With funds from the competition "Climate Neutral Communities", various analyses had been performed since 2010, including a study on coupling the electricity and heating sectors. This showed that 80% of conventional electricity demand can be provided from solar and wind and integrated in the existing energy grid by intelligent coupling with CHP and heat pumps. In 2016 the Local Agenda developed a concept to supply the community mainly from renewable energy sources, assuming that all energy sectors (electricity, heating and mobility) will be widely electrified and coupled intelligently. The community also got involved with the SINTEG project

	C/Sells (a smart grid demonstration project funded by the Federal Government of Germany) where it served as a "participation cell" in its sociological analysis, citizen involvement being a major part of this project. The concept aims to minimize needs for expensive energy storage and grid extension. It relies on intelligent and real-time coordination of flexible assets, depending on renewable energy availability ("virtual batteries"). In the project application phase, the patented technology of Easy Smart Grid GmbH (ESG) for decentral energy management was identified as a suitable approach. During the SoLAR project, the technology, conceived for isolated micro grids, was adapted to the requirements of the European continental grid. The challenges SoLAR meets are to realize "virtual batteries" at highest demands on stability, resilience, privacy protection and cyber security – simultaneously at lowest complexity and cost. The chosen approach has high potential to solve this challenges and constitutes a paradigm shift in energy markets, helpful to boost energy system transition.
Please provide any further relevant facts that concern the implementation of the practice, if there are any. Depending on your practice this can pertain to target group, number of people reached, number of participants, most important technical/physical parameters, functionality, etc. (2000 characters max.)	All inhabitants support the project. Most own the houses and flats they live in. The population of about 60 to 70 people represents a good mix of families with children, couples and singles of various ages. Thus it is expected to gain a good mix on data about energy consumption and available flexibility of the households. As structure and ownership is complex, a lot of legal and organisational challenges are solved, so that SoLAR offers a good blueprint and lessons-learned for follow-up projects. Heat supply is realized with one heat pump for each single semi-detached house and one CHP unit supplying the 3 multi-flat houses. The heat source for the heat pumps is a "cold" heat network, distributing energy from ground water. The estate is equipped with a private electricity grid in which electricity is provided on 3 levels: The owners of the single houses produce and consume their own PV power. Their surplus energy is sold to the contractor and contributes to the local electricity supply of contracted PV and CHP. This energy is sold to all inhabitants with a special tariff that is less expensive than standard as grid fees and energy taxes are not applicable. If local energy is not sufficient, electricity is supplied from the external grid. The installed energy management system consists of 13 microcontrollers, linked over local Ethernet. The meter of each single house is connected with a microcontroller that measures the individual BI of the house and incorporates controller agents for the related controlled flexible devices: heat pump, electric car charger, household appliances and a battery, if applicable. Target is to maximize energy self-consumption of each house.

	A microcontroller, connected to the central meter of the private grid, provides a BI for the whole estate and controls CHP and all the flexibilities of the multi-flat houses. The systems of the single houses also react on this central BI to support maximizing energy self-consumption within the estate.
Practice website / place where additional information can be obtained (you can also include links to other relevant information, such as videos):	Website: https://solarlago.de/solar-allensbach/ An English summary is available at: https://solarlago.de/solar-allensbach/english-summary/ German summary and downloads of detailed reports at: https://solarlago.de/solar-allensbach/projektbericht/
Innovation	
Which elements of the practice were fully new? And which elements were improvements of existing approaches? (2000 characters max.)	Basically there are two existing approaches to utilize flexible assets to balance power and protect the electricity grid: energy trading and direct control. Direct control is normally applied by grid system operators, as direct reaction to grid status, e.g. activation of primary control as a reaction on grid frequency, secondary control to balance control areas, or energy curtailing measures to avoid grid overload. The assets are actively controlled by signals of the grid operators. The control orders are not scheduled, however, in general, selection and payment of assets is organized in markets ahead of activation. Energy trading is traditionally done on markets in advance of operation. Results are schedules for future activation of flexibilities at agreed prices. Trading can be done e.g. OTC, on central platforms or peer-to-peer. To counteract deviations in generation and consumption, multiple market negotiations are executed with decreasing lead times and trading time windows: futures, day ahead and intraday. Current approaches try to further reduce lead and trading time to increase accuracy and flexibility and introduce local markets for grid support. The SoLAR approach establishes an energy market but does not require pre-negotiations and advance commitment. In consequence, market platforms for short-term trading with bi-directional communication become unnecessary. Like with direct control, the grid state is measured in real-time and used to generate decisions. However, this is done indirectly by generating price signals out of grid states. The price signals are locally derived from measurements in the grid cell and broadcast to all participants. The decision on operation, based on prices, is done individually by each prosumer. The backchannel is realized by the reaction of the grid to operation decisions. As an enhancement of current grid “traffic light” approaches, the price signals may also be interpreted as direct control signals in emergency grid states.

What sets your approach apart from others? Are there similar projects? How does your practice compare to them? (1000 characters max.)	Current approaches typically rely on advanced ICT to enhance the current system. The problem arising is growing complexity, associated with higher transaction cost, vulnerability and entrance barriers for smaller enterprises. SoLAR is combining market and physics in a way that overcomes traditional solutions. Trading and control energy perspectively merge into a single system that is basically very simple to implement, but resilient and stable. Moreover, highest privacy protection and cyber security is provided at very low cost. Similar projects, applying dynamic prices to harvest flexibility, normally rely on negotiation or do not provide methods for stability feedback. A comparable approach is “smart balancing” in the Netherlands and Belgium. Every minute, the area control error and the current price for control energy are published. Balance groups are allowed to deviate from internal balance if they support control energy. However, the approach does not activate single prosumers.

Outcomes & impacts	
Please describe the practice's outcomes (immediate results). Please provide supporting numbers/ documentation. (1000 characters max.)	The real-life operation of the system is in preparation. Comprehensive VD results are available. By harvesting the flexibility of heat pumps and CHP the electricity self-consumption rate (SCR) was raised from 50 to 66 %. For CHP it reached 100%. A comparison with a schedule, calculated by an "omniscient solver", showed that the system reached 90% of theoretically possible performance at 1-hour resolution. Adding flexibility from fridges and freezers, SCR only slightly increased. However, power peaks and short-term power fluctuation were significantly reduced. A separate simulation with fridges and freezers, modelling a simplified control area, showed extensive possible contribution to control power. The available positive and negative control power of cooling devices in Germany is estimated to be 2.4 GW. Algorithms for process flexibility like electric vehicle chargers, dishwashers, washing machines and dryers have successfully been tested. A recent report (German) is available here.
What are the impacts (more long-term effects) of your practice? (1000 characters max.)	The results imply that an SCR, largely identical to self-sufficiency rate (SSR), of over 80% will be reached. In a copy-and-paste scenario the cost for applying the system is expected less than the financial profit. This way "virtual batteries" will be available at no extra cost. By further integration of the technology directly into devices, the gross profit is expected to be about 4 cents per kWh of energy demand. Parallel to start up the real-life system with separate microcontrollers, software for implementation of control agents into the own controllers of heat pumps and CHP is prepared. Besides generation and communication of price signals, no extra energy management systems for these devices will be necessary in the future. Implementing controller agents, additional flexible devices of arbitrary type and manufacturer can be enabled to react on real-time price signals. Price signal generation and communication is intended to be integrated in a new generation of smart meters.
Scope & transferability	
Is the practice repeatable and/or designed for long-term use? (1000 characters max.)	The system is designed for long-term use. It is planned to integrate maintenance and improvements into further projects, for which SoLAR can provide the blue-print.

Is the practice transferable to other settings (other circumstances/other geographical regions)? How? (1000 characters max.)	The SoLAR technology is in principle applicable to all types and locations of grid cells with various use and business cases. Sustainable energy management for residential or industrial complexes can be provided. By adapting the price signal accordingly, external power might be integrated, e.g. with power purchase agreements (PPA) or trading schedules for energy spot markets or virtual power plants. DSOs may improve their grid management. Dynamic grid fees may incentive prosumers to avoid congestions and reduce grid cost. Together with utilities, local tariffs may be offered to support the grid. The differential balance group of a DSO could play an important role in future applications, as its power balance is directly measurable in real-time. This way the DSO could be a link between prosumers and TSO: Redispatch and control power could be provided and billed via the DSO balance. The DSO can forward TSO requests with price signals to prosumers, translated to dynamic local tariffs.
Collaborative approach	
Was the solution developed in a collaborative setting? If so, how/with whom? (1000 characters max.)	The community of Allensbach supported citizens, engaged in Local Agenda 21, to build up a comprehensive network of potential partners. Easy Smart Grid, ISC Konstanz and EIFER Karlsruhe became project partners and contribute with their smart grid knowledge and simulation skills. A lot of other research institutes and associations from all over Germany showed interest and gave advise. TU Munich supported the project with research on co-creation. The facility owner and main contractor, Kaufmann Bau, joined the project together with its supplier of heat pumps, Weider, as well as the manufacturer of the CHP, Energiewerkstatt. BSH Home Appliances contributed 18 devices for free. Others, e.g. Miele and Buderus, got loosely involved. The municipal utility of Radolfzell partnered initially. Later, Energiedienst joined as contractor and utility. Moreover, the municipal utilities of Haßfurt and Trier joined to support business development. Several DSOs and TSOs showed interest and got involved.
Have you reached out to peers/experts/relevant stakeholders, or done research on existing best practices for the development of your practice? (1000 characters max.)	The development for SoLAR strongly bases on pre-studies, experience and data from the partners and interested stakeholders. Many SoLAR partners are members of the Smart Grids Platform Baden-Württemberg and involved in the C/Sells project within the SINTEG

	programme on Smart Grids of the Federal Government of Germany. So a large pool of information and scientific reports is available and has been studied. All application documents and project reports refer to state of the art practices and alternative approaches. During project work, research on existing best practises and alternatives is performed continuously.
Do you actively share your insights/findings with others, e.g. via a best practice exchange? (1000 characters max.)	The SoLAR partners have presented and discussed results continuously in various publications and presentations, participating in peer groups, conferences and workshops. Examples: • Dialogue Platform Power-to-Heat, Berlin, 2019 • Smart Grids Congress, Stuttgart, 2019 • E-world, Essen, 2019 • ForDigital Workshops on Local Energy Markets, Karlsruhe, 2019 • Congress „Energy Autonomous Communities“, Freiburg, 2020 • Public Partner Workshop „SoLAR goes LIVE“, Allensbach, 2020 • CIRED 2020, Berlin • Workshop „Markets and Smart Balancing“, Hamburg, 2020 • Grid services market symposium, Lucerne, 2020 • IEEE International Forum on Smart Grids and Smart Cities, 2021 • EHPA: Webinar on new business models for heat pumps, 2021 • ETIP-SNET Regional Workshop, 2021 • German-American Chamber of Commerce, GACC West Virtual Event (California), 2021 Moreover, SoLAR is discussed in meetings with politicians, associations, research institutes, utilities, DSOs, TSOs and manufacturers of ICT and flexible assets.
Evaluation	
Did you evaluate the activity? If yes, how? Please share results and lessons learned. (1000 characters max.)	As SoLAR is realized in a real-life environment with commercial energy contracting and trading, careful evaluation is inevitable. During regular jour fixes, status and results are continuously reviewed and countermeasures planned, if necessary. A great share of capacity has been used to build the Virtual Demonstrator (VD), a very precise virtual twin of the real estate. Population and correspondent energy demand have been carefully defined. The simulation bases on fine grain weather data for Allensbach, used for detailed calculations on building heat balance and PV power generation, including cloud impacts.

	The VD is used to define and check technical KPIs like SCR, SSR, power peaks and power fluctuation as well as financial KPIs, mainly gross margin, induced by intelligent sector coupling. The continuous evaluation made sure so far that KPI and project goals are reached. During a one-year operation period, the system will continuously be monitored and improved, if necessary.
How did your target group and/or other stakeholders evaluate the practice? Please share feedback. (1000 characters max.)	The Ministry of Environment of Baden-Württemberg, has assigned the Karlsruhe Institute of Technology (KIT) to continuously evaluate the project by requesting yearly interim reports and presentations on a Status Colloquium on Environmental Research. Sponsor and KIT also join important partner workshops to get personal insight and give support. As the SoLAR approach is novel, sponsor and KIT requested to split the project in a simulation and a realization phase. Up to date, the feedback on results is very positive. A special version of evaluation has been carried out by the Technical University of Munich. Within the scope of the European research project on co-creation, SCALINGS, interviews with partners and inhabitants have been carried out to learn about expectations, satisfaction with the project and proposals for improvement. Feedback has been positive with some proposals for intensifying co-creation with inhabitants. Unfortunately, the available funding restricts possible measures.
Where do you see room for improvement in your practice? (1000 characters max.)	As both, PV plants and CHP, could possibly feed surplus energy into the external grid, the DSO demanded the implementation of BSI-conform smart meter gateways to measure the load profile of every meter – which is by design not required. Consequently, real-time data from smart meters chosen is not available, yet, and extra meters had to be installed. The supplier is involved to solve this. Up to date, household appliances are only addressable over central Internet servers and Wi-Fi. This causes issues with access cycles and downtimes. Wire bound communication is preferred but induces extra cost for hardware and implementation. So, for future application, it is aimed to develop a new type of power line communication (PLC) technology, broadcasting price signals directly over the grid. System design and algorithms already show high readiness levels between prototype and pre-series. For serial introduction further enhancements, especially for standardization and maintenance are required.

Final pitch	
Why do you think your practice should win the award? What are its central important points? (500 characters max.)	SoLAR has huge potential to boost the energy system transition. Central control of generation and storage, following dumb demand, is substituted with real swarm intelligence, reacting on energy availability. The technology is not only simple and cost effective, but solves upcoming problems of stability, resiliency, privacy and cyber security. Like every paradigm shift, the technology is facing opposition. The RGI award would help finding friends to make intelligent sector coupling successful.

Contact information	
Main contact person for further inquiries regarding the practice:	Stefan Werner Easy Smart Grid GmbH, Karlsruhe Project Coordinator stefan.werner@easysg.de
Project partner(s) who can be approached regarding their role in the practice:	Jonathan Wochner Ministry of Environment, Climate and Energy Economy Baden-Württemberg Department 65 Grid and Storage jonathan.wochner@um.bwl.de Stefan Friedrich Mayor of Allensbach bm.friedrich@allensbach.de Dr. Kristian Peter International Solar Research Center ISC Konstanz e.V. Chairman kristian.peter@isc.de Dr. Enrique Kremers European Institute of Energy Research, EIFER, Karlsruhe Team Coordinator Intelligent Energy Systems enrique.kremers@eifer.uni-karlsruhe.de Klaus Nerz Energiedienst AG, Rheinfelden Director Heat and Energy Solutions klaus.nerz@energiedienst.de Christopher Schneider Stadtwerk Haßfurt GmbH Head of Business Development christopher.schneider@stwhas.de Dr. Andreas Kleiner BSH Hausgeräte GmbH Product Divison Cooling Gobal andreas.kleiner@bshg.com Peter Kaufmann Kaufmann GmbH, Oberstadion General Manager p.kaufmann@kaufmannbau.com

Further requirements: stakeholder/expert review
Please attach a short stakeholder or expert testimonial to your application (200-300 words). This testimonial is meant to show an external view/assessment of your practice and should answer how effective and valuable your target group and/or other relevant stakeholders think your practice is. It can come from a client using the project, a civil society representative or scientist/scholar active in an area your practice concerns or any other expert you deem appropriate. Please also provide the person's contact data for further enquiries.

Jonathan Wochner, Ministry of Environment, Climate and Energy Economy:
„SoLAR fits perfectly into the strategy of Baden-Württemberg to become a leading state in the subject of Smart Grids technologies. The project opens a different perspective on how to improve production and demand side flexibility on a local level. With the decentralized solution of SoLAR, grid operation and local energy consumption can be optimized, as first results show. We are expecting interesting results from the ongoing investigation, that can overall lead to a better energy system."

Stefan Friedrich, Mayor of Allensbach:
"SoLAR is an important step on our community's way to climate neutrality. It is exciting, as it demonstrates in a small scale, but comprehensively, how energy transition works. It comprises solar energy, heat pumps, cogeneration of heat and power as well as electric mobility. But more than that, it even activates single household appliances to integrate a maximum of renewable energy to the grid. Everything is connected – only not via Internet but using the electricity grid itself for coordination."

Dr. Kristian Peter, ISC Konstanz e.V.:
"We burn for the topic. It facilitates comprehensive utilisation of solar energy."

Dr. Enrique Kremers, European Institute for Energy Research, EIFER:
"Flexibility management is a core topic to achieve an emission free energy supply.
SoLAR leverages flexibilities efficiently - it is a promising approach for balancing and redispatch in the upcoming energy market landscape."

Klaus Nerz, Energiedienst AG:
„The future of utilities depends on energy service, on intelligent energy management in all sectors. The SoLAR technology is very interesting in that direction. So simple, still very effective."

Christopher Schneider, Stadtwerk Haßfurt GmbH:
"Our goal as municipal utility is to shape the future, preserve customer loyalty and successfully compete with global players like Amazon or Google. The SoLAR approach is so simple to implement, without complex regulatory measures. We want to try that."

Dr. Andreas Kleiner, BSH Hausgeräte GmbH:
"Finally there is a real application, setting incentives to our customers to use intelligent household appliances for energy management."

Peter Kaufmann, Kaufmann GmbH:
„Kaufmann builds living spaces in natural wood design, providing not only comfortable living climate but supporting climate protection with effective carbon storage and minimum energy consumption due to strong insulation and state-of-the art heat pump technology by our partner Weider. SoLAR is a brilliant supplement to our design. We see good chances for further projects, applying the SoLAR know-how."

The **submission deadline** for this application is **24 September 2021**.

Please also **attach five high-resolution photos or visualisations** that illustrate the practice you apply with. These materials may be used for communication purposes. Please also indicate the copyrights of the pictures.

Any questions? Please contact Stephanie Bätjer: stephanie@renewables-grid.eu, +49 30 7677 194530 or Liam Innis: liam@renewables-grid.eu, +49 30 7677 19455