

Paving the Way to Battle Climate Change

How Two Utilities Embraced Open Source to Speed Modernization of the Electric Grid

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Contents

Foreword3

9 Lessons to Become a Leader in the Digitalization of Energy.....4

Introduction5

Collaboration in Action6

RTE and Alliander: Battling Common Challenges.....7

Lessons Learned: A Playbook for Others.....10

New Incentives Needed15

APPENDIX A: Open Source Projects to Modernize Grids.....17

Acknowledgements20

Disclaimer.....20

Foreword

It is no accident that two European grid leaders, Alliander, a distribution company, and RTE, a transmission company, are allied in an open source foundation to build an open software infrastructure for a fully interactive and fully decarbonized electricity system. We all know how “smart meters” and “smart grids” have revolutionized this industry. A new wave of radical digital innovation starts with “smart companies” like Alliander and RTE.

Such initiatives are essential to the health of populations around the world. It is not possible to overstate why creative open source solutions are required. Since the Industrial Revolution, we have spewed greenhouse gas emissions into the atmosphere, fueling global warming. Unless we urgently reverse our polluting ways, we will likely see many liveable portions of the planet turn into deserts. Large portions of countries that now supply much of the world’s food will become wastelands. We may see increased spread and frequency of monsoons, hurricanes, and wildfires. Much of this is preventable. It is still within our reach to keep the planet habitable. We have to stop extracting and burning fossil fuels like coal, crude oil, and natural gas.

I like to think our job is to respond to the emergency, with nimbleness, and through community. When we recognize the emergency, we respond with a new nimbleness, and take transparent decisions involving all of the community. This case study demonstrates a path and direction every utility on the planet can follow.

1. Emergency

The European Union has already reached its first “20-20-20” energy transition targets in 2020 and is now looking at 2030 targets, with a final “Net Zero” in 2050. Many other countries worldwide have started to embrace ambitious goals with zero net emissions

of greenhouse gasses. Powerful central banks are creating standard financial and banking tools vis-à-vis climate change mitigation. EU energy utilities are at the forefront of this acceleration and should decarbonize two-thirds of their electricity output by 2030.

2. Nimbleness

Time is gone where our electricity systems only comprised vertically integrated companies ruled by rigid hierarchies. Generation does not control demand anymore. Transmission does not transport all generation. Distributed resources, customer production and demand, electric vehicles, and local storage take decisions “behind the meter.” Distribution is no longer a passive one-way pipe that begins with its higher-level power-generation plants producing and selling their product.

3. Community

In a silo, you plant only your seeds and harvest only what they give. In a silo, you do not cooperate with other players because you do not interact. You do your own thing behind clearly defined property walls. In a community, planting and harvesting are shared, because nobody is able to master all interactions with one-sided rules and organized selfishness.

Alliander and RTE have demonstrated the substantial benefits already being achieved by the open source philosophy in the power generation and distribution industry. Moreover, it shows how much more progress could be achieved with open source collaboration. The approach should be adopted by utilities worldwide as soon as possible.

Jean-Michel Glachant, *Director of Florence School of Regulation*

9 Lessons to Become a Leader in the Digitalization of Energy

Find common problems.

Companies are often going "in the same direction and facing the same problems." Work together to solve them.



Start small, but start!

Open source requires a change in culture. When initial investments are small, so too are the risks.



Take time to set up good practices.

Open source requires more communication than typical siloed software development.



Set up an Open Source Program Office.

Use an OSPO to coordinate the open source collaboration with internal and external stakeholders.

Add governance.

Transparent governance helps vendors, utilities, even regulators make the best investment and development decisions time after time.



Release control.

By accepting external viewpoints that come through open collaboration, the risk of taking the wrong path is reduced.



Educate.

Share insights with enterprises and regulators on the economic and efficiency benefits of open source.



Attract talent.

Enterprises leading in open source innovation find their ability to recruit is enhanced.



Develop teams with collaborative skills.

Hire people with diverse skill sets who can interact well with others and make decisions in a constructive and inclusive manner.





Introduction

To arrest climate change is no longer an option, but a must to save the planet for future generations. Key to doing so is to transition off fossil fuels to renewable energy sources, and to do so without tanking economies and destroying our very way of life.

The energy industry sits at the epicenter of change because energy makes everything else run. It is the geo-political axis around which the modern world turns. And inside the energy industry is electrification and our vast power grids. Electricity generation leads the list of sectors that matter most in terms of decarbonization, states the [Yale School of the Environment](#). Like it or not, utilities face vast and fundamental decisions on how to transform themselves while delivering ever more power to ever more people without making energy unaffordable or unavailable.

Collaboration in Action

Given the rapid march of climate change, our old ways of working won't get us where we need to go. Overhauling the power grid requires vast collaboration, rapid change, and supportive regulation. This is the opposite of how utilities have long operated. Whether state or investor-owned, utilities have functioned mainly with siloed operations in monopolies and [lag other industries](#) regarding [digital transformation](#). All told, the approximate 8,000 distribution and 250 transmission utilities largely function in isolation.

MEET THE PROJECT



CoMPAS

configures substations to enhance their automation, enabling efficient onboarding for renewables and greater device interoperability.

MEET THE PROJECT

SEAPATH,

developed by RTE and Savoir-faire Linux, is an open source platform for the edge of the grid that enables more flexible, scalable and innovative automation and protection.



As such, utilities are moving too slowly to meet the climate change challenges at hand. That must, and can, change. Rather than lag on digital transformation, utilities can and must lead. They must shirk any remnants of inertia, recognize that we are at an inflection point, and begin to move more like technology companies and other industries in embracing digital transformation. The end result is that utilities will be at the forefront of sustainable companies and the world will have power grids that gracefully balance supply and demand while delivering power with net zero emissions to arrest climate change.

To that end, LF Energy was set up by the Linux Foundation to nurture development of open source software to decarbonize the power sector, starting with the electrical grid. This has helped foster a rare industry partnership between two European utilities — Alliander, the biggest distribution system operator in the Netherlands, and RTE, based in France and operator of the largest transmission grid in Europe.

Via LF Energy, the companies collaborate on two significant projects, SEAPATH and CoMPAS. Both aim to make electrical substations — where power is converted from high to lower voltages — more modular, interoperable, and scalable, so they can better alleviate the challenges associated with less predictable renewable energy sources. The grid will remain more stable with more nimble substations as the supply and demand of electricity shift.

Working in different parts of the energy delivery system in different countries, Alliander and RTE have found that joining forces via open source collaboration enables them to develop more software solutions — and to do so up to ten times faster than if they worked alone on proprietary software solutions.

In some cases, they can work on cutting-edge software innovations *only because* they're collaborating via open source, and their teams, which alone couldn't handle the work, can do so by partnering.

Steadily, they've expanded their open source teams. Alliander has 15 developers devoted to open source, up from none three years ago. RTE has about 40 employees involved on seven core-business open source projects, up from about five people and one project several years ago.

"Alliander and RTE did not know each other because we do not work together in regular operations," says RTE's open source manager, Lucian Balea. "So our collaboration, I would say, is unexpected. But we both recognize that sharing forces and brains today will put us in a better position tomorrow because the changes that we face are huge transformations."

This is their story, and it provides a roadmap for how other utilities can collaborate with open source and lead the energy transition.

RTE and Alliander: Battling Common Challenges

As a transmission system operator, RTE operates the high voltage power grid. It transports electricity over big distances, managing interconnections with neighboring countries and ensuring the balance between supply and demand in real-time. Alliander, as a distribution system operator, serves 26,000 companies and three million households with electricity or gas.

Alliander and RTE joined forces because they faced the same problem: accommodating more renewable energy sources in infrastructures not originally designed for them, and to do it at the speed and scale required.

Think of RTE, the TSO, as a superhighway, and Alliander, the DSO, as the side roads that go into neighborhoods. While Alliander and RTE do not interface because they operate in different geographies, their TSO-DSO relationship mirrors others around the world and is critical to an efficient, modern power system.

That's because the interface between the transmission and distribution systems, where high, medium, and low voltage coordinates, is the Holy Grail of the future of power system networks. If we are to transform our economies, we need this relationship between transmission and distribution to be smooth, responsive to market signals, and directed by software technologies that do not yet exist.

The growth of renewables is making that interface more complicated. In the past, energy flowed one way: from coal and gas generating plants onto the big TSO lines, to the smaller DSO lines, where it was transformed into a lower voltage suitable for homes and businesses.

Today, energy also flows from homes and businesses, from wind and solar farms, from the DSOs to the TSOs, and back again. Demand response and flexibility of demand is as important as supply. This creates a much more complex system that utilities need to manage. They need new tools to ensure grid stability and handle the increased interfacing between TSOs and DSOs that occurs with the growth of renewables.

Alliander and RTE joined forces because they faced the same problem: accommodating more renewable energy sources in infrastructures not originally designed for them, and to do it at the speed and scale required.

"The energy transition is a big challenge. We discovered we had similar visions, mindsets, and approaches to software development and open source. Also, we had a willingness to be proactive in the transition and not just say, 'This is how it is, and I cannot do anything,'" says Arjan Stam, director of System Operations at Alliander. Soon, the conversation turned to "how can we collaborate on these topics?"

At the time, Alliander primarily built proprietary software for its use. It knew it had to speed up software development to meet the climate change and market challenges at hand. Their choice was to do it alone, like before, or "use what was already there in terms of open source software and make it better," Stam says.

Today, Alliander and RTE collaborate via LF Energy on what RTE's Balea calls "the common plumbing," or tooling common to many grid operators.

"That's the key to being successful and going at the required speed in this energy transition. You don't reinvent things. You reuse what's available and build on top of it," Stam says.

Collaboration Unfolds

Luck and need brought the two companies together.

Alliander has spent 100 years building its power grid to handle needed capacity. Two years ago, Stam noticed the first signs that Alliander couldn't keep up with demand by operating with a business as usual mindset. For the first time, Alliander couldn't connect some new customers to the grid because there was no available power. Also, what had been a handful of congested areas on the grid were starting to multiply rapidly.

Looking ahead ten years, Alliander expected demand to double. "We knew we would run into more congestion problems faster than we could develop our own software to handle them," Stam says. "Also, the work required specialized skills that were hard to find. We needed a different solution to access more sophisticated knowledge and skills and to scale up development. The only way I saw that happening was going open source."

As head of a business unit developing capabilities for the energy transition, Stam started looking for a platform to collaborate on open source software. "Luckily at that time, I started Googling on energy-related open source," Stam says. What popped up was the newly created website of LF Energy. "I was fascinated by the fact that it was there, and the description of what it wanted to achieve. That convinced me I needed to investigate."

Stam had long been interested in open source. Six years prior, he'd tried an open source project at Alliander, and it "completely crashed" because the culture of Alliander was "not convinced that this was the way to go." By the time Stam found LF Energy, he and the other leaders at Alliander had accepted that the company's plans to digitize were "not sufficient to reach our goals."

This time, when Stam went to Alliander's board to make a case to pursue more open source software development, "I didn't even need to make a business case," he said. "Everyone recognized that open source was the only way forward."

RTE came to open source through a side door.

In 2017 and 2018, RTE was developing software to outline future energy needs. Because the scenarios were used in public debate, RTE decided that the transparency of open source would lend the work greater credibility.

"Then, we discovered that open source was actually used by other industries as a collaboration framework," Balea said. While RTE had, in the past, successfully developed open source software, it hadn't built an open source community around the projects.

"So the next question was, how to build a critical governance framework that other partners would feel confident to work in, knowing that it wasn't just for RTE," Balea said.

In pursuing that, Balea also discovered the Linux Foundation, which was building an ecosystem of energy partners, and other, highly successful open source initiatives, such as Kubernetes, the platform enabling the explosion of cloud computing; Hyperledger, which supports the growth of blockchain-based technologies; [OpenDaylight project](#), which catapulted software virtualization for telecommunication networks and set the industry standard for software-defined network infrastructure; and [ONAP](#), a platform for orchestration, management, and automation of network and edge computing services for network operators, cloud providers, and enterprises.

Balea recalls, "It was like a flash. We realized, okay, if these industries are leveraging open source in that way, we could do something big in the energy sector."



MEET THE PROJECT



OpenSTEF

provides more precise load forecasting to enable onboarding of renewable energy from new sources while balancing greater consumer demand.

OpenSTEF: An Example of How and Why Collaboration Works

The way that Alliander and RTE collaborate via LF Energy on a project known as Short Term Forecasting, or OpenSTEF, illustrates the benefits of open source collaboration to tackle common problems.

“Short-term forecasting, for us, is the core of our existence. We need to know what will be happening on the grid. That’s the only way to manage the power flows, and to configure the grid to meet customer needs.”

— Arjan Stam, Director of System Operations, Alliander

“The same is true for RTE and every grid operator across the world.”

— Lucian Balea, Open Source Manager, RTE

To date, Alliander has five people devoted to OpenSTEF and RTE has two.

“We would not have the means to set up a team of five or more people on our own, so joining the existing project is the most efficient move,” Balea says.

Balea says that without joining forces, OpenSTEF would develop far less quickly and RTE may not have been able to work on such a solution in the near term.

Any progress made in improving short-term forecasting will benefit both companies. They do not compete so no edge is lost. The same is true for all utilities. “We have quite heavily regulated businesses, so there’s no benefit in not sharing,” Stam says.

Lessons Learned: A Playbook for Others

Because of their experience with open source collaboration, Balea and Stam suggest others do the following to help make their open source partnerships more fruitful:

Find common problems.

Companies are often going “in the same direction and facing the same problems.” Work together to solve them.



The collaboration between Alliander and RTE made sense from the get-go because the companies were thinking “in the same direction,” Stam says, and facing the same problem. “It doesn’t have to be identical, but at least in the same direction,” Stam says. For Alliander and RTE, the common problem was accommodating more renewables, meeting increased demand for power, doing so without adding to climate change, and doing so with limited developer resources and budgets.

Start small, but start!

Open source requires a change in culture. When initial investments are small, so too are the risks.



Open source requires a culture change, as Alliander found out the first time around. By starting small, the organization can grow into becoming a believer. With one strong voice, a “disrupter,” Stam says, the change begins. Because investment is small, so are risks if it fails. If it succeeds, everyone gets immediately more comfortable doing more. That includes board members and executives, who also manage risk and strategic direction. RTE initially devoted just 1% of its developer resources to open source collaboration, and it started with two projects, both of which are used for core business operations.

Take time to set up good practices.

Open source requires more communication than typical siloed software development.



Open source requires more communication than typical siloed software development. In open source, project owners have to explain and discuss more of their choices. “This might be seen as a burden,” by traditional software development teams, Balea said. RTE coached its people to open their discussions and governance, to apply good practices to organizing meetings, and then hold open meetings where more time was spent discussing why someone thought good ideas were good. Also, invest more time in documenting what you’re doing. “Initially, expect criticism, even internally, that things will take more time,” says Balea. “But this way, you catch the good ideas that come from everywhere.”



Set up an Open Source Program Office.

Use an OSPO to coordinate the open source collaboration with internal and external stakeholders.

An OSPO, or [Open Source Program Office](#), is a “strategic pillar for change,” Stam says. It is the formal expression that open source is part of the company culture, and it is the container for managing software compliance the open source way, in and outside the company. At Alliander, the OSPO was initially “just a label,” Stam says. But because the concept of open source was being talked about more and more, internal software development teams organically started to collaborate more and look for reusable code versus starting all over again. This was the phase of “inner source,” versus open source. Alliander then added roles to the OSPO, including legal and enterprise architecture. The OSPO coordinates the open source collaboration with other partners and educates people internally about the benefits of the open source model. It also advises on various open source projects, organizing events such as hackathons and webinars, and helping build an open source community around specific projects.

Add governance.

Transparent governance helps vendors, utilities, even regulators make the best investment and development decisions time after time.



Before open source, the utilities faced this choice: build what they needed by themselves or buy a product and then build on top of it. Both were problematic. The companies lacked developers to build alone what they needed to modernize the grid. Buying a product off the shelf and then customizing the last bit of it often leads to becoming locked into the proprietary software supplier. This lock-in makes it too difficult and expensive to change suppliers and pursue better products, which stifles innovation. With a modern grid, conditions will change faster than ever. To respond, utilities need to be readily free to change products. Open source enables the utilities to benefit from solutions that ensure the common plumbing is open and interoperable so that other products can be integrated into the grid. Good governance protects interoperability and proprietary IP on top of the open source code. Because of open source governance, companies know that their products will work with others — unlike proprietary solutions that often set up roadblocks. Governance that leads to transparency helps vendors, utilities, even regulators make the best investment and development decisions time after time.



Release control.

By accepting external viewpoints that come through open collaboration, the risk of taking the wrong path is reduced.

Utilities are accustomed to controlling everything. “If you control your grid, you want to control your IP. Going open source is, to my point of view, unlocking control,” Balea says. Once you create a community, the company is no longer in full control. Alliander may decide to go in a direction that we will not follow and vice versa, Balea says. Ultimately, RTE believes it will be more efficient and more productive using open source products and pursuing open source development. This is true even if it doesn’t have full control over every decision or direction a particular open source project takes. Enabling acceptance to external viewpoints also reduces the risk of taking wrong paths.

Educate.

Share insights with enterprises and regulators on the economic and efficiency benefits of open source.



No one wants to give up control over anything if they don't have to. The damage from inaction regarding climate change is now at the point where companies and people all have to be aware of the risk of business as usual. "We need to give up control because we will benefit from greater innovation," Balea. "It's worse to keep control of everything if we are not moving." We all need to educate others on the economies of open source. According to Stam, "It will be more cost-effective to have an open source strategy because you won't have to replace all customizations on proprietary software all the time."

Companies aren't the only ones who need education on the benefits of open source. Regulators do, too, so that they're more comfortable with open source and innovative initiatives, says Carmen Best, VP of Policy & Emerging Markets at Recurve, a platform for energy demand flexibility. Regulators need to understand the core value of open source, its transparency, and how open source enhances their oversight capabilities and their ability to scale clean energy markets by maintaining accountability.



Attract talent.

Enterprises leading in open source innovation find their ability to recruit is enhanced.

The war for talent is especially hard for utilities, which are not often viewed as cutting-edge places to work. By leading on open source innovation, both RTE and Alliander are finding their ability to recruit is enhanced. "We can say to (candidates), you will be working in open source and for the energy transition. It gives a lot of meaning to the job position. We've hired a few people based on the fact that we are doing open source for the energy transition," Balea says. Alliander also enlarged its talent pool, including recruiting, for the first time, outside of the Netherlands. The pandemic also helped Alliander transition to allow remote work.

Develop teams with collaborative skills.

Hire people with diverse skill sets who can interact well with others and make decisions in a constructive and inclusive manner.



Stam's team at Alliander is approximately 150 people, only three of whom were with the company when he started pushing for open source more than six years ago. With open source, new skills are required. "We don't only need good technical developers, but we also need people who can interact with others and discuss and handle divergent uses, find ways to get compromises, and make decisions in a constructive and inclusive manner," Balea says. One of the biggest challenges for finding the right talent, Stam says, is finding people who can work on a team and perform autonomously yet remain focused on the larger vision. Also, managing team dynamics takes more effort. "We are continually seeing how people fit together and what teams need as time passes," Stam says.



New Incentives Needed

Power utilities don't operate alone. They are highly regulated. In the U.S., they almost universally operate under cost-of-service regulation (COSR). In a nutshell, they make money by building stuff. That worked when regions needed utilities to expand with substations, transformers, meters, and power lines.

But now, the world needs less massive new hardware and more software-defined infrastructure connecting an agile and evolving system. We need infrastructure that is easier and cheaper to upgrade continuously. The challenge facing the power sector is, at minimum, a 50% increase in demand by 2050 while at the same time needing to make its services greener and smarter.

Alliander and RTE have an advantage here. The [European energy policies](#) strive to “harmonize practices” across countries, Balea says. “That reinforces the fact that we need the same tools.” This gives RTE and Alliander a lot of influence to push open source development among vendors by being more prescriptive about its open source needs, Balea says.

“This will signal to the vendor community, and to the companies that develop solutions, to go in the open source direction,” Balea says. Open source should also be a consideration for hardware projects, Stam says. Alliander is already discussing making an open source hardware project on new super advanced smart meters. This type of innovation would bring new, perhaps smaller, vendors to compete for the business, Stam says.

Regulations also need to allow utilities to be more nimble and to be able to harness the benefits of smart technology and flexible grid configurations, Stam says. Currently, when a customer orders one megawatt of service from Alliander but doesn't use it, the customer still retains the reservation on the grid. That means Alliander cannot use that capacity to serve someone else. At the same time, the handful of congestion points that Alliander experienced a few years ago has expanded to more than 900. The existing regulation is “not helping us get more people on the grid,” Stam says. “Even though we have the software, the solutions, and the intelligence to do it, the regulation limits us from applying certain solutions.”

Also, regulation could evolve to incentivize open source research and development, Balea says. Publicly funded R&D projects often do not fully benefit the public because the results are private, or the researchers are trying to fix the same problems because they're not sharing their work. By making "open source first" a requirement to get public funds, the public would get more benefit from the work.

Aligned Incentives

In the U.S., misaligned incentives and lack of transparency also hinder more efficient energy saving.

For instance, companies that help customers save energy are paid average values for the efficiency measures they take, which means they don't realize any upside for delivering better results. That gives them an incentive to increase their margins by cutting costs instead of seeking out and engaging in projects that could save more energy, [states Matt Golden](#), the CEO of Recurve. Recurve donated an open source project, OpenEEMeter, to LF Energy to enable better measurement and verification of energy consumption to monetize energy savings. The open source model ensures that everybody is using the same way to measure and monetize energy savings, while Recurve makes its money on services built atop the open source software base-layer.

A Challenge of Will

To scale the engines of our future economy from fossil fuel to non-polluting energy and transportation is not just a technical revolution but a transformation in consciousness. The unprecedented actions necessary to rapidly draw down reliance on fossil-fuels — first to get to 50% decarbonization by 2030 and

then to 100% by 2050 — requires cooperative frameworks of governance for technology investments.

For all players to act in their self-interest to transform energy we need open source technology stacks, permissive intellectual property rights, and open source foundations that can provide transparent, cooperative governance that enables actors to freely invest, support, and use in the digital building-blocks for the future.

LF Energy and the Linux Foundation are certain that we will go much further, faster, if we work together to envision, develop and deploy solutions that enable commercial enterprises to cooperate on the "common plumbing" and compete on top of that to deliver the most efficient and elegant solutions.

Open source is the way. In the past three decades, open source has moved from the fringe of software development to the core, remaking industries such as [telecom](#) and enabling cloud computing, which scaled from a fuzzy idea to the mainstay of modern business in just 15 years.

The same must occur in the energy industry. And while there is no 800-pound gorilla in the fragmented industry to lead the way, Alliander and RTE continue to light the path for others to follow.

APPENDIX A:

Open Source Projects to Modernize Grids

In just two years [LF Energy](#) has tripled its number of projects. This is important because the LF Energy portfolio, when coupled with other enterprise/industrial open source, forms the basis of a software supply chain that will deliver the digital building blocks of a sovereign digital energy market that's competitive, open, sustainable and secure. Those projects are:

Application Layer



[OperatorFabric](#): aggregates notifications and alerts from different applications through a single screen. It includes a workflow manager and remediation scheduling. OperatorFabric is written in Java and uses the Spring Framework to simplify writing and code integration. It's been built using a modern continuous integration and delivery system for ongoing lifecycle management.



[PowSyBl](#): an open source library to model electrical grids. Developers can use PowSyBl to build applications capable of performing dynamic power-flow simulations and security analyses on the network. Written in Java and available under a Mozilla Public License 2.0, PowSyBl handles a variety of data formats and can be extended or customized by developers.



[SOGNO](#): reinvents grid automation and monitoring, turning it from a monolithic and closed environment into a modular system. It's built using a cloud-native, microservice-based architecture so it can readily be scaled up. The vision for SOGNO, which stands for Service-based Open-source Grid automation platform for Network Operation, is to integrate with existing SCADA systems and gradually move those systems' functions to be rewritten as microservices. It will bring a more scalable, data-driven focus to monitoring and control systems.



[OpenSTEF](#): more precise load balancing will be critical as grids take on renewable energy from new sources and experience greater consumer demand. Forecasting will not only be needed to anticipate congestion and perform safety analysis, it will also allow smart grids to balance supply and demand. OpenSTEF, or Open Short-Term Forecasting, uses Machine Learning and feeds on the vast amount of data from consumer systems, markets and generation. It will combine these measurements with external data, such as weather and market prices, to forecast load. Forecasts will be output to a graphical user interface (GUI) via an open Application Programming Interface (API), enabling it to feed into products and services from others in the digital market.



[OpenEEMeter](#): a toolkit to implement and develop a standard method for calculating Normalized Metered Energy Consumption (NMEC). The library contains routines to estimate energy savings at the meter and implements the CalTRACK5 method to estimate metered energy savings.



[Grid Capacity Map](#): using public information, this shows grid capacity and connection cost to consumers and market participants.



[Shapeshifter](#): a project to deliver a common approach to trading and supply of energy by efficiently connecting smart energy projects and technologies. Shapeshifter implements the [Universal Smart Energy Framework](#) and describes market interactions between suppliers to help manage congestion and grid capacity and avoid supply problems. Its market structure, roles, rules and tools, help the commoditization and trading of flexible energy use.



[FlexMeasures](#): this project was conceived to help the introduction of flexible energy services in real time. Developed by Seita BV and available under an Apache 2.0 license, FlexMeasures seeks to achieve this by reducing the development costs and complexity involved in building those services through its use of real-time data integration, uncertainty models and application programming and user interfaces. FlexMeasures provides a means to integrate data in real time, uses the [timely beliefs library](#) to model sensor and environment data from different sources, and features a set of developer tools and resources. FlexMeasures was in the process of being launched at LF Energy at the time of publication.



[Green Energy Hub](#): the objective of this project — which at the time of publication was in the process of being launched under the LF Energy banner with a new name — is to help software engineers

build the digital energy market as a series of interoperable business and technology systems that exchange event data reliably. Engineers can do so without becoming mired in business-process workflows and codes. The project consists of two top-level domains with a series of sub-domains; these span business processes — in areas such as metering and charges — and technology functions — such as log accumulation or sharing secrets. Dividing the hub into small, independent domains means the digital market can be built in stages.

Data and Services



[Grid eXchange Fabric \(GXF\)](#): a software platform to communicate with devices in the field. GXF runs on a server, datacenter or cloud with access to system information through any front end such as tablet, smartphone or PC. It's a highly scalable, secure and open design that lacks vendor lock-in, meaning it's flexible enough for partners to adopt and develop. GXF has been used in a number of projects including micro-grids, smart metering and public lighting.



[CoMPAS](#): a key goal is to develop open source software components for profile management and configuration of a power industry protection, automation and control system. CoMPAS (Configuration Modules for Power industry Automation Systems) uses a microservices architecture built on the open source Docker container system used in digital infrastructures like cloud. It also employs a lightweight browser client, its interface and controls work with different programming languages and it integrates with other open systems.

Infrastructure



FledgePOWER: the transition to sustainable generation will mean operators running a mix of new and legacy infrastructure equipment. Power systems will also need to monitor and interact with a range of new equipment and devices in the home and the workplace behind and in front of the meter. They will interact through a series of high-volume, high-velocity transactions that must be conducted using efficient, robust and secure communications but that employ a range of protocols. FledgePOWER overcomes the complexities of multiple protocols by providing a flexible, lightweight and industrial-grade gateway.



Everest: a standardized software stack for charging electric vehicles that eliminates the complexity of working with lots of different standards, interfaces and systems. Everest is modular and can be customized, and will run on any device from AC home chargers to public DC charging stations.



openLEADR: an open source implementation of **OpenADR** used to exchange demand response information among utilities, aggregators and energy management and control systems. Demand response and demand-side management are used to help regulate use of electricity to stabilize the grid. openLEADR helps utilities adjust consumption of fossil fuels and onboard distributed energy sources.



Hyphae: an efficient and automatic way to describe locally produced sources of renewable energy over a DC grid connecting them to AC grids.



SEAPATH: aims to develop a platform and reference design for an open source platform built using a virtualized architecture to automate the management and protection of electricity substations. Virtualization is one of the technology building blocks of digital infrastructure. Being built on open source would make it easy for open-market partners to plug their applications into SEAPATH — which Stands for Software Enabled Automation Platform and Artifacts (THerein) — thereby bringing new features and offering a springboard for innovation.

Open Standards



Carbon Data Specification Consortium: this will create a dictionary for data in raw and standard formats for use by systems to measure and track carbon emissions from the production and consumption of energy. Establishing these taxonomies will assist in the operation of the grid and planning for the transition to a decarbonized energy system. Not featured in the framework (above), Carbon Data Specification Consortium was in the process of being launched at the time of this report's publication.

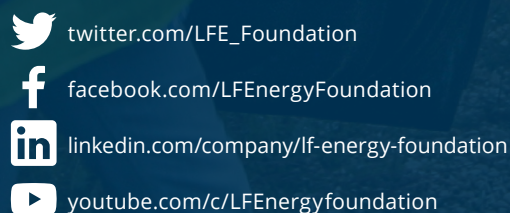
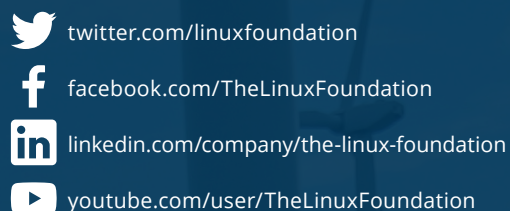


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LF ENERGY

[LF Energy](#) is an open source foundation focused on decarbonization, hosted within The Linux Foundation. LF Energy provides a neutral, collaborative community to build the shared digital investments that will transform the world's relationship to energy.



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