LF ENERGY

Digitalisation of Energy Action Plan:
Linux Foundation Energy Response to European Commission Public Consultation

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Introduction

Digitalisation is transforming every aspect of consumer and business life. The Covid-19 pandemic accelerated that: over the past 18 months companies have fast-forwarded the digitalisation of their customer and supply chain interaction and of their international operations by three or four years, according to consultant McKinsey[1]. The market share of digital or digitally-enabled products accelerated over the past seven years.

In March last year the leaders of Germany, Denmark, Estonia and Finland expressed the opportunities afforded by digital and called on[2] the European Union to accelerate the transition to a single digital market. "We have to foster the Digital Single Market in all its dimensions where innovation can thrive and data flow freely. We need to effectively safeguard the competition and market access in a data-driven world. Critical infrastructure and technologies need to become resilient and secure," the leaders wrote.

Digitalisation of energy has become an area of strategic importance and is seen as key to delivering a better functioning, integrated — and green — energy system. It is also seen as a way to bring sustainable new supplies online, opening up opportunities for business and individuals, and making sure the transition to a green energy system is affordable and fair.

Linux Foundation Energy — LF Energy[3] — believes these objectives can only be delivered using open source as a building block for the digital market. Open source is a culture of technology development and a process of collaboration that opens up markets and lowers the barrier to participation. It is also a system of intellectual property rights and a process of governance to ensure transparency and protect the rights and interests of participants.

In The Open Source Software Strategy 2020-2023[4] the European Commission (EC) has already recognised the important role open source can play in achieving the goals of its Digital Strategy and contributing to the Digital Europe programme. The document puts special emphasis on increasing the use of open source in areas of strategic importance. Moreover, a recent study[5] published by the EC shows that open source software and infrastructure are key for digital transformation and can be a major boost to the EU's GDP.

> Digitalisation of energy has become **AN AREA OF STRATEGIC IMPORTANCE** and is seen as key to delivering a better functioning, integrated — and green — energy system.

Open source has already become the foundation of digital transformation in the wider economy. All the world's supercomputers run on Linux — an open source software operating system. Ninety five percent of the world's public cloud providers use the open source Kubernetes

1 https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/how-covid-19-has-pushed-companies-over-the-technology-tipping-point-and-transformed-business-forever

2 https://valitsus.ee/en/news/heads-government-germany-denmark-estonia-and-finland-europes-digital-sovereignty-gives-us

3 https://www.lfenergy.org

4 https://ec.europa.eu/info/departments/informatics/open-source-software-strategy_en

5 https://openforumeurope.org/open-source-impact-study

orchestration and management software to set up and manage trillions of services for billions of customers in the consumer and business sectors. Half of the cars and other vehicles shipped globally use a version of industrial Linux for their onboard systems.

Only a campaign that is strategic and tactical can **OVERCOME THESE HURDLES AND REALIZE A DIGITAL ENERGY SYSTEM** that's integrated, efficient, sovereign and sustainable founded on open technology and principles.

LF Energy believes digitalisation founded on open source technology and culture will help drive the decarbonisation of energy and in turn, the decarbonisation of our economies. Open technologies will support the decentralization of energy production driven by the shift to a greener system and the democratization of supply. Digitalisation built on open source technologies will facilitate a consumer-driven switch to more sustainable energy services and sources while helping utilities respond quickly to the change.

LF Energy has created a response to the European Commission's call for input on a digital energy action plan. It discusses the vital role open source and open systems can play in helping consumers and businesses shift to a carbon-neutral energy system. A digital energy infrastructure will deliver the innovation and choice demanded by suppliers and consumers founded on free and fair competition and collaboration. Further, it explains how open source will sustain a resilient and secure market with data protection at its core and help the European Union achieve its vision of digital sovereignty.

The digital transformation of the energy system brings a lot of benefits, but it also brings risks and related challenges. All too often, planners and policy makers have set out ambitious visions but failed to put in place the practical systems for the success.

Cultural hurdles can delay adoption of digital advances: ideas or innovations born elsewhere — other countries, competitor businesses, for other purposes — get lost in "not invented here" syndromes. This can mean best practices go unshared leaving others who experience similar challenges forced to reinvent the wheel at cost and delay.

Finally, and with particular respect to the European Union, there exists the particular challenge of the size and the diversity of the European energy market. The need for a sustainable energy system is a universal interest, but the European Union is home to many national, social and economic stakeholders. Their starting points will differ as will their implementations. This will create new challenges, such as mixing legacy and digital technologies simultaneously. These new digital systems and their data will also inevitably come to the attention of cyber attackers.

LF Energy therefore calls on the European Union to adopt an integrated campaign of communications, policy and investment in digital technologies for the energy system. Only a campaign that is strategic and tactical can overcome these hurdles and realize an energy system built on top of communication infrastructure that's integrated, efficient, sovereign and sustainable founded on open technology and principles.

SECTION I

LF Energy's involvement — and interest in — the digitalisation of energy

LF Energy represents individuals from more than 50 organizations globally spanning academia and the technology and energy sectors, all of whom are committed to decarbonizing energy through the application of open source. LF Energy hosts around 20 projects that bring the community together to build new, integrated and interoperable systems, with participants building new software and frameworks that leverage best practices and emerging standards. Projects tackle challenges found in generation, supply, consumption, interoperability, automation, management and data. Participants are working on forecasting and markets, connected edge, system analytics, data models for emissions tracking, and control software. LF Energy also hosts projects that were initially funded by the European Union's research and innovation programmes. These include SOGNO[1] driven by RWTH Aachen University in Germany and PowSyBl[2] — a continuation of the FP7 iTesla project.

Founded in May of 2019, LF Energy began as a collaboration between the Linux Foundation and French infrastructure operator RTE who recognised that a bold approach was

1 https://www.lfenergy.org/projects/sogno
2 https://www.lfenergy.org/projects/powsybl

Building a sustainable and transparent energy supply chain

LF Energy partners with organizations to provide tools and resources essential to running open source, open hardware, and open specification projects needed by a modern, digital energy system. Our tools and best practices allow project participants to get on with the important job of commercialisation, innovation, and industrialisation of power system and transportation infrastructure. These tools help dramatically simplify the administrative overheads involved in setting up and running complex projects. Resources include:

- **GOVERNANCE FRAMEWORKS** and best practices to help establish communities and sustain projects
- **TRAINING AND PROFESSIONAL CERTIFICATION** to build an ecosystem of skilled individuals to implement and manage open technologies and systems
- **ROUTINE SCANNING** of open software code repositories to support license compliance, export control and security
- **FUNDING AND FINANCIAL INFRASTRUCTURE** — proven mechanisms such as membership models and one-off contributions like crowdfunding that relieve project members from managing complex issues such as financial oversight and regulatory filing
- **POLICIES AND TEMPLATES** that allow people and projects to get up and running quickly — these include policies for antitrust, trademark and code of conduct
- **EVENTS, MARKETING AND COMMUNICATIONS** support to grow the project's audience and profile — and to encourage contributions and expanded membership
- **MANAGEMENT OF SOFTWARE RELEASES** using vendor-neutral release engineers
- **A PROJECT PLATFORM** — LFX — to help tackle project build problems in areas such as scalability, mentoring, governance, scanning for security vulnerabilities and so on, at https://lfx.linuxfoundation.org

required to digitalise the industry and tackle new challenges while keeping pace with demand by preserving the reliability and affordability of supply. LF Energy provides both a neutral forum for collaboration on such projects and an important bridge linking R & D work with that of commercialisation in a practical and industrial setting. It was inspired by the examples found in other industries such as telecommunications and automotive that have successfully leveraged open source technology and practices to dramatically transform the efficiency and innovation of their operations.

LF Energy provides both a neutral forum for collaboration on such projects and **AN IMPORTANT BRIDGE LINKING R & D WORK WITH THAT OF COMMERCIALISATION** in a practical and industrial setting.

LF Energy provides a neutral and collaborative community to share ideas, investments and development. It is hosted within the Linux Foundation[1] — a body rooted in the tradition of open systems and of collective enterprise and endeavor. The Linux Foundation is a not-for-profit organization set up in 2000 with the express goal to support[2], promote, protect and standardise Linux and other open source software and technologies. With the Foundation's administrative and legal support, Linux kernel grew in complexity, scope, importance and contributor numbers to become one of the world's most popular open source operating systems.

The Linux Foundation has more than 1,900 members and engages with hundreds of thousands of developers through 750 open source projects that include cloud, cybersecurity, blockchain, web and industry standards such as those for ISO, here[3]. These projects sit at the heart of multi-billion dollar operations in cloud, networking, embedded systems and in vertical sectors[4] such as telecommunications, film, entertainment, healthcare, financial services and energy.

1 https://linuxfoundation.org
2 https://www.linuxfoundation.org/bylaws
3 https://www.iso.org/standard/81039.html
4 https://www.linuxfoundation.org/tools/software-defined-vertical-industries-transformation-through-open-source/

SECTION II

Role of individuals and consumers in digitalisation of the energy system

Digitalisation of energy in everyday life — an example

We talk of digitalisation but what does this mean in the energy sector and how do we achieve it using open systems? Historically, energy supply and demand has been founded on a complex matrix of proprietary systems, from turbines to power lines to home meters. This has made change relatively slow to achieve and costly to effect. Data — that of the systems generating electricity, consumers' data and so on — has traditionally been held in closed systems.

Organizations in the broader economy rely heavily on software to redefine their processes and assets to become more agile. They take the core of their business and transform it into Application Programming Interfaces, functions and cloud assets, turning business processes and assets into software. The widespread use of software defines this transformation — a shift now referred to as “digital transformation”. This is at the heart of the energy transition. Once these processes and assets are software-defined, companies can see the opportunities for converging business functions.

We have seen similar convergence in the telecommunication sector where data and voice services that once used dedicated and proprietary hardware and software that was costly to operate and maintain now share the same software-defined infrastructure and communications protocols. This has allowed telecommunication providers to offer customers new services faster and cheaper. These platforms have been built on open source software such as containers and Kubernetes.

Digitalisation will see energy providers also move from a hardware- to software-defined infrastructure. As in other markets, this digital environment will generate a superabundance of data. When processed and analyzed, it will allow providers to properly orchestrate, choreograph, and coordinate energy supply while offering new business services. The digital energy network will operate like the internet — connecting thousands of power systems and processing data from their substations to generate, transmit and distribute electricity.

Digitalisation also transforms the consumer experience. It means potential new services offered as a result of careful analysis of data. These services, turned on and off via the web or smart application on a device, are built on knowledge of the customer — specifically their energy consumption. Services are offered based on an analysis of this and other data, such as market information on prices, generation and supply. All of this is predicated on a smart device in the home or workplace capturing and sharing the data. It’s also predicated on the consumer’s willingness to share their data with suppliers and the market, to get the deal they want.

LF Energy has helped foster an industry partnership between two major European utilities to help bring this day-to-day reality a step closer. It has worked with Alliander, the biggest distribution system operator in the Netherlands, and France’s RTE, operator of Europe’s largest transmission grid. This high-voltage power grid transports electricity over huge 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.

These services, turned on and off via the web or smart application on a device, are **BUILT ON KNOWLEDGE OF THE CUSTOMER** — specifically their energy consumption.

The companies are collaborating on three significant projects that will impact consumers through changes at infrastructure and service level: SEAPATH[1], CoMPAS[2] and OpenSTEF[3]. The goal of the first two is to make electrical substations – where power is converted from high to lower voltages – better prepared for the challenges associated with renewable energy. Alliander and RTE joined

1 https://www.lfenergy.org/projects/seapath

2 https://www.lfenergy.org/projects/compas

3 https://wiki.lfenergy.org/display/HOME/OpenSTEF

forces because they faced the same problem: the need to accommodate a greater number of renewable energy sources on a proprietary and hardware-defined infrastructure not designed to cope. SEAPATH and CoMPAS will help enable substations to scale up more easily with a modular, interoperable system.

Alliander and RTE found that using open source helped them develop better software faster than if they had worked alone on proprietary systems. Their teams have been able to work together on shared challenges rather than try to break them down in isolation.

In recognition of this and of future opportunities, both companies have increased the size of their open source teams. More than 15 percent of Alliander's developers are now devoted to open source, from none three years ago. RTE now has around 40 employees involved on seven core-business open source projects, up from a handful and one project several years ago.

In it together — open source digital energy partnerships with LF Energy

SEAPATH

Stands for Software Enabled Automation Platform and Artifacts (THerein). The goal is to develop both a platform and reference design for an open source platform built using a virtualised architecture to automate the management and protection of 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 the platform, thereby bringing new features and offering a springboard for innovation.

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 modern, 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.

OpenSTEF

The third project tackles load forecasting. Demand for more precise load balancing is important as grids take on renewable energy from new sources and experience greater consumer demand. Forecasting will be needed to anticipate congestion, ensure supply and perform safety analysis. It will also allow smart grids to balance supply and demand locally within their infrastructure.

Alliander initiative 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 via an open Application Programming Interface (API), enabling it to feed into products and services from others in the digital market.

OpenSTEF is based on open source technology and a microservice architecture for deployment to the cloud. By open-sourcing the stack, the ambition is to provide an industry standard for generating and evaluating forecasts.

Consumer empowerment and citizen engagement in the transition

Decarbonisation will be accelerated through choices made by individuals and businesses in a digital market. The European Union is a single market of 27 countries with just over **half a billion**[1] potential consumers. Every business and individual who connects to a power network has an opportunity to influence the energy produced and consumed, shifting the market to alternative suppliers offering carbon-neutral sources of power generation.

Digitalisation of energy supply and delivery allows companies to speed up delivery of new services in response to demand. Those services might include offers and bundles, or a choice of purchasing models — for example, the option to connect to a subscription-based service rather than make a large upfront investment. This would allow consumers to connect quickly and easily to new services and access more energy-efficient measures as they evolve.

There is the potential, too, for a digital market built on open technologies to empower a new generation of "Prosumers," who consume some of the electricity they produce while contributing their excess capacity to the grid. When their production falls short, they buy power from the grid. As the European Union has **noted**[2], prosumers fall into a number of categories:

- **RESIDENTIAL** — producing electricity for their own property.
- **CITIZEN-LED COOPERATIVES** — for example, housing associations and foundations.
- **COMMERCIAL** — businesses, shops, offices and industries.
- **PUBLIC BODIES** — schools, hospitals and other public institutions.

1 https://eur-lex.europa.eu/summary/chapter/09.html

2 https://www.europarl.europa.eu/RegData/etudes/BRIE/2016/593518/EPRS_BRI(2016)593518_EN.pdf

The EU recognises that self-generation alone is not always the defining feature of prosumers. A proportion are not simply consuming energy but also actively participating in the energy market — generating value for themselves and for others in that market. This definition means prosumers can help balance supply — an act for which they could be compensated.

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Citizen engagement has two consequences for the energy market. First, it means a decentralization of energy generation and consumption. As consumers place solar panels on their roofs, change the way they heat their homes and accept wind turbines in the neighborhood, supply shifts from generation- and distribution-controlling large power stations to a more diverse network of smaller providers, thereby democratizing generation and consumption. Decentralization and diversity of supply creates opportunities for new providers who offer services that are packaged digitally. This, in turn, feeds into greater democracy at the consumer end with more suppliers, services — and, critically, for decarbonisation of the energy market — sources of generation.

SECTION III

Breaking it down — key elements in digitalisation of the energy system

Ensuring climate neutrality of ICT

A digital energy market built on open source will lower the barriers to entry for new suppliers with new services and allow existing suppliers to adapt more quickly to competition and changing demand. Open source will give consumers greater freedom to shop for new suppliers and services. Services delivered using open source and open standards will make new energy services more adaptable and simpler to use, even if the underlying functionality is extremely complex.

There is a concern, however, that digitalisation can delay the transition to a carbon-neutral market for two reasons. First is the number of devices among individuals and organizations required to monitor and manage consumption. The second concerns the growing adoption of cloud technology that is the back-end to many digital services in the wider economy. Cloud provides both the computational, storage and data processing needed by devices and services.

While cloud platforms require the resources to **RUN DATA CENTERS OF TENS OF THOUSANDS OF SERVERS,** evidence suggests greater use has — so far — not resulted in a corresponding increase in energy consumption.

Cloud is important because it delivers the scale of resources combined with specialised software to process, analyze and understand the data to run digital environments and serve consumers. Data is the raw material for power companies to manage grids, forecast demand and provide new services. It also helps consumers understand energy use and manage their consumption.

While cloud platforms require the resources to run data centers of tens of thousands of servers, evidence suggests greater use has — so far — not resulted in a corresponding increase in energy consumption. A 2020 IEA **study**[1] found energy used by data centers since 2010 remained constant, despite an eight-fold increase in workloads and 12-fold growth in internet traffic, suggesting a corresponding increase in efficiency.

In addition to energy efficiency, it is helpful that the remaining energy consumed by the data centers behind cloud is carbon neutral. Corporations purchased a record 23.7GW of clean energy in 2020, up from 20.1GW in 2019 and 13.6GW in 2018, **according to Bloomberg**[2]. Bloomberg cites the flow of companies making clean energy commitments as an indicator of market growth. Importantly, companies in the ICT sector are among the top procurers of renewable energy. Microsoft — one of the world's largest providers of cloud data centers — had, for example, purchased 7.8GW of energy from renewable sources globally as of July 2021[3].

1 https://www.iea.org/reports/data-centres-and-data-transmission-networks

2 https://about.bnef.com/blog/corporate-clean-energy-buying-grew-18-in-2020-despite-mountain-of-adversity/

3 https://blogs.microsoft.com/blog/2021/07/14/made-to-measure-sustainability-commitment-progress-and-updates

Open source, meanwhile, is home to initiatives that will help create a more carbon neutral digital infrastructure. **The Green Software Foundation**[1], founded in 2021 by the Linux Foundation with the goal of establishing standards, tooling and best practices, is developing a method to score the carbon footprint of software to drive more efficient coding of systems and improved reporting. The Foundation has developed the Software Carbon Intensity (SCI) Specification that helps assess carbon emissions created during the operation of a software program. It is supported by SCI Open Data that provides the data sources that can be used as inputs for the SCI Specification. Foundation members include Accenture, GitHub, Microsoft and NTT Data.

Enhancing the cybersecurity of the energy system

Trust and resilience are key to digitalisation. Data is valuable — something cyber criminals and hackers recognise and therefore seek to steal. Data is the foundation of monitoring and management systems responsible for anticipating and provisioning supply and capacity. Data underpins consumer services — harvesting individuals' personal details and information about their consumption and usage in order to provide new services — and is what the consumer carries with them as they change suppliers, thanks to the fact that those suppliers' systems are built on open source technologies and interfaces. If we are to convince consumers to shift to a digital energy market they must trust it.

Resilience is vital, too. Consumers and businesses expect power. Generation and supply is part of nations' critical infrastructure yet, increasingly, utilities globally have been targets of cyber **attack**[2].

Digitalisation means software is no longer distinguishable from the physical infrastructure we all rely on for our daily lives. Applications are built using many software components. These components are shared and developed in an open collaboration model we refer to as open source software. Any individual open source software component could be used in thousands of applications. Open source software components now make up at least 75 percent of the code footprint for **applications**[3] used to build modern, digital systems. In 2021 alone, developers downloaded more than **2.2 trillion**[4] open source components through a variety of software supply chains in order to produce hundreds of billions of dollars of value in high-quality applications.

The open availability of these components offers key benefits in securing the building blocks of digital and, therefore, helping protect data and ensure provider resilience:

- **TRANSPARENCY.** Anyone can inspect an open source codebase, review it, build it and contribute fixes to it. Arguments for "security through obscurity" (security by hiding the source code) have been largely rejected. Open source enables anyone to inspect the codebase, find security issues, and offer fixes or patches to improve it.
- **STANDARDIZATION OF SECURE COMPONENTS.** As open source components become a shared investment within an industry ecosystem, they become a *de facto* standard upon which higher value solutions can be built, without having to repeatedly recreate the standardised layer and introduce new security issues each time. The open source common layer everyone depends on is often highly reviewed, patched and audited, making it a more secure starting point for solutions.

1 https://greensoftware.foundation

2 https://www.power-technology.com/features/the-five-worst-cyberattacks-against-the-power-industry-since2014/

3 https://www.synopsys.com/software-integrity/resources/analyst-reports/open-source-security-risk-analysis.html

4 https://blog.sonatype.com/2021-state-of-the-software-supply-chain

- **SUPPLY CHAIN SECURITY.** Open source components can improve an ecosystem's ability to collaborate on and maintain components that make up their software stack. Open source communities are highly effective at identifying and patching security issues. Industry supply chains with ecosystems of vendors, end users and developers are using a software bill of materials, such as Linux Foundation's **SPDX (ISO/IEC 5962:2021)**[1], to increase the transparency of all components that go into a system, and improve response times to security incidents.

Increasing the level of digitalisation and connectedness will likely result in a greater attack surface for cyber threats. Theoretically, open source software is no more or less secure than closed source software. However, with a distributed development model, extensive software supply chains, and no single company in control, responsibly managing the security of open source software is an inherent part of modern software development. These benefits have propelled the telecommunication industry and many others to adopt open source for their 4G and 5G **platforms**[2].

Another part of this story is the openness of hardware architectures and platforms upon which software is deployed. The Linux Foundation has seen transparency goals extend to the underlying hardware components in addition to the software, thereby providing a level of security simply not possible until now. Manufacturers and end users are collaborating on exciting technologies such as processor instruction set architectures (RISC-V and OpenPower), IP blocks, and hardware development tooling (CHIPS Alliance's work on ASIC and FPGA design tools).

Take-up could be accelerated through an "open, unless" policy that demands public bodies adopt open source offerings unless there is a clear counter-reason. The industry as a whole could be encouraged to collaborate on open source projects by supporting projects directly.

1 https://www.iso.org/standard/81870.html

2 https://www.linuxfoundation.org/wp-content/uploads/software-defined-vertical-industries-092520.pdf

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Enhancing the uptake of digital technologies in the energy system

LF Energy believes EU policies should encourage the use of open source licenses and open governance models to assist digitalisation of the energy system and produce a green grid.

Successful digitalisation is built on platforms that allow data to be exchanged for use in software-based services by utilities and the consumer. These services provide an answer to challenges in the generation, delivery and consumption of energy, such as monitoring, control, demand and load analysis — this in an energy system that's growing in complexity and size with the addition of new services and suppliers, increased demand and new and diverse sources of power.

These platforms will have to interoperate beyond the boundaries of single entities and encompass a broader diversity of stakeholders and even industries. Building a coherent mesh of interoperable technologies that involve so many actors is a major challenge. Overcoming this will take steady innovation rather than a big-bang approach and will need to take into account a diversity of skills and of know-how.

In the past 10 years, the energy industry has started a process of defining such platforms, partly as enterprise development, partly as cooperative research. The EC has been a major driver of this process through research and innovation programmes such as FP7 and Horizon.

The drive to decarbonisation and net-neutrality means we are entering a phase where the uptake of these efforts must be accelerated in the energy sector. New efforts are needed in parallel to bridge the gap between research and development and large-scale industrial adoption.

Utilities have **lagged behind other industries**[1] on **digital transformation**[2]. Obstacles impeding the pace and scale of digital transition in the energy market include:

- the promotion by manufacturers of closed systems, in generation and the consumer setting, that make integration and data exchange difficult or near-impossible.
- the presence of proprietary software that leads to supplier lock-in, growth of monolithic platforms, challenges of interoperability, and poor protection against cyber attack.
- regulators paying insufficient attention to the IT systems, meaning a lack of scrutiny or enforcement on openness that reinforces vendor lock-in and slows innovation.
- fragmentation of the energy sector resulting in slow diffusion and adoption of technologies with experiences often not matching expectations.
- sluggish development of standards — they are not designed to change or evolve at the pace required by developers building modern, digital systems.
- licensing practices of standards that inhibit redistribution, thus putting open source projects at a disadvantage compared to other software developers.
- a lack of encouragement and tools to empower consumers to change: 92 percent of EU citizens support the Union's target of becoming carbon neutral by 2050 but an EU-wide Eurelectric and Accenture study **here**[3] highlights the struggle to involve consumers. Just one third believe they are personally responsible for tackling climate change.

The European Commission has already **recognised**[4] open source's value to the EU's economy, competitiveness and pace of innovation. The report recommends integrating open source software and its communities into European research and general policy frameworks such as the European Green Deal and industrial strategy. It makes the argument that SMEs, micro-enterprises and start-ups as well as individual developers should be supported through funding that focuses on EU-specific goals such as the Green Deal and European industrial strategy.

Cultivating a technology supply chain among these constituents using open source will overcome the obstacles to building a digital energy system for a number of reasons:

- a digital energy system cannot be delivered as a single platform; it must be built incrementally, meaning that applications and systems must be capable of interoperating and integrating during this build-out phase. A system built using open source and open standards will mean long-term interoperability and interaction between systems and data portability.

1 https://www.striata.com/posts/digital-transformation-in-utilities

2 https://static1.squarespace.com/static/5db8a4995630c6238cbb4c26/t/6140cb8c9f2e0c5aa9ea1c86/1631636365566/Valoir+Report+-+State+of+digital+transfomation.pdf

3 https://cdn.eurelectric.org/media/4236/eurelectric-accenture-seeking-shared-success-h-22C4F04C.pdf

4 https://digital-strategy.ec.europa.eu/en/library/study-about-impact-open-source-software-and-hardware-technological-independence-competitiveness-and

- open source technologies are adopted faster than proprietary ones because the code is freely available for download and distributed using a permissive license and governance model. This dramatically lowers the barriers to entry — including cost — thereby promoting experimentation and adoption and helping companies engage with a new community of developers.
- security and data privacy are key concerns for consumers worried about theft and sharing of data without consent. Open source provides the building blocks for a system of integrated and interoperable data protection capable of securing data and managing consent as that data moves from its owner and across the market between suppliers and across geographies.
- open source is a mature ecosystem upon which providers and consumers can depend. The community functions under clear rules of governance to create structure, guarantee fairness, foster trust and ensure the long-term health and integrity of open source projects and code.

Developing a European data-sharing infrastructure for new energy services

The infrastructure of the digital energy system is going to be complex. It will be built on numerous devices and appliances in the home from various manufacturers — all of which need to act in concert with one another. These will gather the consumers' data and use market information about the carbon footprint of a service, availability of power and cost.

Data, crucially that of consumers, is key to the digital energy market and will help suppliers to innovate and offer new services. Greater choice for customers as new suppliers enter the market to meet demand identified in the data — specifically power generated using renewables — moves us closer to a more decarbonised grid.

This can only become a reality, though, when there is a consistent system of permission-based data exchange.

For consumers to truly be empowered, they should have access to their own energy usage data and the ability to easily transmit that data to new providers of their choosing — whether to a web service, smartphone app or energy consultant.

FOR CONSUMERS TO TRULY BE EMPOWERED, they should have access to their own energy usage data and the ability to easily transmit that data to new providers of their choosing — whether to a web service, smartphone app or energy consultant.

Fortunately, the European Commision has already created a clear legislative framework thanks to the General Data Protection Regulation (GDPR). It will continue to be important to reflect the GDPR as part of the software development process that enables data exchange while still preserving personal data sovereignty.

Eurelectric and Accenture **found that**[1], while participants in their Europe-wide focus groups recognised the potential opportunities, they were concerned about data security and privacy for providers and consumers. Incidents of sharing data without consent, data breaches

1 https://www.eurelectric.org/15-pledges-to-customers

and the resulting need to tighten regulations about the use and protection of personal data, have all made consumers wary. Consumers want greater transparency and control over how their data is being shared and to make their own choices — for example, to be asked to opt in to sharing rather than be forced to opt out.

Successful digitalisation means that the inherent technical complexity of orchestrating different systems is concealed from consumers using elegant software solutions. Customers must trust this process to work effectively without the necessity to verify all the technical details. The only way to achieve the lowest-cost decarbonised energy system is to build a system and a process that is open, transparent and truly interoperable so trust is automatically part of the picture.

From an IT perspective, the data and technology components must be standards based, stakeholder driven, interoperable and open. This is a multi-layered challenge that requires the following:

- **CONSISTENCY OF DATA.** Systems can interoperate if they share the same semantic definitions of data, for example, if the data model is uniform.
- **A STANDARD FOR THE DATA MODEL, SEMANTICS AND ONTOLOGIES.** Definitions should be open and have an open source reference implementation.
- **OPEN STANDARDS AND PROTOCOLS.** Use of common Application Program Interfaces (APIs) by services allow, for example, services to request data from each other.
- **APIs WITH AN OPEN STANDARD AND OPEN SOURCE REFERENCE IMPLEMENTATION.** This ensures fair access for all and to foster rapid adoption through simple re-use.
- **CONSISTENT AND USER-FRIENDLY PROCEDURES AND MECHANISMS**. The consumer must be allowed to withdraw their permission to share their data. Suppliers should make these policies available through websites, devices and mobile apps
- **FLEXIBLE PROCEDURES AND MECHANISMS.** They should be flexible enough to work with a variety of implementations at the local level in member states — and outside the EU.
- **REGULATORY OVERSIGHT.** Governments or relevant, independent authorities should build technical and enforcement capabilities to ensure that interoperability exists in practice, without necessarily needing to mandate specific, static formats
- **INFORMED CONSENT AND CONSUMER PROTECTIONS.** These must be consistent with the laws of the EU and its member states.

International cooperation on digitalisation of energy

Digitalisation is transforming the economy. It has the potential to transform the European energy market, too, making it more efficient, integrated and greener. It has the potential to decarbonise the generation and supply of energy by making supply more diverse and democratic. Digital has the potential to change consumers'

Incidents of sharing data without consent, data breaches and the resulting need to tighten regulations about the use and protection of personal data, have all **MADE CONSUMERS WARY.**

relationship with suppliers, granting them greater choice of service and taking the energy market closer to carbon-free.

For all its potential strengths, however, digital has revealed shortcomings in the supply of European technologies and services. As the leaders of Germany, Denmark, Estonia and Finland noted[1] a “significant” amount of digital innovation and added-value takes place outside Europe. For example, the vast majority of cloud services are provided by a small handful of suppliers in the US. As noted, cloud is an important platform for digital — delivering the kinds of tools and resources in compute, storage, data analytics and AI that make digital valuable. These providers are able to offer such services at vast scale on demand and at incredibly competitive cost.

Digitalisation has seen data become the new commodity of business. It’s become the raw ingredient of new services as organizations have become data driven. Consumers remain concerned about ownership and safety of their data and those participating in the digital market are denied convenient access to data.

Failure to address the imbalances would produce a digital market that is reliant upon specialist providers and an undemocratic energy market. Failure to change would mean innovation goes unrealized in Europe. Finally, it would breed unfair competition as those responsible for the building blocks of digital and holding data gain first-mover advantage.

The digital energy market must be robustly sovereign — it must eliminate points of reliance on one or a handful of suppliers, as defined by corporate hierarchy or geographic location. It must, however, remain connected to the global ecosystem of innovation, development and ideas. As much as the monopoly on supply cannot come from outside Europe, so it’s true that Europe does not own the monopoly on innovation and ideas. A successful digital energy system will come from being plugged into the global supply chain of innovation and creation in technology and business.

The digital energy market must be robustly sovereign — **IT MUST ELIMINATE POINTS OF RELIANCE ON ONE OR A HANDFUL OF SUPPLIERS,** as defined by corporate hierarchy or geographic location. It must, however, remain connected to the global ecosystem of innovation, development and ideas.

To summarise, open source provides a means to achieve digital sovereignty and international cooperation for a number of reasons:

- **The code is free to download and available under a permissive license.** Nobody “owns” the code and it’s free for individuals and commercial interests to use and adapt. Further, open source is built using standard interfaces and APIs. Together this means customers using products or services built on open source cannot be tied into one product or service and have the choice to replace the product or supplier for another using the same code
- **Open source is made and governed under an open community model.** Even in projects where

1 https://valitsus.ee/en/news/heads-government-germany-denmark-estonia-and-finland-europes-digital-sovereignty-gives-us

there are one or two major parties contributing to the majority of development, those parties cannot claim ownership of the project or assume a leadership role. Contributions are voluntary and projects governed using an open and transparent model that ensures equal recognition and accountability with participation

- **Open source is a global community that can accelerate alignment on standards.** There's no single corporate or geographic center that dominates and innovation takes place around the world. Further, the open nature of the code and the permissive nature of its license means open source can be easily adopted by developers and integrated with other open source and standards-based systems. Open source software components comprise 75 percent of the code footprint for **applications**[1] used to build digital systems. Developers in 2021 downloaded more than 2.2 trillion[2] open source components through a variety of software supply chains in order to produce hundreds of billions of Euros of value in high-quality applications. A digital energy market built on open source would therefore be plugged into a global supply chain without becoming dependent upon any single provider, product or service.

1 https://www.synopsys.com/software-integrity/resources/analyst-reports/open-source-security-risk-analysis.html

2 https://blog.sonatype.com/2021-state-of-the-software-supply-chain

A digital energy market **BUILT ON OPEN SOURCE** would therefore be plugged into a global supply chain without becoming dependent upon any single provider, product or service.

Ultimately, open source has been a superpower that's transformed every aspect of business and consumer technology. From the fabric of the internet to the data centers running cloud, from consumer devices like cars and cameras, from business applications to server software, open source has been unstoppable. What began as a niche pursuit in the last 40 years went mainstream taking out one after another proprietary system that was costly and difficult to work with. We have seen proprietary technologies that were variations on eachother replaced using code and interfaces that are standardised and open. This has allowed those building systems to devote their energy and time to focus on building new features, services and offerings for the customer — bringing value further up the software stack and innovating further and faster than ever before.

Appendix

LF Energy — technology principles

The European Union wishes to become carbon neutral by 2050. But with production and use of energy for power systems, transportation, and the built environment responsible for **75 percent**[1] of the EU's overall greenhouse gas emissions, decarbonisation of the EU's power systems is critical. Three quarters of the EU energy system relies on fossil fuels.

Generation, consumption, transmission, private consumers, large commercial and industrial customers and renewable sources of power are key considerations in the move to carbon neutral. Digitalisation across each will help balance supply and demand of power and facilitate the transition to a decarbonized energy system that's integrated, efficient, robust and fair.

Digitalisation can only be delivered using open source and proprietary software services where the technologies, projects, frameworks and reference architectures are complementary. Through a process of community consultation to ensure that the technology portfolio evolved over time towards our North Star — to support society and the planet — Linux Foundation Energy has established a set of principles that provide a consistent and measurable level of quality to guide those building the components of the digital energy system. Without these principles, exceptions, exclusions, inconsistencies and favoritism would inevitably emerge and undermine the desired outcomes of democratised energy markets.

The building blocks essential for industrial and economic decarbonisation must therefore:

- **INTEROPERATE BY DEFAULT** — interoperability is the foundation of a competitive market for both suppliers and customers. It lowers the barriers to entry and unlocks customer choice, as systems from suppliers can work together without need for special action. By extensions, interoperability supports easier adoption and — therefore — faster uptake. Designing-in interoperability means software suppliers must pay as much attention to interfaces that communicate with other systems as to the core system features and functions. They should clearly identify potential synergies and adopt internationally recognised standards, where possible royalty-free
- **BE RESILIENT BY DESIGN** — the transition to a new and sustainable market will mean an increase in renewable sources that will inevitably result in more volatile and unpredictable supply. Systems will therefore need to adopt design and software practices that minimize downtime — including planned maintenance — and that provide failover, scalability and automation
- **EMPLOY A SIMPLIFIED ARCHITECTURE** — the digital market will be built using an ecosystem of providers at different levels in the software stack providing different capabilities and with different skills. The move to a digital energy market will be an evolution, not a big bang. Components used to build that market should, therefore, be designed to be easy to articulate, implement, install and maintain. Nor should architecture be over-engineered or optimized: simplification will further interoperability, adoption and help lower costs
- **BE SECURE AND SAFE BY DESIGN** — these must be at the core of technologies and projects to protect the data and systems driving the digital transition. In practical terms this means using established practices to identify and manage risks, exercising due diligence on components sourced from third parties and setting secure defaults. For authorization, projects and technologies must adopt a zero-trust model of security based on identity rather than location, and employ standards-based authentication and authorization.

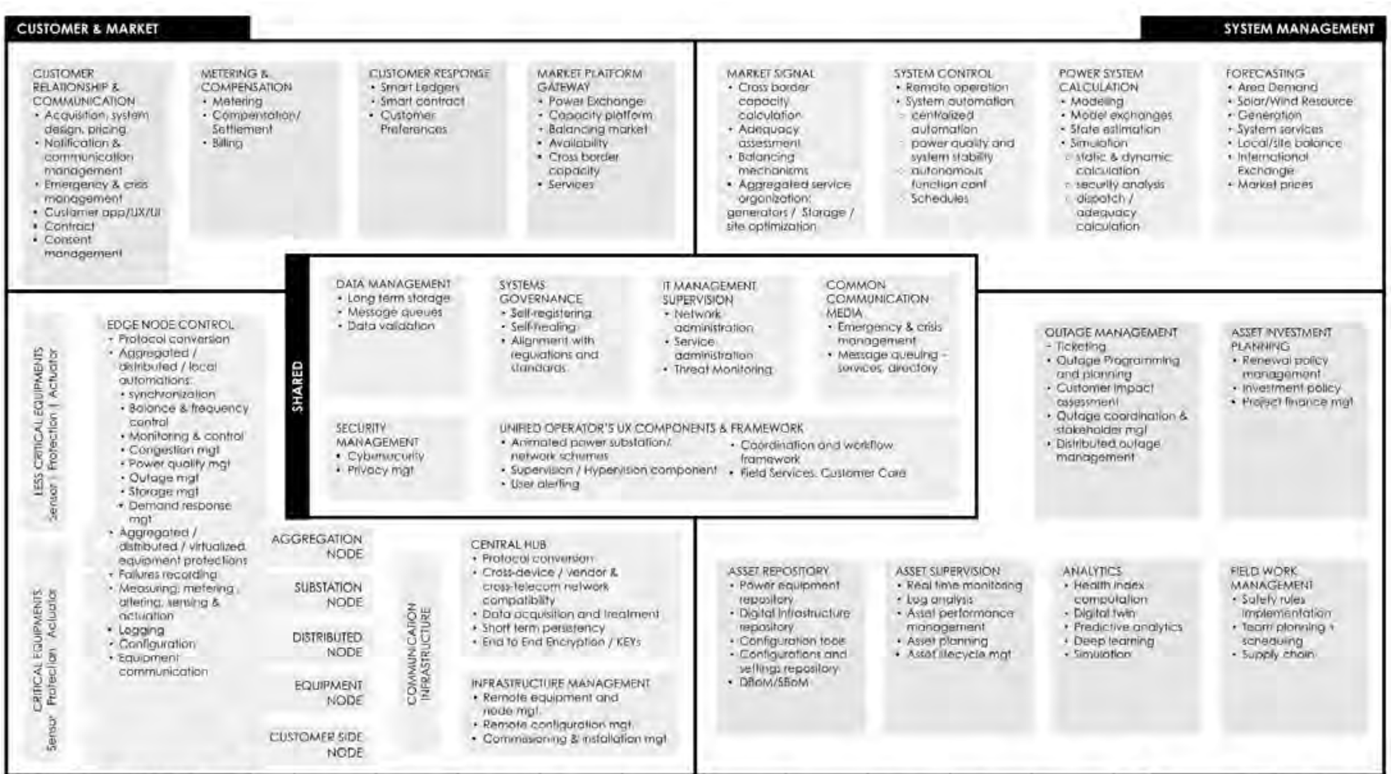
1 https://www.europarl.europa.eu/RegData/etudes/STUD/2021/695469/IPOL_STU(2021)695469_EN.pdf

The LF Energy architecture

A group of enterprise architects from across Europe gathered in summer 2019 to define the functional architecture that would underpin LF Energy's approach to gradually and iteratively building the power systems of the future. It was an attempt to find a shared language — or taxonomy — to describe what each utility needed to operate. They established a technology architecture (below) to define an energy system that would help achieve our shared climate and energy transition goals, saying: "Our architecture provides a clear picture of the capabilities software should deliver to build a digital energy system on open source."

The functional areas of this energy system fall into five high-level categories, or facets, that comprise approximately 200 functional capacities:

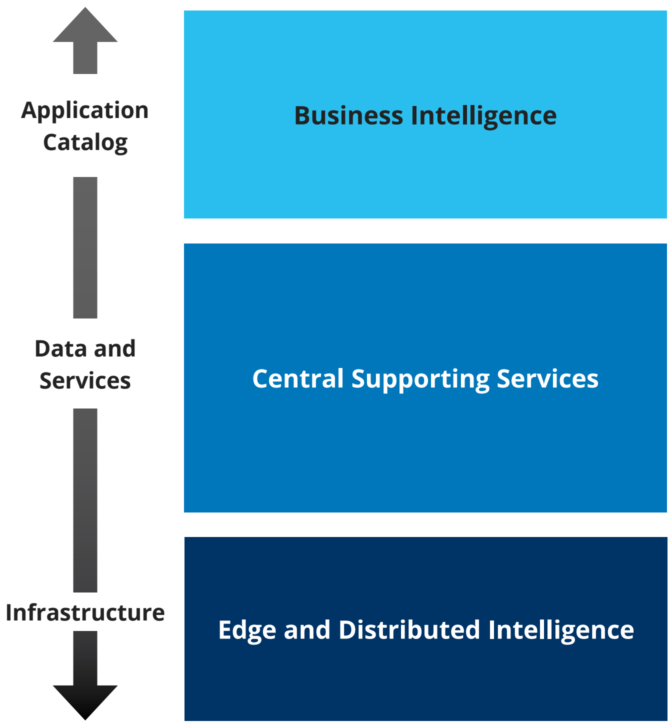
- **CUSTOMER AND MARKET** — capabilities that allow the customer to manage their service and engage with their supplier and the market. Such systems include customer relationship management systems, metering and compensation, customer response and market gateways.
- **SYSTEM MANAGEMENT** — software and services to manage the physical flow and distribution of power. This would include tools that help providers forecast capacity and demand, and that calculate generation working on huge sets of customer, market and third-party data.
- **ASSET MANAGEMENT** — systems that allow power generators to manage and resolve incidents, supervise the performance of power generation and supply and manage the inventory and lifecycle of power generation systems from installation to maintenance and retirement.
- **ACQUISITION AND CONTROL** — the digital market will be a highly distributed environment — from smart



LFE High-Level Functional Architecture V1.0 - CC 4.0

devices in homes and workplaces, to sensors working at the edges of conventional computing across the provider's supply network. It will be decentralized, too, with a growth in new suppliers and sources of supply — from new enterprises to those generating their own power for consumption or sale back to the market. A range of new devices will be required to facilitate this, including nodes for measuring, metering, communication, aggregation and outage management. Centralized hubs will be needed to manage services such as encryption, to convert protocols and process data and devices commission and configure and install systems remotely.

- **SHARED** — this facet comprises shared systems for the previous four categories and includes the management of data storage and access, governance, the management and supervision of IT systems, security management, communications media and unified human machine interfaces.



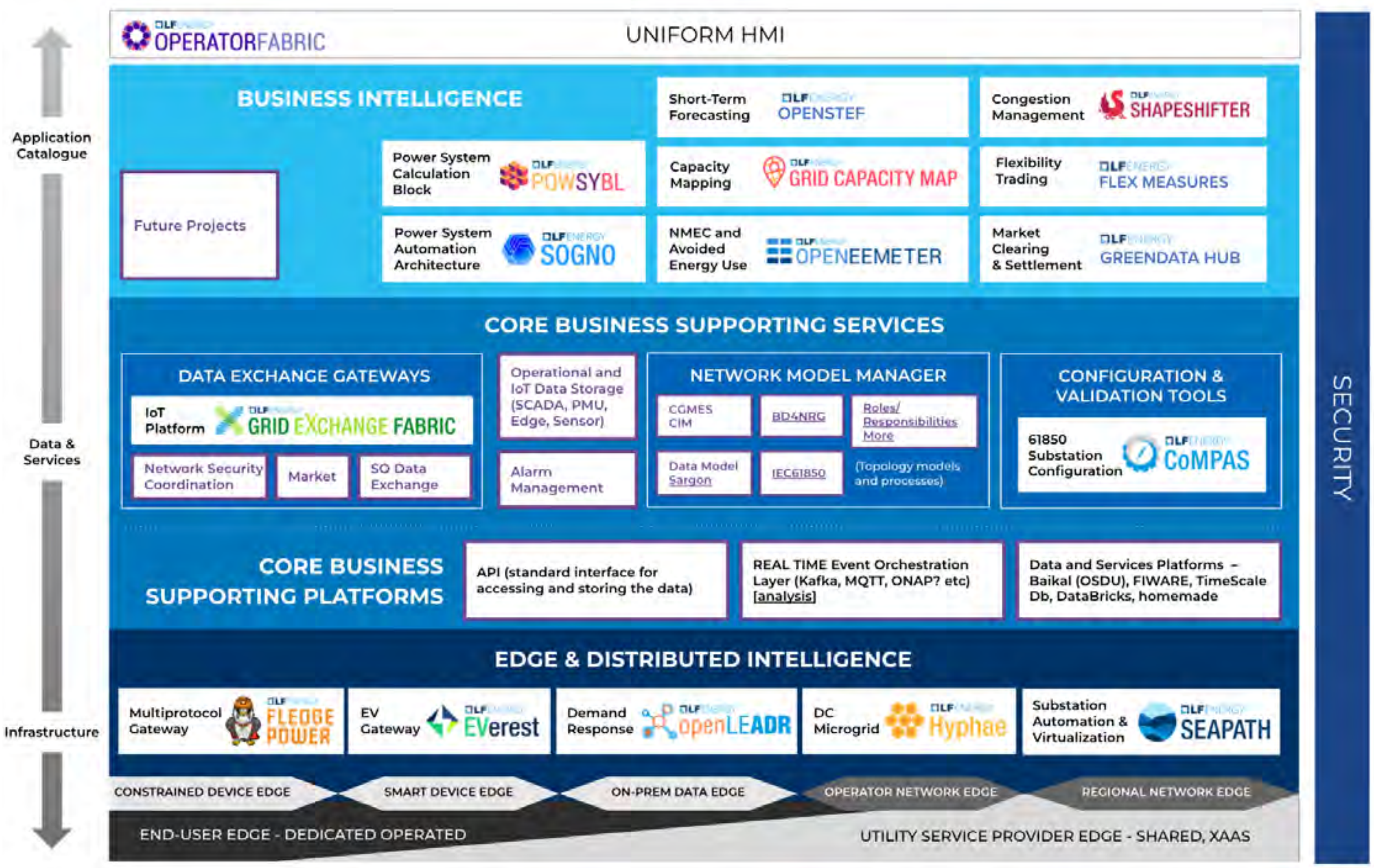
Three-tier technology stack

LF Energy convened a group of utilities and systems experts in the winter of 2021 to define the next levels of the architecture. It was agreed that it made little sense for the architecture to depart from best practices in telecommunications, networking, and the fields of edge and cloud computing that are driving the transition to digital elsewhere, notably transport and industry.

Modern, digital systems are built in three layers: applications, data and services, and infrastructure. These layers (outlined below) apply no matter whether the systems are part of a central computing environment or function on the remote edge, whether they are data-centric or a core service. It includes an application catalogue that makes use of all aspects of this layer.

We grouped the projects currently hosted by LF Energy within this three-layered architecture. As part of the process, we also identified areas for collaboration and listed the projects that utilities had developed, saw as critical and necessary and were willing to share. The resulting framework (below) is an immensely valuable resource, showing clearly how technologies and projects fit together to help realize an integrated digital energy system that's fit for the future. LF Energy has begun using the framework to work with members, partners and start-ups in the open source ecosystem in a more targeted way. The framework is also helpful to vendors and OEMs to help them to understand how to commercialise and provide value added services and technologies to their customers. Open source is not about removing the vendor, but upleveling the paradigm for new products and services that provide value and enable us to scale faster.

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 projects, 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[1]: 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[2]: 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[3]: 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.

1 https://www.lfenergy.org/projects/operatorfabric

2 https://www.lfenergy.org/projects/powsybl

3 https://www.lfenergy.org/projects/sogno

OpenSTEF[1]: 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[2]: 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 **CalTRACK**[3] method to estimate metered energy savings.

Grid Capacity Map[4]: using public information, this shows grid capacity and connection cost to consumers and market participants.

Shapeshifter[5]: 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**[6] 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.

1 https://wiki.lfenergy.org/display/HOME/OpenSTEF

2 https://ec.europa.eu/info/news/commission-launches-public-consultation-feed-action-plan-digitalise-energy-system-2021-oct-05_en

3 https://wiki.lfenergy.org/display/HOME/EM2+-+CalTRACK

4 https://wiki.lfenergy.org/display/HOME/Grid+Capacity+Map

5 https://www.lfenergy.org/projects/shapeshifter

6 https://www.usef.energy

FlexMeasures[7]: 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**[8] 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[9]: 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)[10]: 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.

7 https://github.com/FlexMeasures/flexmeasures

8 https://www.iso.org/standard/81039.html

9 https://github.com/Energinet-DataHub/green-energy-hub

10 https://www.lfenergy.org/projects/gxf

CoMPAS[1]: 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[2]: 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[3]: 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[4]: an open-source implementation of OpenADR[5] 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[6]: an efficient and automatic way to describe locally produced sources of renewable energy over a DC grid connecting them to AC grids.

SEAPATH[7]: 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 standard

Carbon Data Specification Consortium[8]: 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.

1 https://www.lfenergy.org/projects/compas
2 https://www.lfenergy.org/projects/fledgepower
3 https://www.lfenergy.org/projects/everest
4 https://www.lfenergy.org/projects/openleadr
5 https://www.openadr.org
6 https://www.lfenergy.org/projects/hyphae
7 https://www.lfenergy.org/projects/seapath
8 https://github.com/carbon-data-specification/the_way_we_work

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