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Accelerating the Transition to Sustainable Production Systems

The Internet of Things and the Circular Economy: Rethinking the Design of Computers and Heaters

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Key messages

- Qarnot computing has developed a high-performance computing (HPC) service based on a decentralised cloud-based computing heater, lowering the carbon footprint of computations by up to 75 per cent.
- Qarnot has a two-sided business model, offering free heat and an intelligent solution for all kinds of buildings, and a competitive HPC service for companies.
- Qarnot's innovation emerged from identifying the complementarity between sectors (information technology and buildings) that seldom work together, yet share common technical issues.
- Disruptive cross-sector innovations do not always fit within existing regulatory frameworks, so it is important to develop the case for exemptions early in the process.

Introduction

The huge amount of energy consumed by the production and use of information and communication technologies (ICTs) contributes significantly to climate change. The heat emitted by computer processors is of special concern for hardware security and generation of waste energy. Today, data centres consume 3 per cent of the world's electricity,[1] doubling every five years, to answer the growing need for cloud-based services. Waste heat has become a critical issue and is tackled currently by air conditioning and air flow management systems, which generate significant financial and ecological costs. Indeed, up to 40 per cent of electricity consumed in data centres is for cooling.[2] Qarnot computing is convinced that energy consumption could be reduced substantially if technologies were designed with eco-efficiency and circular economy principles in mind.

While data centres pay to remove heat, considered as a waste product, residential and commercial buildings pay for heating. The buildings sector accounts for over one-third of global energy consumption, with heating and cooling systems consuming nearly 60 per cent of the total energy requirement of buildings.[3] Waste heat is considered increasingly as a potential source of energy and experiments have been conducted to recycle it within surrounding buildings, transfer it to local heat networks and use it to warm greenhouses[4] and swimming pools.[5] However, such schemes currently suffer from shortcomings in that they need dedicated engineering and large investment specifically for each site, and inefficient

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heat storage and transport limits their replication potential.

To overcome these shortcomings, Qarnot has designed a solution to move data instead of heat through a distributed data centre. This system relies on a computing heater (Q.rad) and a software distribution platform (Q.ware). The Q.rad is the first heater to use embedded computers as a heat source. Totally silent and connected to the Internet, it performs complex operations for companies and institutions that need external computing capacity and are willing to pay for it. The heat produced by workload processing provides free and efficient heating for homes and offices. Q.ware software distributes computing jobs to the Q.rads, depending on heat demands. Q.rads act as servers and radiators, and can be located in buildings around cities, drastically reducing the carbon footprint of cloud high-perfomance computing (HPC).

This *Insight* presents innovations by Qarnot computing (a French member of the Climate-KIC community) and shows how they form a new green cloud computing model. The authors discuss the main challenges and share the lessons learned from Qarnot's commercialisation process.

Technical innovation: Qarnot's green cloud computing system

By rethinking the design of computers and heaters, Qarnot developed the Q.rad, a computing heater that can be deployed in all kinds of buildings, where it acts as a heat source and a decentralised data centre providing remote computing services. A Q.rad does not need to be cooled; instead, the heat is produced where it is needed. Qarnot's solution reduces the carbon footprint of computations profitably by producing computing services and heat with the same electricity spending, without having to cool data centre buildings (see Figure 1). In addition, Q.rad avoids the need to build a dedicated data centre and therefore saves land for agriculture, housing or other purposes.

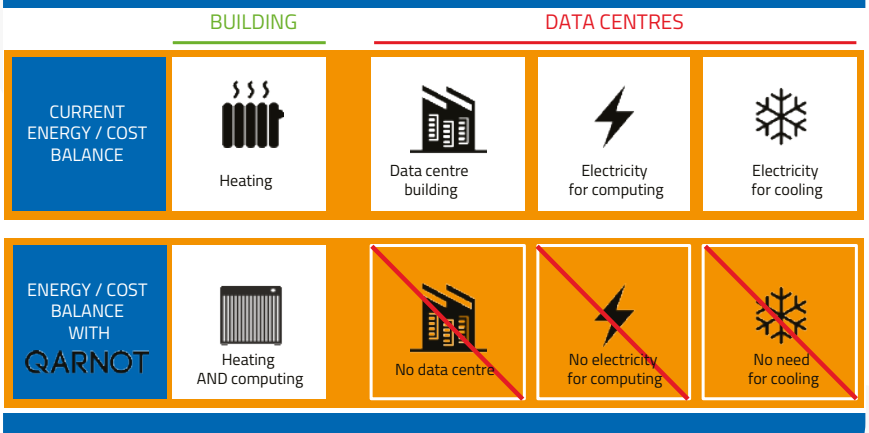
Q.ware, the software platform, distributes HPC workloads securely and efficiently across the computing grid, according to the host's need for heat and HPC workloads. The Q.rad heater works silently and gets its computing instructions through the Internet. It is also the ultimate connected platform for the smart home, with more than 20 sensors and interfaces in each device. These features are an example of the Internet of Things[6] working in practice. For instance, fire detection is done by using sensor fusion techniques such as external fire alarm sound, correlated with temperature and CO_2 levels measured directly through connected heater embedded sensors.

Commercialisation of Qarnot's two-sided business model

Qarnot began commercialisation in 2010 by developing and building the computing heater. However, the intention was not to disrupt the usage of the radiator. In conjunction with the visible hardware, Qarnot worked intensively on the software, which is essential to fill the heaters with computing jobs. A first version of the product was deployed in 2014 in 110 homes within social housing, supported by the mayor of Paris, Anne Hidalgo.

Commercially, the main message is structured around Qarnot's value propositions on both sides of its business model; i.e. free and green heating for buildings, and cheap and reliable computing power for such companies as banks (including BNP Paribas and Société Générale), 3D animation studios (including Fabelfjord and Disney Animation Studios), research labs and other industries doing modelling (including Air Liquide). Since 2015, BNP Paribas has used the Qarnot computing HPC grid for risk computing,[7] while Supamonks,[8] a 3D animation studio, added flexibility to its render farm by using Qarnot services. Qarnot has continued its research and development (R&D) activities, since innovation is a strong driver of growth, both externally and internally. See Figure 2 for the business model.

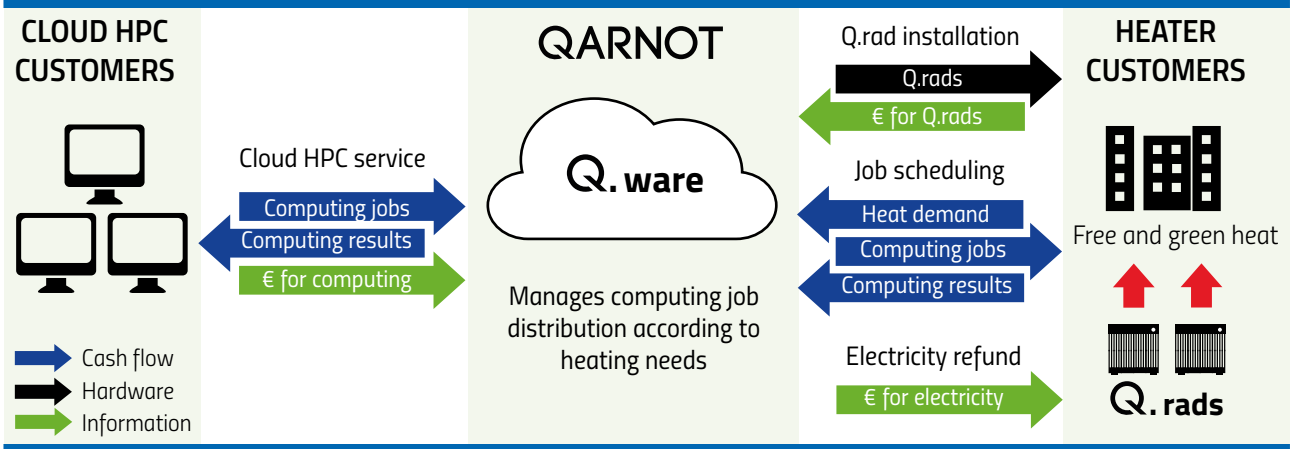
Figure 1. Qarnot computing energy and cost balance



Source: Qarnot computing

Regarding free heat beneficiaries, users experience the Q.rad as a high-quality radiator with advanced smart home[9] features. It can heat up to 28 m² in a building meeting modern insulation standards. After a one-year pilot in Qarnot's first residential building, the users were permitted to switch back to their old system if they were unhappy; however, none chose this option. Today, 400 Q. rads have been deployed in buildings all around France.

Figure 2. Qarnot computing's business model



Source: Qarnot computing

On the HPC side, to make Qarnot's service available to a larger customer base, in September 2016 it released a public application programming interface, a gateway to Q.ware enabling any customer to access the service online. On the heating side, Qarnot has received many requests from individual customers but has decided to focus on business-to-business customers, who are easier to deal with since they represent clusters of end-users. Qarnot directly deploys and maintains each installation and this requires staff involvement, which is feasible only in larger sites.

Enabling factors and challenges

From a technical viewpoint, the main challenge faced by Qarnot was to design a middleware, software that smartly connects computing services users with heaters and monitors the grid, to match the geographically distributed demand for computing power with that for heat. This system disrupts traditional models, which are centralised and do not consider the demand for heat. It needed to ensure continuity and stability of service. After seven years of R&D, Qarnot can provide a cloud computing platform that lowers the carbon footprint of computations and buildings without having to reduce the number of computations or the capacity to innovate.

In buildings, the main challenge was public resistance to new designs of heating equipment, regardless of potential benefits. Market success relies on a deep understanding of customer needs, on simple and clear explanations about a complex innovation, and on an efficient communication strategy. Qarnot ensured market acceptance by working closely with a designer to deliver a 'wow effect' from the look, feel and functionality of the system, while ensuring the heaters conformed with more traditional designs.

To compensate for the reduced heating demand in buildings during summer, the Q.rad processors are set to low power modes to allow Qarnot to maintain a minimum computing capacity that still ensures the grid they provide remains profitable. To meet year-round demand for computing power, Qarnot partnered with a European data centre and has developed different products for sites where heat is required all year (e.g. water, manufacturing and agriculture sectors). Nordic countries are a key part of Qarnot's international development plan, partly because of their longer winters. Expansion in these areas would enable Qarnot to compute at full capacity year-round, while this is not possible in France due to higher summer temperatures.

Providing a reduction in carbon footprint is a strong commercial advantage. Qarnot worked with the Building Scientific and Technical Centre (CSTB), the French national organisation for building quality and safety, to define the actual electricity and thus carbon savings offered by the Qarnot solution. In 2016, CSTB estimated the computing heater had used 75 per cent less energy than a conventional system. However, business-to-business clients are generally not convinced only by the 'green' argument; they are paying for a product or service, so it needs to perform at the same, and preferably higher, level than the competition.

Partnerships with academic research labs (e.g. Centre National de la Recherche Scientifique and Institut National de Recherche en Informatique et en Automatique) and European companies working within the innovation ecosystem have helped Qarnot access public funding for its R&D. Among others, in 2016 Qarnot led a scoping project on demand-response funded by Climate-KIC.

Lessons learned: implications and guidance

- Companies that want to design and sell a climate-friendly option should make products and services green by design, remembering that a reduced carbon footprint alone does not guarantee success.
- Start-ups should be competitive in all, or most key buying criteria of their customers. It is important to speak the customer's language and understand their business pains.
- Start-ups delivering innovative products need a strong marketing and communication strategy that pays adequate attention to visual design.
- It is important to master the business cycle in an individual industry, which includes planning how to increase the scale of activities.
- Local governments and authorities seeking to implement a disruptive eco-friendly solution need to ensure buy-in from traditional stakeholders and other end-users. Investing in broad stakeholder communication is essential to ensure adoption of innovative solutions.
- Regulations (buildings in this case), should not be considered as an insurmountable hurdle. It is important to consider, as early as possible, how regulations could affect product adoption and deployment and to develop a case for applying for exemption to existing frameworks if necessary.

Conclusion

By rethinking the design of computers and heaters in light of the Internet of Things and the circular economy, Qarnot computing's innovations demonstrate that it is possible to implement new alternatives that combine environmental and economic benefits. Qarnot's innovation emerged from identifying the complementarity between sectors that usually do not work together, but share common technical issues. The case study illustrates that green cloud computing models are viable and have the potential to be scaled up, thereby disrupting the traditional ICT and building sectors while delivering substantial climate benefits.

Q.rad digital heater

Endnotes

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Climate Innovation Insights is a platform for reflection and discussion on the lessons, challenges and opportunities of addressing climate change through innovation. It brings together key insights, informed opinion, best practice and methodological approaches to understand how research, education, business and government can, together, accelerate the transition to a zero-carbon economy. The series is developed and published by Climate-KIC, Europe's largest public–private partnership focused on climate innovation. We would like to thank the Series Editor, Dr Geraldine Brennan and the two external reviewers, Dr Carmen Ruiz Puente and Dr Inês dos Santos Costa.

About Climate-KIC

Climate-KIC is Europe's largest public–private partnership addressing climate change through innovation. With a focus on sustainable production systems, Climate-KIC is building a new foundation for industry in Europe – developing climate-friendly and economically viable circular models of manufacturing for a zero-carbon economy. Climate-KIC is supported by the European Institute of Innovation and Technology (EIT), a body of the European Union.

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About Qarnot computing

Qarnot computing is an innovative company founded in December 2010 and based in Paris. As of the beginning of 2017, the company employs 27 people.

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