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## Project details

### ABCOT U.K. LIMITED

#### Organisation type

Business

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**Competition name**

Innovate UK Smart Grants: January 2020

**Application name**

High efficiency electric boilers for domestic Hotwater and Heating

**When do you wish to start your project?**

20 April 2020

**Duration in months**

18 months

**Innovation area**

Energy efficiency

**Is this application a resubmission?**

No

**Selected research category**

Industrial research

**Project summary**

For environmental and safety reasons the government has set a deadline for gas installations in new builds by 2025 and no real alternative solution exists to replace gas boilers. The boilers will remove the need for gas installations in high-rises and homes and remove a lot of the moving parts that cause conventional gas boilers to break down.

This project aims to develop an electric Combi boiler that can match the performance of conventional gas boilers, even in properties with limited power supply.

These electric boilers will use cutting-edge heaters, battery storage technology, Internet of Things connectivity and a patent pending heat exchange design to ensure as much heat transfer to the water as possible.

4kW is an important power goal as most countries worldwide such as Italy, America and Turkey are limited to 3-6kW household connections. This product would be perfect for a European market which is the ultimate goal, as gas and oil boilers are primarily what are used. In this ever-growing eco friendly demand, a solution to gas heating is needed across Europe; battery technology and cartridge heater technology are now at a place where a solution to this problem can now be tackled.

Currently we have two designs: a centralised Combi boiler and a point of use heater, both using the same patented technology to outperform gas rivals.

**Point of use heater**

The system will be capable of mimicking a 24kW gas boiler using 4kW of grid power with supplementary battery backup. Each of these units will be distributed to a bathroom, hence "point of use system". The point of use heater forms a modular system that can be adapted from a home as small as a caravan to hotel-sized solutions.

## **Electric combi boiler**

The boiler focuses on efficient heat transfer from the heater to the water through low-volume, high surface area patented heat exchange. Further to this, a solid state diverter valve will divert the heat to the radiator system, with virtually no transfer loss, when required. This reduction in moving parts removes a lot of complexity and manufacturing intricacies. This is a direct replacement for a Gas combi boiler, offering heating and hotwater. The added battery will act as an energy storage akin to a tank of hot water, without the excess energy loss and bulky installation.

## **Public description**

Our electric boiler aims to directly replace the current gas/oil boilers in domestic and high-rise situations across Europe.

Using our patent pending heat exchanger design, we have come up with two electric boilers:

1. Combi electric boiler, mainly for the UK market and a direct replacement for a centralized gas combi boiler. Can directly replace a 24Kw gas boiler.
2. Point of use boiler for households with limited energy supply. This would suit homes across Europe and America which are limited to 3- 6kW.

Our boiler revolutionises how water heaters / combi boilers will be produced in the future; The basic design of heating water has not changed for over decades, this is fundamentally a large flame over a heat exchanger with losses of energy through the flue and unscrubbed fumes ventilated into the atmosphere.

Through the use of electricity, a more efficient heat exchange design that gives greater control can be produced. This can be run off renewables and if using fossil fuels, focus all fumes to a powerstation who will scrub the toxins such as dioxins from the emission. These fumes will not be emitted at the household improving city emissions and pollution levels.

The boilers can make use of batteries to replace conventional energy stores (such as hot water tanks) which means a more compact, energy dense solution. Batteries are more stable and can retain the energy with fewer losses than a tank. This allows our boiler to emulate much larger boiler systems in low power households.

Our boilers have one moving part as opposed to a gas boilers' minimum of 5 parts, reducing the chance of something going faulty. The boiler is compact,

almost a quarter of the size of a conventional boiler without the need for a flue, gas installation, gas safety checks and carbon monoxide monitoring.

If the UK's CO2 targets are to be met by 2050, the replacement of gas boilers will play a pivotal role in driving that change. Mesh networking, Heater and battery technology has come far enough that a serious electric solution is now achievable for domestic hot water and heating for all types of properties.

### **How does your project align with the scope of this competition?**

Our electric boilers would be game changing in an industry that hasn't really changed since the 1970's. Presently our company is the first and only electric Combi boiler on the market and have sold over 5000 electric boilers since launching 6 years ago. Demand for these boilers is on a steady increase and we constantly get requests from overseas, such as Italy, to supply boilers. Our current boiler can't be supplied to these markets as the power supply to each household is too low.

Calling upon our extensive knowledge and experience, we've patented a newly designed heat exchanger that not only increase efficiency but also allows us to satisfy european demand where low power is delivered to homes.

The idea behind a battery storage system is a novel idea that will mean that a small boiler can emulate the power of a larger more powerful gas boilers. The boiler itself, the electronics and batteries will be assembled by us with the heat exchanger being outsourced as it would require specialist skill to manufacture. Along with the patent pending heat exchanger and the Internet of Things connectivity, we believe these boilers will make a difference akin to Tesla in the car market.

Once a product has been design tested and approved, using our already large customer base and distribution network, we would market the boilers here in the UK first. This would be shortly followed by our current distributors in Italy and hopefully onward to America, which also has low power problems in residential homes.

The funding will mainly be used to enable the iterative design process with the heat exchanger, design the electronics and anti-scaling hardware, and push the design through the consumer electronics testing and regulations. The funding would allow us to purchase a metal 3D printer to rapid prototype the heat exchanger design, study the feasibility of the design and iterate to create the most cost effective product to manufacture. After this, the printer will enable production of a small volume batch to beta test, from which we will go to commercial development.

With the successful completion, production will be based here in the UK, generating jobs and R&D capabilities. The overseas market will call for high volume production, meaning as we scale, more jobs producing and developing will

follow. These boilers are essential for a carbon neutral future and to enable gas free homes by 2050.

## Application questions

### What is the business need, technological challenge or market opportunity behind your innovation?

Gas boilers are said to be banned from newbuild households by 2025 to tackle emissions. As the leading electric Combi boiler manufacturer on the market, we have seen exponential growth in sales of our electric boilers since starting 6 years ago. To match the heating power of a gas boiler, you need a minimum of 12kW which is what our current boiler is based upon. Our motivation and aim was to improve on our current range of electric combi boilers and gas boilers, which rely on old fashioned technology. This is either an immersion heater in a tank of water or a flame under heat exchanger with most of the energy lost to heated fumes.

The problem arises when a household doesn't have enough amperage supply to the house and the boiler. For example, we get requests from Italy and America for our boilers, but most Italian and American homes only have 3-6kW power supply. This lends an opportunity to tackle this problem and gain custom across Europe and the world.

Our new boiler design, based on our preliminary tests, can mimic the power of a 24kW gas boiler with 4kW of electricity. This is done through a patent pending heat exchanger which lowers the volume, increases the surface area and maximises the time the water is spent in contact with the heater. Couple this with an external battery for added power and a distributed mesh networks of the heaters around the house, this system could become a new standard of heating a home.

The nearest state-of-the-art system is our 12kW electric Combi boiler, which is compliant with Flicker and Harmonica and tested to IECCE-CB standards. Our aim is to reduce the power consumption of our boiler to satisfy these foreign markets and streamline them into a small, sustainable, reliable, price-competitive units. The potential in these untapped countries is vast as no real alternative to fossil fuel exist.

The boiler will be far more reliable, removing the need for a flue, carbon monoxide monitoring, gas supply and all the problems associated with gas. So far we have undergone proof of concept testing with the new heat exchanger, which is performing exactly as expected. We have computer simulations and models which are extremely encouraging. We aim to have a product on the market within 12 months and have a production line set up here in the UK.

### What approach will you take and where will the focus of the innovation be?

Our company is currently the leading electric Combi manufacturer in the UK having sold 5000 boilers since 2015. Our current boiler is currently the market leader for electric boilers, and is being copied by companies in China and Europe. To stay ahead we have innovated a new cutting edge heat exchanger. We have two boiler designs, based around this technology, to fill the market:

1. Combi boiler
2. water heater.

## **Combi boiler**

The Combi-boilers will make use of a low volume, high surface area heat exchanger which uses the sanitary hot water as the primary and the central heating as the secondary system. This means only one heat exchange happens and no excess heat is wasted warming up a tank of water. The double pass system will act as a variable insulator, containing the heat in the primary side heating when demand is needed and allowing the heat to pass to the central heating as the water stops flowing through the primary pass. This removes 90% of the components in a conventional boiler, quarters the size and production price. The unique heat exchanger allows a 2kWh battery to be used with the a 4kw heater to boost the power from 12Kw to 16 Kw (for half an hour). This battery can be increased to match the house size.

## **Water heater**

For the water-heater, we will place 8kW heaters around the house, one supplying each bathroom, kitchen and the central heating. 4kW will come from mains power and 4kW will come from a 1kWh battery to provide 15 minutes of 8kW. This will produce, from our tests, 40 degrees at 5L/m. The heaters will interconnect either through Wi-Fi or a vibration signature on the water pipe to let the other heaters know when they are on. The network of heaters will modulate down or switch to battery sources so the energy supply of the house is not tripped.

This distributed system would open up new markets such as Europe and the Americas where we already have distribution channels through our current business. From the output of the project, we hope to have a design for a boiler that is smaller, electric, has fewer faults and more reliable at a competitive price point. From here we will start to manufacture and sell in the UK.

[boiler.pdf \(/application/51585/form/question/13885/forminput/33343/download\)](#)(opens in a new window).

## **Who is in the project team and what are their roles?**

### **The Team**

We currently have 5 team members working on the project

- Balvinder Nagi - Managing director and technical specialist
- Jaskiran Nagi - Research and development Engineer
- Rupesh Naique - Electronics Engineer
- Gurprit Dhillon - Supply chain and marketing manager
- Bindu Nagi - Graphics designer and CAD modeler

For more information on the team please see the Appendix.

## Equipment needed:

To complete the project, the use of additive manufacturing for an iterative design process for the heat exchange is needed, most of the funding would go towards purchasing a metal 3D printer to speed up this process. The 3D printer will be used to produce a special design head gasket on the heat exchanger, but will also allow us to rapid prototype new designs and products. Using the patent that we have filed, we have several products to develop for different markets and applications (such as houses to flats to low power households). The 3D printer will allow us to develop all products in tandem and drastically reduce the time to market. The printer would allow small batch production for beta testing and enable future innovation.

## Ties

Our current boilers are produced in Italy by Fiamma. Fiamma have 40 years' experience in producing gas boilers and currently make our electric Combi boilers. We will utilize their knowledge and experience to develop a factory in the UK to assemble these boilers. The R&D, software development and assembly will be done here in the UK. Further to this, Electric Combi Boilers has close ties to Harji Precision Engineering machine shop who specialise in milling and lathe work based in the UK. We will use Harji Precision to aid in the prototyping, subcontracting parts to be made once the 3D print prototype gives us the optimal geometry. Once the design has been finalised, we will subcontract parts to Fiamma to build and aim to assemble in the UK.

## Gaps

To facilitate the supply line, we will be looking to employ an initial team to assemble and package the boilers which will increase as the demand increases. Further to the team of 5 engineers we employ now to fix our current boilers, we will be looking to move across the UK and offer training courses so that independent electricians and plumbers can repair and install the new electric boilers.

[Team.pdf \(/application/51585/form/question/13886/forminput/33348/download\)](/application/51585/form/question/13886/forminput/33348/download)(opens in a new window).

## What does the market you are targeting look like?

Currently there are over 26 million gas boilers sold each year with 1.6 million units sold in UK in 2017. Near to 100% of these boilers are gas condensing boilers which will need to be replaced if gas is to be banned in new builds by 2025, outlined by Future Homes Standard. This includes high-rises and business premises. This represents a large market, one that we have a lot of knowledge and experience in. Up until mid 2019, we were the only electric Combi boiler in the world, we have seen exponential growth that exceeds our manufacturing



capabilities since starting 6 years ago. We started with selling only 30 boilers in the first year of trading and now supply 1500 a year.

The UK is the 3rd largest gas boiler market in the world, following China and South Korea which saw around 4.6 and 1.77 million units respectively bought in 2017. Turkey and Russia also show over 1 million gas boilers installed annually which shows that no real alternative exists to gas condensing boilers to countries with low power supply to the average household. Italy, France and Germany each saw around 600,000 gas boilers installed in 2017. North America saw 400,000 gas boilers installed and this is due to the 3-6kW supply to households in most of Europe and America. We have been contacted by many companies from America and Europe looking to distribute our current boilers which will not work as the power supply to the average household is a lot more in the UK. Our primary focus would be Europe and the UK before expanding and licensing out the boiler design.

Our new boiler design has been engineered so that it will satisfy these markets and help meet the CO2 goals set out by the Paris agreement. Based on our preliminary tests, at 4kW our new innovative boiler design can match the heating of a 24kW gas boiler.

The UK has pledged 80% reduction in greenhouse gasses and to meet the goal of limiting 1.5 degree increase, household boilers will need to play a pivotal role. With the estimated growth of the European gas boiler industry to \$12bn dollars by 2024, the electric revolution would be akin to Tesla in the car market. This boiler design would put the UK at the forefront of the electric boiler market.

<https://www.phamnews.co.uk/global-gas-boiler-sales-revealed/>

<https://www.globenewswire.com/news-release/2018/03/27/1453337/0/en/Europe-Boiler-Market-worth-over-12-billion-by-2024-Global-Market-Insights-Inc.html>

### **How are you going to grow your business and increase your productivity into the long term as a result of the project?**

We currently are the leading suppliers for electric Combi boilers in the UK and although having requests from companies in both Russia and Italy, we don't have the supply chain to supply these areas. We would use our current platform and supply chains, along with using the funding to form a higher capacity supply chain, to distribute across Europe. We have strong ties to Fiamma, an Italian boiler manufacturer and distributor who would distribute to Italy and establish a brand for the electric boilers. Once a known brand has been established, we would look to license out the boiler designs to satisfy markets further afield.

We would assemble the boilers in the UK, and part of the funding would be spent building an R&D centre. This would include additive manufacturing providing jobs and the capabilities to further develop ideas pertinent to the heating industry. We would produce the electronics, battery cells and assemble in house and look to manufacture the heat exchange design in the UK. The profit would come from

boiler sales and acting as a distributor for the European market. The IP and patent protection would make it difficult for other companies to compete with our low power capabilities giving us a unique position in the market.

For larger markets such as Russia, North America and Asia, we would look to license out the patent pending boiler design and let an agent in those market autonomously sell. The long-term vision is to use the project as a stepping stone to produce an advance R&D centre that focuses on applying new technology to create solutions for other products.

The funding would be used to finalise a design and iteratively prototype to produce a cost effective easy to assemble boiler. The funding would be used to help purchase the machinery necessary to prototype the patent pending heat exchanger including a metal 3D printer. Additive manufacturing is the future of the design process, allowing same day testing of designs and drastically reduce manufacturing costs. This will not only be essential to developing this design and future designs, but place specialist knowledge in the UK where we can help their businesses innovate in a similar way. Hopefully the project will grow our company, diversify our capabilities, provide manufacturing jobs and stimulate the local economy through UK manufacture.

### **What impact might this project have outside the project team?**

The UK has committed to ban gas installs in new builds by 2025 and have net zero carbon emissions by 2050. This boiler would be a key piece of the puzzle, offering an alternative to gas without any compromise in heating power. Carbon dioxide, NOx and methane are all released when burning natural gas, the removal and isolation of this pollution to a power plant would allow for better, cleaner scrubbing and lowering of our carbon footprint and as renewable source come online, the boilers would form a clean infrastructure already in place. Gas boiler replacement is an essential problem that must be tackled to achieve the current climate goals outlined by the Paris agreement. The batteries also double as a home storage system for PV solar and other renewable energy sources, aiding with grid stabilisation in the future during peak demand.

The project will have a direct impact on the safety of the homeowners who use the electric boiler. With the electric boiler, there will be no need for a flue, no carbon monoxide detection and no need for a gas supply. This would drastically improve the safety and mean the boiler can be mounted anywhere within the home. As the boiler is close to 100% efficient, this will save the consumer money on their bills and on breakdowns. This boiler has only one moving part, a pump, whereas a conventional boiler has minimum of: a fan, gas valve, pump, diverter valve and a microswitch. This would mean breakdowns would be far rarer and easier to repair. In fact, each boiler would be supplied with a 7-year warranty. Built-in redundancy in the heaters mean the household will never go without hot water should one heater fail.

Safety in high-rises would benefit massively as the need to run gas would be eliminated and the boilers would run more efficiently, being able to modulate down to fit the size household. The 4kW electric boiler is capable of mimicking a 24kW gas boiler, reducing the energy demand and improving the energy demand of the UK.

The manufacture of the boilers could directly create up to 20 new jobs immediately in the local area and plenty more to do with logistics, supply chains and design. As demand increase, we expect the jobs to assemble to boiler will rise drastically so satisfy demand.

### **How will you manage the project effectively?**

The project has two end products, an Electric Combi boiler to directly replace existing Gas combi boilers and a point of use water heater to offer a solution to houses without a 50A supply. Both projects are run in tandem as they will share the same control boards and heaters, varying only in the design and geometry. The overall project lead is Balvinder who has outlined the specification. Reporting to him will be Jaskiran, Rupesh, Gurpit, bindu and any other sub contractors.

Within each product, there are 3 areas of development.

- Electronic control board and Battery management
- Heat exchange design and manufacture
- Software Development

### **Electronic control board and battery integration**

The electronics will be lead by Jaskiran Nagi and Rupesh, who has extensive experience in PCB design for gas boilers.

He will design the control boards and source the batteries. Jaskiran is also responsible for the CE regulation testing of the batteries and the control boards. The bulk cost of this will be importing the batteries and the CE testing. Our partners Fiamma, have a lot of experience with regulation testing and will liaise with them. The estimate for the completion of the electronics design including man hours would be £50,000.

### **Heat exchange design and manufacture**

The patented heat exchange geometry is one of the main features that allows the boiler to perform as well as it does. This requires advance manufacture techniques such as metal 3D printing. We would like to purchase a metal 3D printer to allow rapid manufacturing and prototyping and to allow us to expand our capabilities to eventually become an R&D centre for businesses across the UK. We will use the machining knowledge of a subcontractor, Harji Precision engineering and Bindu Sehmi to set up an efficient work flow to design the parts on the 3D printer. Once the parts have been tested, Harjit Precision will be responsible to machine the prototypes to ensure that manufacture process is

achievable. Jaskiran will act as a consultant as he has mechanical engineering experience having designed safety shut downs mechanisms for nuclear reactors. The printer cost and labour are expected to be £500,000.

## Software Development

The software for the boiler and the distributed network will be written by Jaskiran but app integration will be handled by our partners Fiamma. The budget for this is £30,000

[Project plan.pdf \(/application/51585/form/question/13890/forminput/33368/download\)](https://apply-for-innovation-funding.service.gov.uk/application/51585/form/question/13890/forminput/33368/download)  
(opens in a new window).

## What are the main risks for this project?

The main risk is not capitalising on the market soon enough and someone copying our design. The market is in a good position as there are no real competitors but time is essential to ensure that a good brand is established. With the plumbing industry, it is important to establish a brand so that engineers feel comfortable with installing and servicing your boilers.

The technology is not out of reach of any large company, which is why a rapid prototyping and manufacture such as 3D printing is essential to gain a pole position as other companies start releasing electric boilers. The patent pending 3D printed heat exchanger design would give us a performance edge that can only be matched by investing in the same technology. It would allow us to adapt as we continually improve the design and innovate.

Scale build up could be a problem and is something we predict could clog up the heat exchanger design. This can be mitigated through an innovative ultrasonic transducer mounted on the base of the boiler that runs twice a day. From initial tests, this is enough to break up scale forming on the heater. The ultrasonic transducer will run twice per day for ten minutes to remove the scale build up and flush it from the system. Alternatively water softeners could be used to remove scale.

The battery store is essential to match the performance of current gas boilers for households without 50A supply and will need to be sourced accordingly. A potential risk will be passing the CE regulation with the battery storage technology we wish to go with. CE certification is an extremely costly process so we must ensure the system passes first time to reduce development cost and bring the product to market quicker.

The control board and the heaters will need to go household regulatory testing. The batteries need to go through stress testing and also go through regulatory testing if this has not been done by our supplier. The boiler itself will need to comply with anti legionella regulations which should not be an issue as no water is stored in the boiler at any point. Overall testing is imperative to the safety of our

system as we are putting a lot of energy in a small volume. General safety, fail safes and control mechanisms will all need rigorous testing to ensure a fail safe product.

[Sheet1.pdf \(/application/51585/form/question/13891/forminput/33372/download\)](#)(opens in a new window).

### **Describe the impact that an injection of public funding would have on this project.**

With the funding provided we can enter the market a lot quicker than if we were to fund the project by ourselves. The advantage of having a 3D printer to prototype would shave a year of designing the main heat exchange unit, giving us an edge on the market to competitors. It would also mean we could produce the part in the UK, creating more jobs and saving on transport costs. This time is critical as this is an untapped market that we predict will become very competitive in the coming years. This time is essential to generate a brand and have a product that leads the industry. The patent pending design is internationally protected for a year, which meant the product must be exploited to fund the international patent which is considerably more expensive.

The direct impact on our electric boilers company would be the ability to develop and prototype a lot of other products that we currently don't have the funding to pursue. It would allow the company to diversify to start manufacturing and prototyping products. The metal 3D printer and other equipment would allow us to build a rapid prototyping centre where we can develop and design parts for companies around the UK. With the analogue and digital PCB development experience, material science and additive manufacturing experience and the industry ties that we have across Europe, we could become a cog in the wheel of British R&D.

Without the funding, we would have to pursue a different method of manufacture, one that doesn't involve rapid prototyping and double the timescale to market. We would also need to stagger the project and focus solely on the electric Combi boiler, and revisit the low power distributed boiler further down the line. It would mean future projects would also be hard to design and prototype, and mean sourcing parts from other countries instead of manufacturing here in the UK.

The added machinery would create jobs in the production line and post processing and increase the capabilities of British research and development. Rapid prototyping is a very new player in the design process field, our end game is using this project as a stepping stone into the rapid prototyping market and become a world expert in applying the technology to manufacture goods and improving efficiencies through the capabilities that 3D printing allows.

### **How much will the project cost and how does it represent value for money for the team and the taxpayer?**

The main project goal is to produce an extremely efficient electric boiler that has markets globally. We wish to not only target the UK market, but foreign markets which currently have no current solution to the problem. We wish to set up a production line here in the UK to manufacture the boilers and the develop an R&D center where we have the tools needed to develop and innovate future products for us. The entire project plan is to have a manufacturing line setup within 12 months. With the specialist machinery such as the 3D printer, the eligible project costs is expected to be around £600,000.

We are requesting £400,000 from the grant to help fund the specialist machinery and push project forwards including the electronics, heat exchanger, software and R&D. The rest will be self funded by Abcot, as an investment in our future, moving towards production and R&D. This project will be completed solely by Abcot with subcontractors used for any specialist parts needed.

The taxpayer will benefit from a project like this in multiple ways. The first is the manufacturing and assembly line of the boiler. This would directly create jobs for manufacturing and assembly, and due to the predicted demand from foreign markets, could see multiple assembly lines opening in the future. It would call upon multiple UK based subcontractors to create specialist parts for the boiler such as the heat exchanger and thus creating business. The product itself will lower carbon emissions drastically and help the UK reach its carbon targets. It will clean up air quality and allow for better scrubbing at the powerplants to reduce particulate count across the UK. The safety of the general public will also be improved as there will be no risk of carbon monoxide poisoning or gas leaks in any households. Finally the grant will stimulate advance R&D in the UK through the machinery the grant will help fund.

Without the grant, the product would need to be designed in China as the prototyping is much more affordable and has quicker time scales than the UK. This would mean adding a year to production as the parts are refined and waiting for it to be shipped before we can test. At present 95% of boiler parts are imported, through our development and manufacturing, we hope to reverse this trend.

# Finances

To make changes to your organisations' finances, go back to the [your project finances \(/application/51585/form/section/5668/\)](#) section.

Organisation	Total costs	Funding level (%)	Funding sought (£)	Other public sector funding (£)	Contribution to project (£)
ABCOT U.K. LIMITED	£460,897	70.00%	322,628	0	138,269

## Funding breakdown

Organisation	Total	Labour (£)	Overhead costs (£)	Materials (£)	Capital usage (£)	Subcontracting costs (£)	Travel and subsistence (£)	Other costs (£)
ABCOT U.K. LIMITED	£460,897	172,414	34,483	97,500	144,000	0	7,500	5,000

[View finances \(/application/51585/form/FINANCE\)](#)

## Terms and conditions

The following organisations have not yet accepted:

- ABCOT U.K. LIMITED

This application cannot be submitted until all partners accept our terms and conditions.