DERri
Distributed Energy Resources
Research Infrastructures

Template for a TA proposal under DERri

User-Project Proposal:

Use-Project Acronym	PEMFCOLD
User-Project Title	Cold start up procedures and test for portable fuel cell
Main-scientific field	Renewable Sources
Specific-Discipline	Fuel Cell

Lead User of the Proposing Team:

Name	Walter Castagna
Phone	:+39 039 63 96 501
E-mail	walter.castagna@genport.it
Nationality	Italian
Organization name, web site and address	GENPORT srl Via Lecco, 61 20871 Vimercate (MB) - Italy PI/VAT NR: 03174200133 website: www.genport.it email: genport@genport.it
Activity type and legal status* of Organization	Battery and Fuel Cell Small or Medium size private enterprise
Position in Organization	Chief Engineering Officer

* Higher Education Institution (1) – Public research organization (2) – Private not-for-profit research organization (3) – Small or Medium size private enterprise (4) – Large private enterprise (5) – other (specify)

Additional Users in the Proposing Team:

Name	Stefano Limonta
Phone	+39 039 63 96 501
E-mail	Stefano.limonta@genport.it
Nationality	Italian
Organization name, web site and address	GENPORT srl Via Lecco, 61 20871 Vimercate (MB) - Italy PI/VAT NR: 03174200133 website: www.genport.it email: genport@genport.it
Activity type and legal status* of Organization	Battery and Fuel Cell Small or Medium size private enterprise

Position in Organization	Fuel Cell Systems – Project Leader

* Higher Education Institution (1) – Public research organization (2) – Private not-for-profit research organization (3) – Small or Medium size private enterprise (4) – Large private enterprise (5) – other (specify)

(Repeat for all Users)

Date of submission	22/11/12
Re-submission	NO
Proposed Host TA Facility	VTT - Finland
Starting date (proposed)	15/03/13

Summary of proposed research (about ½ page)

Prepare a ½ page summary describing the relevance and the scope of the proposed work, and the expected outcome(s)

The aim of this project is **the definition of a standard test procedure and the execution of an environmental experimental test activity at – 20 C to diagnostic the startup, operation and shutdown of the portable fuel cell** G300 HFC realized by Genport srl.

Genport srl – Spinoff del Politecnico di Milano makes lightweight portable electric energy sources based on the combination of fuel cells, lithium batteries and solid H_2.Our value proposition is delivered thru reliable, high energy density, zero impact, power solutions designed to extend in off-grid contest runtime of electronics. In off-grid situations, diesel generators cause logistical problems, noise, heat signature and detectable emissions. Acid Lead batteries, as a complementary or substitute solution in the short run, are extremely bulky, heavy, not efficient, unreliable. These power sources technologies are inadequate to fulfill the needs of emerging portable electronics used by dismounted *soldiers or rescue teams*. Use of electronics for remote telecoms, sailing, camping or agriculture is effected by unreliable, short-run batteries and noisy diesel generators. Applications like portable electro-medical devices, portable industrial electronics need more reliable and lighter batteries.

Genport offers portable hybrid fuel cell systems, which combine lithium batteries, fuel cells and solid hydrogen: G300 HFC is a CE compliant portable hybrid fuel cell, a 400W system (3 times the power of today's systems that are based on fuel cells only), G300 HPS is 1400W fuel independent power system that even integrate a solar panel and a subsystem to regenerate hydrogen and store hydrogen until it is needed again to generate electricity (the subsystems to generate hydrogen is also offered separately ($GenH_2$, to refill hydrogen and $GboxH_2$, a re-chargeable thermo-regulated canister to storage and released the fuel). In contrast to the problems with diesel generators and batteries, these systems satisfy requirements for long life, design flexibility, high energy density, compact configuration, high cycling, high rate discharge, and offer the ability to operate in extreme environmental conditions. On top of that, they produce no noise, no emissions or vibrations and therefore they can be utilize indoor as well outdoor.

The company offers an additional solution to reduce the logistic problem caused by the transportation and storage of large quantities of batteries. GENFUEL is a safe and clean solid fuel based on Sodium Borohydride ($NaBH_4$). This storage solution has advantages over other methods to store hydrogen (i.e. methanol, GPL): it stores hydrogen in a *non-toxic and safe* powder with excellent volumetric characteristics (energy capacity per volume and weight), no environmental impact, and with the catalyst included in the powder (unlike other solutions, no external catalyst is

needed to generate hydrogen - just adding water is enough).

From 200 Wh/kg of lithium batteries, 400 Wh/kg of Solid H_2 in Metal Hydrides, Methanol 800 Wh/kg, GENFUEL enable to extend the energy density to 1200 Wh/kg (6 time more then lithium).

Besides offering the hybrid energy generation systems and the hydrogen storage products, the company also designs customized high end lithium ion battery packs for battery-powered devices with strict requirements, such as medical devices, military equipment's. Knowledge in this lithium battery domain offers a competitive advantage, since it is also applied in the hybrid fuel cell systems. Genport has developed owned smart technologies for battery managements based on TI. **G300 HFC is an electric generator that uses hydrogen as the sole source of energy based on PEMFC.** Inside a fuel cell (fuel cell stack) converts the chemical energy stored in hydrogen into electrical energy. The internal reaction is electrochemical. The hydrogen reacts electro-chemically with oxygen (taken from the air) and returns as a reaction product of pure water, heat and electrical energy.

The technology of fuel cells is integrated with a battery pack that allows the generator to operated an a combined source of energy (hybrid system).

The battery pack allows the switching on and off of the system, provides an additional delivery of energy dynamically required by electronic devices such as pumps, radio transmitters, medical devices. When a high electrical loads is requested, the batteries are joined to the fuel cell to reach the peak power. When a low power consumption is required, only the PEM fuel provides the requested energy.

The fuel cell during operation generates electricity and heat. The exhausted air is ejected outside through the ventilation grid through an internal heat exchanger. The hydrogen at the input is intercepted by a solenoid valve which acts as a switcher and a safety device.

Downstream of the solenoid valve, a pressure reducer adjusts the pressure in input to the correct value for the fuel cell. The hydrogen line is equipped with detection sensors for low and over-pressure of the inlet hydrogen fuel cell.

An hydrogen sensor analyzes the air continuously; in the case of any leaks, it sends promptly a signal to microcontroller and the power electronics to ensure the continuous safety operation of the generator.

The microprocessor and the power electronic controls the system all the fuel cell parameters, it supervises the entire electronic protections built into the control board and via a touch-screen interface communicates interactively the status of operation to the operator.

G300HFC is CE market and it is compliant to IEC 62282-5-1 (construction, test requirements, safety, portable Fuel Cell), EN 60529 (grade of protection of enclosures) EN 60529/A1 (grade of protection of enclosures) EN 61000-6-1, EN 61000-6-3 (Electromagnetic compatibility), EN 60335-1 (safety of electrical devices for domestic and industrial application).

Successful **start-up from subzero temperatures is of paramount importance for the commercialization of PEMFCs for practical applications, such as backup power and automotive applications and during this project a hybrid fuel cell system will be tested to diagnostic potential fault at low temperatures.**

State-of-the-Art (about 1 ½ page)

Describe in brief (in about 1½ pages) the current knowledge on the subject, citing recent relevant references. Identify any knowledge gaps and their relevance.

The polymer electrolyte membrane fuel cell (PEMFC) is widely regarded as a potential power source for portable and mobile applications, due to its noteworthy features of high efficiency and zero emission.

Successful start-up from subzero temperatures is of paramount importance for the commercialization of PEMFCs for practical applications, such as backup power and automotive applications.

Under freezing environmental conditions, water produced at the cathode has a tendency to freeze in open pores in the catalyst layer and GDL, rather than be removed from the fuel cell, thus creating mass transport limitations which, eventually, end the ability for operation.

Even though various external heating methods can be used to ensure the cold start capability, the volume and weight of the system, as well as the operation complexity and installation costs, all increase with the increment of the external heating power requirement.

Analysis of the various cold start processes to achieving optimal design and operating strategy is therefore critical to simplify or cast off the external heating system.

While the characteristics of PEMFC dynamics have been studied by several groups, research on PEMFC cold start-up is relatively new and some aspects of degradation caused by freeze/thaw cycling are discussed controversially in literature.

Water is produced during the operation of a fuel cell; in PEMFCs, water within the cell is necessary to ensure high proton conductivity of the polymer electrolyte membrane. During normal operation, the generated waste heat is sufficient to keep the water within the cell above the freezing point, even at ambient temperatures significantly below 0°C. However, when fuel cells are switched off under sub-zero conditions, the volume expansion by ice formation within the cell can lead to structural damage.

In order to ensure good gas diffusivity and to extend the electrochemically active surface area, the materials of the gas diffusion layers, micro-porous layer and electrodes are highly porous. If water freezes within these media, volume expansion can lead to cracks in their structure and a change in the pore size distribution of the electrodes.

The physical state of water within the membrane seems to be a key issue in membrane degradation under freezing conditions. Due to the high capillary pressure in small pores, the freezing point of water within the membrane can fall below 0°C. In a Nafion membrane, besides free and loosely bound freezable water, non-freezing water can be present, which is still moveable even at –20°C.

For the membrane/electrode interface, some authors reported delamination of the electrodes from the membrane due to freeze/thaw cycling, while some others didn’t find any indication for delamination of catalyst layers. Performance degradation in PEMFCs is highly dependent on the cell components. Purging with reactant gases (dried or humidified) seems to be a promising approach to prevent degradation of PEMFCs caused by freeze/thaw cycling. Such purging procedures are applied before switching off the cell, in order to remove residual water from the porous media.

In summary, to avoid degradation at low temperatures, water has to be removed before freezing from the cell or the PEMFC components have to be redesigned with greater material flexibility to allow volume expansion at the phase transition of liquid water to ice.

References

List relevant References

1. **Cold start of polymer electrolyte fuel cells: Three-stage startup characterization** Yun Wanga,□, Partha P. Mukherjeeb, Jeff Mishlera, Rangachary Mukundanb, Rodney L. Borupb a Renewable Energy Resources Lab (RERL) and National Fuel Cell Research Center, Department of Mechanical and Aerospace Engineering, The University of California, Irvine, Irvine, CA 92697-3975, United States b Los Alamos National Laboratory, Los Alamos, NM 87545, United States.
2. **Effect of sub-freezing temperatures on a PEM fuel cell performance, startup and fuel cell components** Qiangu Yan a,□, Hossein Toghiani b, Young-Whan Lee a, Kaiwen Liang b, Heath Causey a Center for Advanced Vehicular Systems (CAVS), Box 5405, Mississippi State University, MS 39762-5405, United States b Dave C. Swalm School of Chemical Engineering, Box 9595, Mississippi State University, MS 39762, United States .
3. **Design for the cold start-up of a man-portable fuel cell and hydrogen storage System** C. A. Ward, D. Stanga, L. Pataki and R. D. Venter Department of Mechanical Engineering, University of Toronto, Toronto, M5S
4. **Analysis of PEMFC freeze degradation at−20 ◦C after gas purging** Junbo Houa,b, Hongmei Yu a,□, Shengsheng Zhang a,c, Shucheng Suna, Hongwei Wang a, Baolian Yi a, Pingwen Minga a Fuel Cell R & D Center, Dalian Institute of Chemical Physics, Chinese Academy of Sciences, 457 Zhongshan Road, Dalian 116023, PR China
b Graduate School of the Chinese Academy of Sciences, Beijing 100039, PR China c School of Science, Beijing Jiaotong University, Beijing 100044, China.
5. **Investigation of residedwater effects on PEM fuel cell after cold start** Junbo Houa,b, Baolian Yia, Hongmei Yua,□, Lixing Haoa,b,Wei Songa,b, Yu Fua,b, Zhigang Shaoa a Fuel Cell System and Engineering Laboratory, Dalian Institute of Chemical Physics, Chinese Academy of Sciences, 457 Zhongshan Road, Dalian 116023, PR China b Graduate School of the Chinese Academy of Sciences, Beijing 100039, PR Chin.
6. **Characteristics of subzero startup and water/ice formation on the catalyst layer in a polymer electrolyte fuel cell.** Wang □ Electrochemical Engine Center (ECEC), and Department of Mechanical and Nuclear Engineering,The Pennsylvania State University, University Park, PA 16802, United States.
7. **Behavior of water below the freezing point in PEFCs**Y. Ishikawa a,□, T. Morita b, K. Nakata b, K. Yoshida a, M. Shiozawa aa Nippon Soken Inc., 14 Iwaya, Shimohasumi-cho, Nishio, Aichi 445-0012, Japanb Toyota Motor Corporation, 1 Toyota-cho, Toyota, Aichi 471-8572.
8. **Effects of various operating and initial conditions on cold start performance of polymer electrolyte membrane fuel cells** Kui Jiao, Xianguo Li* Department of Mechanical & Mechatronics Engineering, University of Waterloo, 200 University Avenue West, Waterloo, Ontario N2L 3G1,Canada
9. **Numerical studies of cold-start phenomenon in PEM fuel cells** Hua Meng□ Center for Engineering and Scientific Computation, School of Aeronautics and Astronautics, P.O. Box 1455, Zhejiang University, Hangzhou, Zhejiang 310027, PR China
10. **A review of PEM fuel cell durability: Degradation mechanisms** and mitigation strategies
JinfengWua, Xiao Zi Yuana, Jonathan J. Martina, HaijiangWanga,□, Jiujun Zhanga, Jun Shena, ShaohongWua,Walter Meridaa
11. **Cold start of polymer electrolyte fuel cells: Three-stage startup characterization** Yun Wanga,□, Partha P. Mukherjeeb, Jeff Mishlera, Rangachary Mukundanb, Rodney L. Borup
12. **Statistic analysis of operational influences on the cold start behaviour of PEM fuel cells** M. Oszcipok □, D. Riemann, U. Kronenwett, M. Kreideweis, M. Zedda Fraunhofer

Institute for Solar Energy Systems, Germany

13. **Conductance of Nafion 117 membranes as a function of temperature and water content**. Marcella Cappadonia, J. Wilhelm Erning, Seyedeh M. Saberi Niaki, Ulrich Stimming Institute of Energy Process Engineering (IEV), Research Centre Jtilich (KFA), O-52425 Jiifich, Geitnany
14. **Characteristics of subzero startup and water/ice formation on the catalyst layer in a polymer electrolyte fuel cell.** Shanhai Ge, Chao-Yang Wang ∗ Electrochemical Engine Center (ECEC), and Department of Mechanical and Nuclear Engineering, The Pennsylvania State University, University Park, PA 16802, United States
15. **Degradation effects in polymer electrolyte membrane fuel cell stacks by sub-zero operation**—**An in situ and ex situ analysis** R. Alink, D. Gerteisen∗, M. Oszcipok Fraunhofer Institute for Solar Energy Systems, Freiburg, Germany
16. **Characteristics of subzero startup and water/ice formation on the catalyst layer in a polymer electrolyte fuel cell** Shanhai Ge, Chao-Yang Wang Electrochemical Engine Center (ECEC), and Department of Mechanical and Nuclear Engineering, The Pennsylvania State University, University Park, PA 16802, United States
17. **Effect of sub-freezing temperatures on a PEM fuel cell performance, startup and fuel cell components** Qiangu Yan a,□, Hossein Toghiani b, Young-Whan Lee a, Kaiwen Liang b, Heath Causey a Center for Advanced Vehicular Systems (CAVS), Box 5405, Mississippi State University, MS 39762-5405, United States.
18. **A PEM fuel cell model for cold-start simulations** Hua Meng□ Center for Engineering and Scientific Computation, School of Aeronautics and Astronautics, P.O. Box 1455, Zhejiang University, Hangzhou, Zhejiang 310027, PR China
19. **Experimental and Numerical Study on the Cold Start Performance of a Single PEM Fuel Cell**

Calvin H. Li1 and G. P. Peterson Department of Mechanical, Industrial, and Manufacturing Engineering, The University of Toledo, Toledo, OH 43606, USA Woodruff School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0325, USA

20. **Investigation of residedwater effects on PEM fuel cell after cold start** Junbo Houa Baolia Yia, Hongmei Yua,□, Lixing Haoa,b,Wei Songa,b, Yu Fua,b, Zhigang Shaoa, A Fuel Cell System and Engineering Laboratory, Dalian Institute of Chemical Physics, Chinese Academy of Sciences, 457 Zhongshan Road, Dalian 116023, PR China Graduate School of the Chinese Academy of Sciences, Beijing 100039, PR China

Synergy with ongoing research (about ½ page)

Provide information on any concurrent research project with the same or similar subject with the one proposed. Describe the synergy (if any) that will be sought between the existing and the proposed project.

Although there is a massive research activity at the fuel cell materials and stack level to comprehend the phenomena related to cold-start of a PEMFC, there is a limited public knowhow available for fuel cell systems.

Genport has already carried on a state of art analysis and We have identified and implemented a control strategy into the portable hybrid fuel cell system G300HFC during the FESR project funded by Lombardy Region under the topic of Energy Efficiency on 2009.

Genport is interested to benefit of *WP7 Derry Project* to carrying on a subsequent activity focused on experimental test to validate the control strategies and the physical layout of the electric generator under severe environmental condition. During the previous project, Genport has carried on an intensive campaign of functional and cycling tests at the 5-40 deg. temperature range. Following this activity,

Genport has carried on a further campaign of qualifications aiming to obtain the CE mark.

The G300 HFC unit that will be utilized to conduct the cold-start test is compliant to IEC 62282-5-1 (construction, test requirements, safety, portable Fuel Cell), EN 60529 (grade of protection of enclosures) EN 60529/A1 (grade of protection of enclosures) EN 61000-6-1, EN 61000-6-3 (Electromagnetic compatibility), EN 60335-1 (safety of electrical devices for domestic and industrial application).

Consequently the test campaign under the Derry project, are fully in synergy with the previous research projects.

Dissemination – Exploitation of results (about ½ page)

Describe the means through which the results to be obtained from the proposed project will be diffused and made broadly known.

Dissemination

The task of disseminating project results is the responsibility of **GENPORT**. The aim is to ensure high visibility of ***PEMFCOLD*** at the international level, and to create awareness across the scientific and media world of ***procedures and result*** commercial and energy saving potential.

One of the main methods of achieving this is the submission and presentation of papers at scientific and trade conferences and workshops, and in journals, particularly for renewable energy in general and energy storages and fuel cells in particular. Presentations will also be made at more specialized venues.

Project progress will also be available in the publicly accessible part of the ***Genport*** website, which will regularly be up-dated to ensure widespread dissemination to the community at large. The results will be also be disseminated through the EC networks on *Derry website* with possible visibility on related portals.

In addition, Genport will focus on the efforts in dissemination activities by means of international exhibitions (Fuel Cell Seminars (US) , Fuel Cell Expo (GE), public pitches.

Moreover, results of the project will be gathered in concise overviews suitable for professionals active in the security, defence fields by publication of proceedings.

Exploitation

Cold start is an essential feature requested in many field of application of fuel cell technologies. In professional application such as Defense and Emergency in cold territories, the fuel cell has to power electronics devices at low temperatures.

The cold start test carried on within Derry project represents an essential step to validate cell of the portable hybrid fuel cell system under a well defined test standard procedure.

Therefore, Genport will benefit enormously from Derry project; sharing experience and competence with other experienced researchers of the consortium, Genport will have the opportunity to run the fuel cell system under a wide range of operating temperatures down to -20 Deg.

Thanks to these tests and the associated activity carried on by Genport to modify the HW&SW setup of the system, the opportunity of applications and territories will be extended with a consequent impact in the growth of the company business and employment base.

Detailed Description of proposed project : Objectives – Expected Outcome – Fundamental Scientific and Technical value and interest (2-3 pages)

Provide a detailed description of the objectives of the proposed activity, the way these objectives will be fulfilled through the proposed work, as well as indications on the expected outcome and the fundamental scientific and technical value and interest of the proposal. Specify the type of TA infrastructure (distributed generation simulator; domotic house; etc.) and the test setup. With the understanding that these aspects will be discussed with the TA infrastructure after approval of the proposal and specified in the Agreement to be signed between the TA infrastructure and the User team, indicate the number of tests to be carried out and their sequence, the response quantities to be measured through the instrumentation, etc. Describe any special requirements for equipment, standards, safety measures, etc. Point out any shortcomings, uncertainties and risks for the fulfillment of the project objectives, as well as the means to mitigate relevant risks.

The polymer electrolyte fuel cell (PEMFC) is widely regarded as a potential power source for portable and mobile applications due to its noteworthy features of high efficiency and zero emission.

PEMFCs must have the ability to survive and start up from subfreezing temperatures, also called cold start, to be successfully deployed in extreme off-grid environment. Under freezing environmental conditions, water produced has a tendency to freeze in open pores in the catalyst layer and GDL, rather than be removed from the fuel cell, thus creating mass transport limitations which eventually end the ability for operation. Cold start is essentially a transient phenomenon. Currently, the majority of the efforts are focused on the steady-state characteristics of PEFCs.

The first key item to enable cold startability is the sub-system that controls the water content in the FC stack at the beginning of power generation.

During Derry Project cold startability will be studied at system level with the unit G300 HFC, a hybrid portable fuel cell developed by Genport srl.

G300 HFC is an electric generator that uses hydrogen as the sole source of energy. Inside a fuel cell (fuel cell stack) converts the chemical energy stored in hydrogen into electrical energy. The internal reaction is electrochemical. The hydrogen reacts electro-chemically with oxygen (taken from the air) and returns as a reaction product of pure water, heat and electrical energy.

The technology of fuel cells is integrated with a battery pack that allows the generator to operated an a combined source of energy (hybrid system).

The battery pack allows the switching on and off of the system, provides an additional delivery of energy dynamically required by electronic devices such as pumps, radio transmitters, medical devices. When a high electrical loads is requested, the batteries are joined to the fuel cell to reach the peak power. When a low power consumption is required, only the PEM fuel provides the requested energy.

The fuel cell during operation generates electricity and heat. The exhausted air is ejected outside through the ventilation grid through an internal heat exchanger. The hydrogen at the input is intercepted by a solenoid valve which acts as a switcher and a safety device.

Downstream of the solenoid valve, a pressure reducer adjusts the pressure in input to the correct value for the fuel cell. The hydrogen line is equipped with detection sensors for low and over-pressure of the inlet hydrogen fuel cell.

An hydrogen sensor analyzes the air continuously; in the case of any leaks, it sends promptly a signal to microcontroller and the power electronics to ensure the continuous safety operation of the generator.

The microprocessor and the power electronic controls the system all the fuel cell parameters, it supervises the entire electronic protections built into the control board and via a touch-screen interface communicates interactively the status of operation to the operator.

The **main objective of PEMFCOLD** under Derry Project is to **investigate the impact of low-temperature cycling** on a G300 HFC unit which will be frozen within a climatic chamber for testing fuel cell systems under realistic conditions.

It will be investigate the operation of fuel cell systems under environmental conditions in a range between − 20 ◦C and 60 ◦C, and 10% and 98% RH.

A preliminary activity will be therefore the **definition of a test protocol**, number of test which can be representative of the real extreme environmental condition faced by the hybrid fuel cell.

The following activity will be to setup the test bench, which include a climatic chamber, a set of equipment, sensors, actuators valves to manage the fuel cell unit. All the main components will be controlled by LabView© and all signals will be monitored via a data logger. An electronic load will be utilized to execute a typical cycle of current.

Performance measurements will be conducted between several sub-zero experiments (cycles or cold startups). Steady-state performance will be measured. EIS will be eventually recorded and product water will be analyzed.

The major **risk** associated to the expected outcomes is related to the limited time available to carrying on the test campaign.

It could happen that during the execution of the test some relevant failure delays or cause the interruption of the serious damage to the system and

In order to tackle this major threat, We could implement an effective methodology based on the long term experience that Genport has developed during the past with an intensive activity of functional test.

Secondly a simulation activity could be carried on to predict eventual failure and improvement to HW and SW of the fuel cell system will be implemented before conducting the test.

A twin backup fuel cell system unit will be eventually available to continue the tests without compromising the results within the time schedule.

Some minor risk is associated to failure of test equipment (control system, sensors, data acquisition) which could cause some delays. This risk is mitigated with the experienced methodology implemented by the research team.

Originality and Innovation of proposed research – Broader Impact (1-2 pages)

Demonstrate the originality and innovation of the proposed work and the impact the expected results will have on current and future research or practice, public safety, European standardization, competitiveness, integration and cohesion and on sustainable growth.

The polymer electrolyte fuel cell (PEFC) is widely regarded as a potential power source for portable and mobile applications due to its noteworthy features of high efficiency and zero emission. PEFCs must have the ability to survive and start up from subfreezing temperatures, also called cold start, to be successfully deployed in automobiles, portable electric generators. Under freezing environmental conditions, water produced has a tendency to freeze in open pores in the catalyst layer and GDL, rather than be removed from the fuel cell, thus creating mass transport limitations which eventually end the ability for operation. Cold start is essentially a transient phenomenon. Currently, the majority of the efforts are focused on the steady-state characteristics of PEFCs. There is a lack of thorough investigation on the dynamic behavior, though the importance of dynamic characteristics is obvious for automobile and portable applications of fuel cells which are frequently subjected to fast load variations.

Since today there is not a standard protocol to conduct cold start test for portable fuel cell systems. The massive diffusion of portable fuel cell systems and the related safety issues require the extension of standard procedure to low temperature startup.

This project will provide the opportunity to the supply chain constituted of prominent research institution and a leading fuel cell company proposing this project, to investigate with a feasibility project the relevant aspects to tackle, parameter range, procedure to define an effective test guideline. The outcome of this project could be the submission of a project proposal within the FHC-JTI.

Proposed Host TA Infrastructure/Installation – Justification (about one page)

Specify the type of TA infrastructure (e.g. distributed generation simulator; domotic house; etc.) and if possible which one of the 13 TA Infrastructures in DERri may better serve the scope of the proposed research. Justifications should be provided on the grounds of the test set-up, testing method, equipment, past experience in relevant subject, etc. State whether the TA User team intends to deliver to the premises of the TA Infrastructure parts or components to be tested at the TA User's expense and responsibility, or to cover the whole or part of the construction/adaptation cost of the specimens to be tested

VTT Technical Research Centre of Finland

VTT Technical Research Centre of Finland is the biggest multi-technological applied research organisation in Northern Europe. With its staff of 3,100, its unique research facilities and extensive global co-operation networks, it provides leading-edge technology solutions and innovation services. VTT works to enhance its customers' competitiveness and competence, creating the prerequisites for society's sustainable development, employment and wellbeing.

Since its establishment 70 years ago, VTT has become an important centre of technological expertise and developer of new technologies. The development path of Finland as a whole as well as the events and phenomena of each era are reflected in VTT's history. It reveals one of the keys to VTT's success: the organisation has always been able to meet challenges by adapting to changes in its environment.

VTT fuel cell research supports industry product development by maintaining a development platform comprising a large selection of research facilities, a selection of developed modelling tools and know-how encompassing different technologies over the whole business chain.
A large network, especially among universities and industry within Finland and Europe, can be utilised to form research groups of high competence to solve different problems. VTT actively participates in European projects as well as European and international networks.
Currently, the main research areas are SOFC, PEFC and micro fuel cells, including systems, applications, demonstrations, stacks, components and materials.

GENPORT has had two web meetings with VTT to discuss technical and schedule details (with Dr. Kari Mäki, Senior Scientist Energy Systems, Energy Infrastructure Dpt in VTT). After the meetings Dr. Mäki felt confident about the proposed tests and schedule as VTT have done similar tests in the past.

Time schedule (about ½ page)

Provide an indicative time-schedule for the proposed work and a target starting date. Give an indication of the overall number of days of stay at the facility and of use of the facility. The two *numbers should be consistent*

The scheduled target date is Monday, 18th March 2013. The project is structured into four main activities: Definition of the test specification, Setup of the test equipment's, execution of the experiments and analysis of the result.

The use of the test facility is estimated into 10/15 weeks. Most of the setup will be executed remotely using conference tools. During the execution of the test, Genport engineers are expected to stay 10 days. Five days just before the beginning of the trials to validate the specification, check the test equipment's and assist during the startup of the test. Additional five days will be utilized for the final inspection of the fuel cell system, support at the disassembly of the test bench and joint analysis of the results. It is also foresee additional 5 days to support the research center for maintenance assistance during the execution of the tests.

Proposed experiments:

1) WARM START-UP

1.1) Switch on G300 HFC @ 20°C, RH 5% and with a load of 300 W @ 24 Vdc ==> cool down to -20°C keeping absolute humidity constant, while max power is supplied to the load. All the internal parameters are kept monitored. If any alarm goes off, test must be stopped.

1.2) Switch on G300 HFC @ 20°C, RH 5% and in stand by condition (no electric load) ==> cool down to -20°C keeping absolute humidity constant, while stand by condition is maintained. All the internal parameters are kept monitored. If any alarm goes off, test must be stopped.

2) COLD START-UP

2.1) G300 HFC switched off @20°C, RH 5% ==>cool down to 5°C with absolute humidity constant. Wait for thermal balance of the masses and switch on G300 HFC. Electric load profile needs to be defined. Shut down.

2.2) G300 HFC switched off @20°C, RH 5% ==>cool down to 0°C with absolute humidity constant. Wait for thermal balance of the masses and switch on G300 HFC. Electric load profile needs to be defined. Shut down.

2.3) G300 HFC switched off @20°C, RH 5% ==>cool down to -5°C with absolute humidity constant. Wait for thermal balance of the masses and switch on G300 HFC. Electric load profile needs to be defined. Shut down.

2.4) G300 HFC switched off @20°C, RH 5% ==>cool down to -10°C with absolute humidity constant. Wait for thermal balance of the masses and switch on G300 HFC. Electric load profile needs to be defined. Shut down.

2.5) G300 HFC switched off @20°C, RH 5% ==>cool down to -15°C with absolute humidity constant. Wait for thermal balance of the masses and switch on G300 HFC. Electric load profile needs to be defined. Shut down.

2.6) G300 HFC switched off @20°C, RH 5% ==>cool down to -20°C with absolute humidity constant. Wait for thermal balance of the masses and switch on G300 HFC. Electric load profile needs to be defined. Shut down.

For each of "cooling down" and "switch on" test internal parameters will be kept monitored and logged. If any alarm goes off, test must be stopped.

3) CONDENSATION TESTS

3.1) Characterization of G300 HFC for condensation tolerance. General guideline for tests are: Cool down G300HFC (switched off) to -20°C ==> warm up G300 HFC at different combination of final T and RH in order to understand condensation phenomena and fix the maximum range for operation condition and climate variations. The results of the tests represent the input for future developments/upgrades of G300 HFC (if needed for real application or compliance to regulations).

Description of the proposing team (as long as needed)

Give a short description of each member (organization and persons) of the proposing team including publications, experience in test campaigns and role in the proposed project.

GENPORT research team has long-term experience in the Fuel Cell technologies.

A strong international scientific activity is resulted in more than 100 scientific publications and 8 patents; 15 years in international and national programs focused on breakthrough technologies and methodologies for improving durability, performance and future mass production of portable fuel cells generators brings Genport be a leading designer, developer and manufacturer of advanced, lightweight technology for portable *high energy density electric generation.*

In PEMCOLD Project , *GENPORT*, in cooperation with the Derry partners, will provide support for the of simulations of the FC system, setup of the test bench, the analysis and dissemination of the test result.

Description of key personnel:

Paolo Fracas: co-founder and CEO of Genport srl and Genport North America. Electrical Engineer with a postgraduate certificate in international management at MIT, He has 25 year of professional experience in business development, research and development, marketing, sales, system

engineering in multinational companies. He developed innovative fuel cells materials based on nanotechnologies, numerical simulation approaches for composites materials. He is author of 10 patents and publications. He was acting at the Advisory Board of UK PEMFLOW Project, in the Board of the Hydrogen and Fuel Cell Italian Association (H2IT), Plasmatech of WP5, Mesh (WP6). He also coordinates several regional research projects.
Walter Castagna: Head of Power Electronics and Battery Department. Electronic engineer, 25 years of experience in power electronics.
Stefano Limonta: electrical engineer with background in Energy; he works as research engineer specialized in development and testing of PEM fuel cell stack and BOP
Marco Spimpolo: automation engineer, he works as research engineer specialized ion lithium battery packs and power electronics.

Andrea Alberti: Doctor in industrial Designer, 10 years of experience. He works as senior research engineer specialized in design and industrialization of fuel cell system and components and batteries.

Michela Marchiano: degree in Politic Science, 10 year of experience in managing EU proposal and funding projects.