

# **nanoFlowcell**

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*THE ADVANCED ENERGY COMPANY*

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Corporate Information 2019

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## Foreword by Nunzio La Vecchia

The issues of environmentally friendly energy and sustainable mobility have been in the media and thus in the public consciousness for many years. nanoFlowcell Holdings has presented its vision of a sustainable and zero-emissions future – nanoFlowcell®. We believe that nanoFlowcell® technology, based on flow batteries, will play a key role in the sustainable auto-mobility of our society and in the transition of our society from being a coal and nuclear energy depended society to a society based on environmentally friendly and sustainable energy.

Since it was founded in 2013, nanoFlowcell has concentrated on the research and development of this innovative energy storage technology and is the pioneer in the technical adaptation of flow cell technology for mobile application in vehicles.

Starting on the basis of a NASA patent from 1976, nanoFlowcell has achieved significant progress in the charging and conduction capabilities of electrolyte liquids that can justifiably be described as revolutionary.

As the Chief Executive Officer of nanoFlowcell Holdings Ltd, I am proud of what has been achieved. Our research and development team has shown courage by forging new ways in the research of flow cell technology that leading scientists dismissed just a few years ago as dead ends. We have proven ourselves in the face of all doubters and developed a technology that will change the world.

We developed the first low-voltage sports cars powered by flow cell energy. Ostensibly. But the QUANT 48VOLT is more than just one of many. It is the expression of our entrepreneurial quest and offers a view of a possible future in which energy is produced in an environmentally compatible manner, is harmless to health in use and is also safe and practical to work with. QUANT 48VOLT is a dazzling ambassador for our outstanding energy technology.

With the QUANT models – QUANT 48VOLT and QUANTiNO 48VOLT – powered by nanoFlowcell®, we have created unique electric vehicles that demonstrate the opportunities of nanoFlowcell®-based mobility which is sustainable and free of harmful emissions.

We want to make people curious, stir emotions, provide food for thought – we want to invite people to follow our ideas with the help of tangible technology and to mentally usher themselves out of our “fossil” age.

Our interest lies in broad dissemination of our nanoFlowcell technology, so that we can achieve tangible changes in the near future that will impact the environment. We will seek partners who share our vision of a greener environment and a better future and are helping to shape it; partners who, like us, will do everything within their power to make sure nanoFlowcell® establishes itself within the market for environmentally friendly and sustainable energy.

For nanoFlowcell® to establish itself, there is no need for decades of infrastructure planning or tedious and onerous bureaucratic processes, just the courage and the will to make our future that little bit better.

As a research and development company, we are well aware of our responsibility – as a pioneer and shaper of future thinking in mobility and as a mentor for energy that is environmentally compatible and can be sustainably structured.

nanoFlowcell® offers clean and safe energy – wherever, whenever.

Nunzio La Vecchia  
*Chief Executive Officer nanoFlowcell Holdings Ltd*

## NANOFLOWCELL: INTRODUCING OUR COMPANY

nanoFlowcell Holdings Ltd (NFC) is a worldwide leading research and development company for modern flow cell technology and its applications.

Under the brand name nanoFlowcell®, NFC is developing advanced flow cell energy systems for mobile and stationary applications; object of innovation is the material structure and composition of the nanoFlowcell® membrane as well as the chemical composition of the complementary electrolyte named bi-ION®. Outstanding features of this innovative energy technology are uncompromising health and environmental compatibility, inherent safety as well as high energy density and scalable power.

The in-house developed electric vehicles under the brand QUANT (QUANT E, QUANT FE, QUANT 48VOLT, QUANTiNO 48VOLT) serve as unique reference projects for high voltage and low voltage applications of NFC's proprietary flow cell energy technology. Advanced applications research provides NFC with complimentary technological and scientific know-how, from which business partners will benefit greatly. One result of NFC's advanced applications research is e.g. the nanoFlowcell® 48VOLT low-voltage drive is the lightest, safest, most environmentally compatible and economical powertrain system currently driving an electric sports car.

NFC's holistic approach to flow cell applications research is a strategic driver for sustainable and continuous corporate value creation. It strengthens NFC's core competencies as a leading research and development company for applied modern flow cell technology – an asset NFC's research and development partners (innovation partners) are benefitting from in form of more integrated and efficient applications development.

NFC's overall aim with nanoFlowcell® is to improve the efficiency of electric energy storage and supply as well as the wide use of sustainable energy sources. With the claim „nanoFlowcell® - the new energy“, NFC proves herself as strong R&D partner to companies from a wide range of industries, supporting them by uncovering new business and performance potentials, which are inherent to NFC's nanoFlowcell® flow cell energy applications.

The bundling of competencies, i.e. technological know-how, personnel as well as organizational and structural resources, is considered key for conducting advanced flow cell applications research; hence, NFC will retain the project lead for all R&D projects that are assigned to NFC by third parties or which are carried out together with innovation partners. NFC will not become engaged in series production of flow cell applications herself but will award licenses and patents to external partners (i.e. innovation partners).

To start with, NFC is concentrating on energy intensive industries, which are highly compatible with flow cell energy such as automotive / transportation (mobile energy) as well as grid-integrated and off-grid energy supply (stationary energy). However, the potential of NFC's flow cell technology in other industries is enormous.

The business potential of NFC is explained by the need for clean and sustainable urban mobility and the trend of vehicle electrification as well the requirement for making eco-friendly generated energy become mobile and widely available without supply interruption (energy black outs). For its stationary power supply offering, NFC has developed a complementary innovative business model around energy banking and energy leasing, including a reinsurance for power outages, delivering on nanoFlowcell's “the power is always on” promise.

## nanoFlowcell at a Glance

### *Company Structure*

Companies currently under the umbrella of nanoFlowcell Holdings Ltd are nanoFlowcell Management AG, nanoFlowcell IP AG, nanoFlowcell Production GmbH, as well as nanoFlowcell Research SA (QUANT-City).

nanoFlowcell Holdings Ltd

- nanoFlowcell Management AG
  - General administration and organizational development
  
- nanoFlowcell IP AG
  - Copyrights
  - Licensing
  - Patent Management
  
- nanoFlowcell Production GmbH
  - World Manufacturer Identifier
  - Registration certificates (Quant vehicles)
  
- nanoFlowcell Research SA (QUANT-City)
  - R&D
  - Product Piloting
  - Science Management

### *Company Information*

Date of incorporation	1996 (start of business); Founding date of nanoFlowcell Holdings Ltd on February 23, 2016
Share capital	CHF 100,000
Investments to date	> CHF 150,000,000 (since 1996)
Fiscal year end	31 December
Accounting standard	IFRS
Consolidation	voluntarily
Ownership Structure	100% private shareholders

## *Management Board*

Nunzio La Vecchia	CEO & CTO Strategy, Business Development, Legal, Corporate Communications, Business Cooperation, Research and New Technologies
Hektor Bertschi	COO Operative Business Units, Patenting & Licensing, Human Resources and Quality Management
Kloter Rechtsanwälte AG	Legal Advisory
BDO London	Accountants
Knüsel Treuhand AG	Finance and Controlling

## nanoFlowcell Corporate Milestones

**1991** Nunzio La Vecchia commences research and development work in the field of energy recovery, energy storage and energy conversion; intensification of private studies in quantum mechanics and quantum physics.

**2001** Digilab opens in Zurich. Systematic alignment of research and development work with the aid of digital modelling and simulation techniques.

The experience and findings acquired here will be decisive in optimising development time in later research given the increasing complexity of modern energy storage systems and their applications.

**2003** First technical outline for an ecologically sustainable mobile energy conversion solution in an automobile.

**2008** Cooperation with a Swedish sports car manufacturer to build an innovative electric sports car, the first Quant prototype. Innovative energy technology supplies power to the vehicle's electric consumers. Besides initial conceptual techniques for incorporating flow cell technology into an electric car, it also includes thin-film solar cells to feed power to the air conditioning while the car is parked outside during hot summer months.

**2009** Presentation of the first QUANT prototype with thin-film solar technology, appearing as a design study at the Geneva Motor Show.

Over the years that follow, the decision is taken to focus research and development work on forward-looking flow-cell based energy technologies.

**2010** First in-vivo lab version of bi-ION®. Proprietary design of molecular nano-structures enables greater energy density than conventional flow cell electrolytes. Because bi-ION® is not regenerative (not rechargeable), it differs fundamentally from conventional electrolyte solutions in flow cells.

**2012** Successful tests with a flow cell energy storage system. The cell's compact construction and the high energy content of the electrolyte liquid predestine the new technology for mobile use in electric vehicles.

First technical plans for building a prototype vehicle powered by a flow cell.

**2013** The company announces a breakthrough in flow cell research relating to the compact size and performance of its energy storage system. Flow cells are now finally feasible as energy storage systems for modern electric vehicles and innovative battery technology is given a name – nanoFlowcell®.

Corporate direction is also agreed and the foundation of nanoFlowcell AG completed.

**2014** February. Maiden drive of the world's first electric car powered by nanoFlowcell®, QUANT E, the only truly environmentally friendly super sports car.

March. Official world premiere of the QUANT E at the Geneva Motor Show.

July. QUANT E prototype with nanoFlowcell® drive is approved by Germany's TÜV for use on European roads.

October. Further EV prototype development with 2-speed transmission for electric sports cars; first technical studies for the QUANTiNO, an electric vehicle with a 48 V low-voltage drive system.

November. Foundation of nanoFlowcell Research SA based in Lugano, Switzerland.

December. Foundation of nanoFlowcell Production GmbH based in Waldshut/Germany

**2015** The new QUANT F demonstrates advanced electric mobility at the Geneva International Motor Show: An environmentally compatible electric drive system with 1090 hp output.

QUANTiNO is presented to the public for the first time as the first and only nanoFlowcell® electric car with 48 volt low-voltage drive.

**2016** February. QUANTiNO prototype EV has been further developed to homologation level; QUANTiNO is approved by Germany's TÜV for use on European roads. In an initial durability test, the QUANTiNO powered by nanoFlowcell® drives 14 hours non-stop without refuelling – a unique record for an electric vehicle.

March. QUANT FE ("E" for Evolution) and QUANTiNO are presented to the world at the Geneva Motor Show and call for a rethinking of electric mobility. Contrary to prevailing BEV concepts, the QUANT brand's mind is on electric mobility without compromise in environmental compatibility, range and performance as well as safety and comfort.

September. QUANT FE is approved for use on European roads. All three nanoFlowcell® test vehicles are now fully road legal and approved for low-volume production.

October. First official media test drives confirm the performance of nanoFlowcell® technology as an energy source for electric vehicles. NFC engineers develop a technical option for making flow cells directly controllable. Expensive and heavy supercapacitors previously used as electrical buffer storage in the nanoFlowcell® drive become redundant.

November. The direct control of the flow cell opens up new technical options for powering electric vehicles. It marks the start of the QUANT 48VOLT concept: state-of-the-art fuel cell technology as basis for a unique nanoFlowcell® 48VOLT low-voltage electric drive system.

**2017** QUANT 48VOLT celebrates its premiere as the world's first low-voltage sports car at the Geneva Motor Show. The new nanoFlowcell® 48VOLT low-voltage drive is introduced – currently the most powerful, lightest, safest, most environmentally compatible and economical drive system there has ever been for electric vehicles.

**2018** April. NFC starts its search for a plot of land of up to 500,000 square metres for setting up „QUANT-City“; location evaluation for several European sites are underway throughout 2018 and 2019.

May. QUANTiNO 48VOLT successfully travels more than 150,000 kilometres; NFC proves the longevity of the nanoFlowcell® 48VOLT drive for electric cars.

June. NFC receives order for 500 QUANT 48VOLT and 25,000 QUANTiNO 48VOLT vehicles with a contract value of more than 3.1 billion Euros. The order is considered an investment for setting up QUANT-City.

**2019** March. NFC successfully completed its long-term testing with QUANTiNO 48VOLT – 350,000 kilometres under real-life conditions; the nanoFlowcell® system shows hardly any wear and worked practically maintenance free. NFC is confident about nanoFlowcell® longevity, guaranteeing a life span of 50,000 operating hours (equals to 1.8 million kilometres in a car).



## nanoFlowcell: R&D Leader in Flow Cell Energy Technology

*“As a research and development company specialised in flow cell technology, we are working on the future of energy supply – practicable energy for mobile applications, predictable energy for stationary energy supply.”*

Our competitive edge is that we are a young company, without technological heritage and established corporate thinking. We are flexible to think differently than the established players in the industry and free from rigid, innovation-adverse hierarchies, which allowed us to develop breakthrough innovations. We are convinced that technology cannot be allowed to compromise, particularly when it comes to energy supply. Energy carriers of the future must be powerful yet safe to use, environmentally compatible and sustainable. They must also be straightforward to access without political implications. Simple requirements perhaps, but nanoFlowcell® is currently the only energy storage technology that can assert all of these claims.

### **nanoFlowcell®**

nanoFlowcell® marks the start of the modern age of mobile energy carriers. nanoFlowcell® converts the electro-chemical energy stored in bi-ION® into electricity. A compact flow cell superior to all battery technologies currently available. Scalable in output for a wide variety of applications. Powerful enough to drive even sports cars on electricity alone. Cost-effective, making e-mobility affordable. Environmentally compatible, enabling sustainable use. It is also practical and safe to handle. nanoFlowcell® is the power of the future.

### **bi-ION®**

bi-ION® is a liquid energy storage solution comparable in its energy density with the very latest lithium-ion batteries yet – unlike these – offering safety and environmental compatibility. bi-ION® is the first source of mobile drive energy that conserves resources, is environmentally compatible and non-harmful to health, opening up new perspectives for the use of renewable energies – on land, on water and in the air.

### **nanoFlowcell® 48VOLT**

The low-voltage driveline architecture that we have developed is unique in the automotive industry. QUANT prototypes with nanoFlowcell® 48VOLT demonstrate the potential of nanoFlowcell® low-voltage technology compared with common high-voltage systems. They are powerful and environmentally compatible, while delivering a high degree of functional safety, low production costs and straightforward vehicle homologation.

Our market potential is enormous considering the advantages of nanoFlowcell® technology over carbon-based energy production and traditional battery technologies. The need for sustainable and environmentally compatible energy in industries such as automotive and transportation, construction, maritime, aviation as well as grid- and off-grid power supply is estimated to be in the trillions of CHF.

## nanoFlowcell: Our USPs

nanoFlowcell Holdings Ltd has all the qualities to be successful in the world of new energies.

- NFC has achieved technological leadership in compact flow cell technology through consistent and systematic R&D.
- Comprehensive applications know-how and continuous expansion of vertical integration (e.g. 48Volt low voltage drive system) provide high level of added value and give NFC competence leadership in applied flow cell technology.
- Enforcing market leadership due to academic and R&D exclusivity on mobile and stationary flow cell technology (→ QUANT-City)
- nanoFlowcell® is the world's first and only ecological sustainable mobile AND stationary form of energy, a motor for innovation in a multitude of industries – NFC is pioneer with a unique market position for mobile and stationary flow cell energy systems, offering a unique value-adding selling propositions.
- Progressive growth through gradual development of new application areas: automobile + transportation, aviation, rail, maritime as well as mobile / stationary generators and grid power.
- Continuous application research (commissioned research) secures revenue streams from growing patenting and licensing; strong cash flow allows for value adding investments, which secure NFC's balance sheet strength as well as innovation leadership.
- High visibility of business development because of top-level strategic business partnerships, which provide a broad base for nanoFlowcell® technology (risk minimization for all partners due to polypolic business model).
- Attractive cooperation model: innovation partners are participating in NFC's patenting and licensing → maximum of one innovation partnership per industry sector.
- Creating innovative business models around nanoFlowcell® energy system such as Energy Banking and Energy Leasing, incl. reinsurance business to protect against power outages; worldwide unique power delivery promise by NFC in case of power outage.
- IPO → shareholders will be profiting from the success of the R&D company and its technology.
- Potential outsourced application manufacturing (e.g. for QUANT EVs) to accelerate the market penetration of nanoFlowcell® as well as related sales, service, and after sales structures.

# NANOFLOWCELL®: INTRODUCING OUR TECHNOLOGY

## The Redox Flow Cell Principle

The nanoFlowcell® is a revolutionary development of the already tried-and-tested flow cell technology. With their ground-breaking technology advancements, nanoFlowcell Holdings has enabled the first use of a battery system with flow cell technology in an automotive application.

nanoFlowcell Holdings has considerably improved the efficiency of the flow cell principle with its proprietary nanoFlowcell® technology. The extremely high energy density of its electrolyte bi-ION® plays a major role in this and distinguishes nanoFlowcell® from a conventional redox flow cell or flow battery. With five times the energy density of a regular flow cell electrolyte, bi-ION® is delivering remarkable benefits in the storage and conversion of electrical charge.

The new QUANT low-voltage EV prototypes such as QUANT 48VOLT and QUANTINO 48VOLT are developed for non-stop driving ranges of 1,000 kilometres and beyond.

## The principle of the flow battery or redox flow cell

Redox flow batteries (red for reduction = electron absorption, ox for oxidation = electron release), also known as flow batteries or liquid batteries, are based on a liquid electrochemical storage medium. The principle of the redox flow battery was patented in 1976 for the American space agency NASA. Its aim was to drive the rapid development of energy storage systems for space travel. The 1976 patents have long been open and are being extensively applied. Redox flow batteries are seen as highly promising for future use as an extremely simple and effective way of storing electrical energy. The first stationary redox flow installations are already integrated into the domestic electric infrastructure, largely as buffer batteries or reserve sources for uninterrupted electricity supply in the use of solar and wind-power plants.

In contrast to lead batteries or lithium-ion batteries, redox flow batteries store energy in liquid electrolytes. The electrolyte liquids for flow cells are usually metal salts in an aqueous solution that flow in two fully independent circuits. A special membrane positioned between them divides the cell into two half cells. The membrane prevents the two electrolyte liquids from mixing but permits the exchange of ions. The electrolyte liquids in the two half cells are now pumped past the membrane, where the actual chemical reaction takes place in the form of reduction or oxidation, and energy is released.

Because the electrolyte liquids outside of the cells are stored in separate tanks, a redox flow battery is classified as an electrochemical energy storage medium, similar to a traditional fuel cell. The energy capacity and power output of a redox flow battery can be changed independently of one another. The larger the tank for the electrolyte liquid, the larger the energy capacity. Likewise, the concentration of the electrolyte liquid decides the amount of energy that can be transported. Storage systems based on redox flow technology can therefore be variably adapted to the respective application.

Conventional redox batteries are recharged by feeding them with energy. Because the tanks can be filled manually, the batteries could alternatively be recharged through simply exchanging the electrolyte liquids.

## Battery Comparison

In general, energy transfer within the flow cell runs between two platform-shaped poles (plus and minus) via an ionisable liquid, very similar to the time-honoured lead-acid car battery. The disadvantage of lead-acid batteries is that, at 50 Wh/l, they are relatively poor energy carriers, while their high lead content makes them very heavy. Furthermore, after around 500 charge cycles, they start to lose a lot of their capacity due to the so-called memory effect. Modern lithium-ion battery technology, with four times the charge density (120 Wh/kg)

and a limit of around 1,000 charge cycles are currently seen as an acceptable interim solution. Modern flow cells, on the other hand, already offer roughly the same power density as lithium-ion batteries, plus they show greater longevity due to the absence of the memory effect.

## One Step Ahead - nanoFlowcell® Flow Cells

### **nanoFlowcell® - not Just Different, but Unique**

In general terms, the nanoFlowcell® is an extremely high-performance and compact flow battery. However, nanoFlowcell Holdings uses specially developed electrolytes called bi-ION® that have enabled a significant increase in the energy density of the nanoFlowcell® system compared with simple flow batteries.

With nanoFlowcell®, the energy is likewise stored in liquid electrolytes held in two separate tanks and pumped through a converter in a fashion similar to a traditional redox flow cell or fuel cell.

The separation of the energy converter and the energy storage medium in the nanoFlowcell® also means that the amount of energy stored is no longer dependent on cell size. Thanks to its unrestricted scalability, its uncomplicated structure and its ease of use, the benefits of the nanoFlowcell® as a drive for electric vehicles are clearly evident.

Charging the nanoFlowcell® is not the same as for a regular flow battery through feeding it with energy, but through topping up the spent bi-ION® electrolytes. In the nanoFlowcell® used in the QUANT models, the electrolyte tanks empty while driving and the spent electrolyte liquid is dispersed harmlessly into the atmosphere. Filling the tank of a QUANT model and the fuelling process itself is similar to that for a regular petrol or diesel vehicle.

Another aspect relevant to the environment is that nanoFlowcell® does not require rare and comparatively expensive substances – unlike conventional redox flow batteries. In contrast to conventional energy carriers such as petrol, diesel, hydrogen or lithium-ion batteries, the bi-ION® electrolyte liquids in the nanoFlowcell® are neither flammable nor explosive and are completely harmless to health.

Also, during the production processes of nanoFlowcell® and bi-ION® there is no possibility of environmental pollution since all chemical residues and waste materials are neutralized during the production process itself.

### **nanoFlowcell® in Practice**

nanoFlowcell® is a further development of the DigiLab, nanoFlowcell Holdings' digital simulation lab in Zurich. The nanoFlowcell® system is fully scalable; Current applications are the QUANTiNO 48VOLT with a capacity of 85kWh and the QUANT 48VOLT with 300 kWh respectively; operating voltage in both cars is 48V.

The higher performance of the nanoFlowcell® is founded on the special characteristics of the newly developed electrolytes – a special compound of metal salts in a high-quality electrolyte liquid. Defined nano mechanisms in the field of quantum chemistry enabled adaptation of the charge carriers within the carrier liquid to achieve a whole new level of energy density – and thus the amount of energy stored. Remarkably, charge cycling within the cell takes place virtually without losses. The internal efficiency of the nanoFlowcell® is more than 90 percent.

The energy density of the nanoFlowcell® is currently 20 times higher than that of a lead accumulator. This means the stored energy provides a range 20 times higher than with a battery of the same weight. Compared with the present-day lithium-ion technology used in many modern electric cars, the nanoFlowcell® achieves five times higher energy density and thus correspondingly longer range.

With an energy density of 600 Wh/l, nanoFlowcell® is five to six times better than the capacity of lithium-ion batteries. And because the nanoFlowcell® suffers no memory effect even after 10,000 charge cycles, it also has greater longevity (50,000 operation hours are guaranteed) and is therefore rightfully in pole position when it comes to the development of forward-looking electric mobility concepts.

## Unbeatable Mileage

The first road-legal QUANTIÑO 48VOLT needs just 12 kWh for a distance of 100 kilometres. With its two 95-liter tanks, the QUANTIÑO 48VOLT has a range upwards of 1,000 kilometres on just one filling of electrolyte liquid, which would be sufficient to cover the distance between Berlin and Rome. Further increases in range would be straightforward, as expanding the tank volumes in the QUANTIÑO package, for instance, is relatively uncomplicated. From an engineering perspective, tank volumes can be designed into the body shell structure of a modern vehicle considerably more easily than heavy battery systems with complex series connection and cable routing as well as a separate wiring harness for the accurate monitoring of all the individual cells.

A further trump card held by nanoFlowcell® is its conformity with the requirements of potential buyers of electric vehicles. They are defined primarily by economic considerations – moderate manufacturing costs and a long lifespan as well as the avoidance of costly battery exchanges.

## Easy to Refuel

The nanoFlowcell® works on-board as an inexhaustible energy source for the central storage medium, for as long as there is sufficient bi-ION® electrolyte in the tank. If all the bi-ION® in the tank has been “used up”, it can simply be fuelled again. Following its reaction in the actual flow cell during operation of the nanoFlowcell®, the electrolyte solution is not consumed just like regular fossil fuel in an internal combustion engine or hydrogen in a fuel cell, but rather “used”. The redox process does not change the volume of the bi-ION® liquids but they are not reactive anymore.

The bi-ION® electrolyte liquids, which are made from an aqueous solution with a small amount of organic and inorganic salts for transporting the charge carriers, are harmless to the environment and non-hazardous. Therefore, in mobile applications of nanoFlowcell®, they are simply vaporized during the drive. At speeds above 80 km/h a generator powered by drive energy is used to release the liquids into the environment as harmless water vapor. The actual charge carriers and salts are filtered out and will be environmentally friendly recycled when changing the filter (every 10,000 kilometres).

The empty tanks can therefore be refilled directly with fresh bi-ION® electrolyte liquid. The fuelling process for a nanoFlowcell® vehicles is largely similar to that for modern petrol or diesel-driven cars, with the exception that two bi-ION® liquids are filled simultaneously into two separate tanks within the vehicle. It would be straightforward to build a fuel-station infrastructure suitable for nanoFlowcell® by very simply retrofitting the existing fuel-station network. Standalone fuelling systems are also conceivable, installed in convenient locations or at home. The electrolyte liquids are already inexpensive to manufacture with current technology. And because the electrolyte liquids are neither toxic nor flammable, they have considerable benefits in terms of logistics and storage, neither of which are subject to the strict regulatory conditions applied to fossil fuels.

## On the Safe Side

In contrast to the battery systems currently used in electric vehicles, nanoFlowcell® has major safety benefits. Because the electrolytes are stored outside the converter unit, there is no risk of a sudden release of energy caused by an uncontrolled reaction of the reactants. Because the electrolytes flow, they serve as coolants for the cell, enabling configuration of an energy management system that is simpler and safer overall.

The temperatures within the nanoFlowcell® system reach up to 94 degrees Celsius depending on power output. This low temperature level also contributes to the excellent efficiency of more than 90 percent – no energy lost through heat.

A further benefit of the nanoFlowcell® compared with other battery systems is that monitoring the charge status of the battery system is simple, as there is only one electrolyte. There is no need for charge equalization of the sort required by conventional Li-ion and Li-po systems. Dangerous situations that might occur in a

battery system, caused by unwanted reactions such as total discharge, are not even technically possible with nanoFlowcell®.

## **For Mankind and the Environment**

nanoFlowcell® is notable for its absolute environmental compatibility and non-toxic properties. nanoFlowcell® was conceived to be highly efficient, cost-effective and environmentally friendly through the application of well-established elements that are readily available in large quantities. Precious metals and rare earth metals are not used in either the cells themselves or in the electrolyte solutions. The main elements of the electrolyte solutions are water, as a carrier liquid, salts and crystalline structures, all of which can be sustainably obtained, are harmless to health and can ultimately be disposed of in an environmentally friendly manner.

## **nanoFlowcell® in Tomorrow's World**

The current QUANT vehicles with nanoFlowcell® drive show how we could smooth the path to the electro mobility of the future. However, the vision of its inventor, Nunzio La Vecchia, goes further than that. Comparatively high energy density for an electric storage medium, high efficiency and the environmentally friendly storage of electrical energy also open up the perspectives of nanoFlowcell® technology for applications in a variety of industries.

Asides advancing environmentally compatible electric mobility, the further testing of nanoFlowcell® will examine also those application options. The approach of nanoFlowcell Holding is a holistic energy concept based around the nanoFlowcell® that will sustainably change our environment for the better.

## NANOFLOWCELL: INTRODUCING OUR PRODUCTS

### nanoFlowcell® – Eco-Powerhouse of the Future

*“The development of the nanoFlowcell® makes flow cell technology powerful and mobile – nanoFlowcell® opens up completely new technical perspectives in a vast number of applications. Be it in electric mobility or in grid-supporting and off-grid power systems.”*

Right now, people know flow cells only as garage-sized constructions for stationary energy storage in wind and solar power installations. With nanoFlowcell® we have succeeded for the first time in reducing a flow cell to the size of a briefcase and at the same time to increase tenfold the energy density of the electrolytes. The development of the nanoFlowcell® makes flow cell technology powerful and mobile – nanoFlowcell® opens up completely new technical perspectives in a vast number of applications.

**Innovative Energy.** nanoFlowcell® is currently the most innovative and powerful energy supplier for mobile and stationary electrical applications. Unlike conventional batteries, the energy for the nanoFlowcell® comes in the form of liquid electrolytes (bi-ION®), which can be stored away from the cell itself.

Just like in regular flow cell batteries, the positively and negatively charged electrolyte liquids are stored separately in two tanks and, as in a traditional flow cell, pumped in separate circuits through a converter (the actual cell of the nanoFlowcell system).

Here, the two electrolyte circuits are separated only by a permeable membrane. As soon as the positive and negative electrolyte solutions pass on either side of the converter membrane, an ion exchange takes place. This converts the chemical energy contained in bi-ION® into electricity, which is then directly available to the electrical consumers.

**Scalable energy.** With nanoFlowcell®, the separation of the energy converter and energy storage medium means the energy stored is no longer dependent on the cell size. This is where a flow cell differs from traditional types of battery. With the nanoFlowcell®, the amount of energy available is dependent on the concentration of electrolyte in the electrolyte liquid and on the volume of the electrolyte tank. Thanks to its unrestricted scalability, nanoFlowcell® can therefore be adapted to an extremely diverse range of applications – from electric cars to power stations.

**Fuelling electricity.** Unlike the electrolyte solution in conventional redox flow cells, bi-ION® is not reversible, i.e. it cannot be recharged. As a result, what makes the nanoFlowcell® special is that it is no longer subject to an onerous recharging process like conventional batteries or flow cells. Instead, the spent bi-ION® electrolyte liquids can simply be replenished. To avoid the emittance of solids, the used electrolyte liquid is filtered to remove the dissolved salts and electrolytes before releasing. A generator powered by the energy of the driving vehicle ensures that the remaining water is vaporised and released into the atmosphere – an environmentally neutral process. The electrolyte tanks empty while the car is driving, as in a conventional vehicle with an internal combustion engine. Fuelling the empty electrolyte tanks is likewise comparable with filling up a regular petrol or diesel vehicle. A minor difference is that the bi-ION® filter has to be changed roughly every 10,000 kilometres, after which it can be harmlessly recycled.

**Environmentally friendly energy.** nanoFlowcell® technology is fully environmentally compatible and harmless to health. The nanoFlowcell® is very efficient, cost-effective and environmentally compatible to produce using commonplace materials that are readily available in large quantities. Precious and rare-earth metals are not used in either the cell itself or in the bi-ION® electrolyte solution. All the raw materials required



for the nanoFlowcell® and its electrolytes can be sustainably acquired, used without harm to health and ultimately disposed of in an environmentally compatible manner.

**Long-lasting and recyclable.** The nanoFlowcell® is also exemplary in terms of raw materials recycling thanks to its extended lifespan. The nanoFlowcell® thus eliminates the problem of performance loss experienced by conventional batteries as the nanoFlowcell® concept does not suffer from memory effect. As far as the lifespan of the nanoFlowcell® is concerned, the hardware comes with a guarantee of more than 50,000 hours of operation. In a car running at a motorway cruising speed of 120 km/h, this would add up to a theoretical range of around 6,000,000 kilometres, vastly exceeding the lifespan of a modern car. Furthermore, the self-discharge of the cell and the electrolyte solution when not in use is negligible.

**Safety with certainty.** Another benefit of the nanoFlowcell® compared with other battery systems is that monitoring the battery-system charge status is straightforward to implement as there is only one positively charged and one negatively charged electrolyte. Equalization charging of the kind required by conventional Li-ion or Li-po systems is not necessary. Also, the electrolyte solution is neither sensitive to vibration nor at risk of impulse discharging.

**High efficiency.** In contrast to an internal combustion engine, the efficiency of the nanoFlowcell® stands at more than 90 percent. When used in electric mobility applications, the operating temperature is a maximum of 96 °C. The entire nanoFlowcell system is also incredibly reliable and low-maintenance as it has no moving parts aside from the electrolyte pumps.

High reliability, low costs and long durability rightly place nanoFlowcell® front and centre when it comes to the development of forward-looking energy solution – be it in electric vehicle or off-grid power systems.

## bi-ION® – Liquid Energy for Modern Electricity

*“bi-ION® is the energy carrier for the nanoFlowcell®. bi-ION® is liquid power for a world that has based its existence on the uninterrupted availability of energy.”*

The power density of the bi-ION® electrolyte is comparable with that of modern lithium-ion batteries, but its energy density is five times greater. bi-ION® is the perfect fuel for environmentally compatible and sustainable electric drive. In road traffic alone, the widespread use of bi-ION® could avoid 19,250 megatons of CO<sub>2</sub> emissions per year caused by burning fossil fuels. That equates to 75 percent of the CO<sub>2</sub> emissions generated worldwide by all transport and traffic.

**Innovative charge carrier.** bi-ION® is one of our most important innovations and crucial to the power characteristics of the nanoFlowcell® system. Through years of research, we have succeeded in developing special charge carriers that give our electrolyte liquid a significantly higher power and energy density than all fluid batteries currently available on the market.

In our digital simulation lab, we researched new molecular structures and mechanisms for charge transport. Our simulation options massively shortened the development time for bi-ION®, enabling us to synthesise an initial physical model and test it in-vivo in just under five years' time.

bi-ION® is an aqueous carrier liquid containing dissolved organic and inorganic salts to transport the actual charge carrier, the bi-ION® electrolytes. The electrolytes are nanoparticles that were designed specifically for the nanoFlowcell® in order to be able to transport the high levels of charge.

**MINI-MAX.** The charge carrier we developed permits a significantly higher charge and concentration than the previous electrolytes in conventional redox flow cells (30 – 90 Wh/l).

At the current development status, we are achieving an energy density of 600 Wh per litre with bi-ION®. Compared with lithium-ion batteries of the kind used in most modern electric vehicles, a nanoFlowcell® running on bi-ION® delivers sufficient energy for five times the range of a conventional electric vehicle running at the upper range of its power output.

**Not different, better.** Compared with conventional energy carriers like petrol, diesel, hydrogen and lithium-ion batteries, bi-ION® is not harmful to health or the environment and is neither flammable nor explosive. The bi-ION® electrolytes contain absolutely no environmentally polluting substances. Moreover, bi-ION® is sustainable and environmentally compatible to produce. Industrial production of the electrolyte liquid is considerably less expensive than refining fossil fuels or the manufacture and use of lithium-ion batteries.

**Non-politicized energy.** In contrast to fossil fuels, the bi-ION® electrolyte solution is not extracted and refined in just a few countries but can theoretically be manufactured more or less in-situ all over the world (given the appropriate production equipment).

**Fuelling up as usual.** Distributing and selling bi-ION® does not call for the construction of a dedicated fuel station network. Existing fuel stations can also be used for bi-ION® with just a few minor modifications to the pumps and nozzles. Thanks to its properties, the bi-ION® electrolyte liquid is not subject to any hazmat obligations, unlike fossil fuels. The manufacture, transportation and distribution of bi-ION® is therefore relatively straightforward.

Static applications such as nanoFlowcell® power stations would be supplied with bi-ION® by tank trucks. The ability to produce bi-ION® locally is an advantage for grid-supporting and off-grid power systems.

## **Benefits of bi-ION®**

- Non-explosive
- Vibration safe
- Non-flammable
- Non-toxic
- Non-harmful to water
- Non-harmful to reproduction
- Non-carcinogenic
- No harmful emissions
- Extraction of raw materials environmentally compatible
- Recyclable
- Cost effective to produce, distribute and store
- No self-discharge /no thermal runaway
- Long shelf life (no 'diesel bug' issues)

## nanoFlowcell® 48VOLT Drive – Driving Force of Modern Electric Mobility

*“The future of driving is low-voltage! The QUANT 48VOLT is challenging conventional high voltage design of electric vehicles. Right now, the nanoFlowcell® 48VOLT low-voltage drive is the most powerful, most environmentally compatible, safest and most cost-effective drive system there is for electric vehicles.”*

Until now, standard practice has been to fit electric vehicles with a high-voltage drive system of around 400 volts. People accept the intrinsic potential dangers of the high-voltage system as there is no other way of achieving the desired performance. In fact, the automotive industry is even currently considering increasing the voltage in future electric vehicles to 800 volts in the interests of higher vehicle performance.

**Against the current.** With the QUANT 48VOLT, we are placing a big question mark above this potential development in electric automotive technology and making a globally unique statement: Flow cell technology in the QUANT 48VOLT enables extreme performance (>560 kW) with a safe battery voltage (maximum 48 V). But why are we going to such lengths as to build prototypes? We see nanoFlowcell® as much more than an innovative form of energy. Instead of focusing on nanoFlowcell® as a singular technology, we always look at the application – the overall system – into which our technology is incorporated. In the case of the QUANT 48VOLT and QUANTiNO 48 VOLT, we have consequently developed a completely new electric drive the likes of which does not exist on the market – the nanoFlowcell® 48VOLT low-voltage drive for electric vehicles. We are not a vehicle manufacturer, but an enthusiastic development team that would like to provide an impressive demonstration of the efficiency and modularity of the nanoFlowcell® by building prototypes of electric vehicles.

**High performance.** While many manufacturers think of low-voltage technology in terms of electric bikes and e-scooters, we have developed a dedicated low-voltage drive for the QUANTiNO 48VOLT and QUANT 48VOLT. It may sound succinct, but those cars are the only road-legal EVs with low voltage drive in the world. Powerful sports cars with distinct day-to-day usability. We are demonstrating that high-performance electric mobility is possible at low voltages and that high-voltage compromises are a thing of the past. With the QUANT 48VOLT, we draw attention to the fact that electric vehicles cannot be permitted to make compromises when it comes to “functional safety”.

**More safety.** With the nanoFlowcell® 48VOLT, we are also addressing the safety concerns associated with electric mobility. By executing the drive at low voltages across the board, the entire vehicle is inherently safe from an electrical standpoint. The full protection required for high-voltage electric vehicles against contact and arcing is not necessary for low-voltage vehicles. The nature of the flow cell’s poles mean they can be touched without any danger to life and limb. In contrast to conventional lithium-ion battery systems, there is no risk of electric shock to vehicles occupants, other road users and first responders, even in the event of a serious accident. Furthermore, the electrolyte liquids used by the nanoFlowcell® are neither flammable nor explosive.

**Lighter and more cost-effective.** The concept behind the low-voltage drive architecture in the QUANTiNO 48VOLT and QUANT 48VOLT marks a major development step in the design of production-feasible, low-voltage electric vehicles. The standardization of the low-voltage components is a substantial benefit for the industrial series-production of a nanoFlowcell® electric vehicle. There is no need for expensive high-voltage safety measures as functional safety is easier to implement for low-voltage vehicles and leads to significant cost reductions in development, production and upkeep. With nanoFlowcell® 48VOLT, electric vehicles will thus not only be safer in future but also less expensive. Moreover, the technical maintenance of a nanoFlowcell® 48VOLT electric car can also be carried out by personnel without high-voltage training.

With the move to nanoFlowcell 48VOLT low-voltage drive, we were able to save several hundred kilograms of weight in the design of the QUANT 48VOLT compared with the QUANT FE with the high-voltage system – weight that was attributable entirely to the high-voltage components.

One example of this is the innovative 45-phase low-voltage motors in the nanoFlowcell® 48VOLT drive, which facilitate high power paired with minimized cross-sections in the electrical wiring. The special feature of these low-voltage motors is their solid aluminium mesh structure, which replaces the complicated copper windings used in conventional electric motors. This reduces the volume of the motor relative to its power output, while lowering weight and cost, and simplifying series production.

## QUANT EVs: Pioneer Models for Modern Electric Mobility

*“QUANT 48VOLT and QUANTINO 48VOLT set reference points in advanced EV engineering – not only for their innovative flow cell drive system, but also for their unique approach to low voltage drive trains.”*

### QUANT 48VOLT

#### **Powerful. Save. Environmentally sound.**

The QUANT 48VOLT is the world’s first road legal EV powered by a nanoFlowcell® 48VOLT low voltage drive system – the lightest, safest, most ecological and economical drive system for electric on-road performance vehicles.

A new electrolyte called bi-ION is the fuel for the innovative nanoFlowcell® flow cell drive system. The QUANT 48VOLT is designed as a GT, having energy for over 1,000 kilometres on-board, able to drive – fully electric and non-stop – the distance from Zurich to Monaco and back.

The extravagant bodyshell of the QUANT 48VOLT underscores the uncompromising character of this exceptional performance car and its EV pioneering spirit in terms of mileage, engine performance, acceleration and above all – environmental compatibility.

#### **Technical Data QUANT 48VOLT (2019)**

Body style:	GT
Top speed (km/h):	300
Acceleration (0-100 km/h):	2.4 s
Transmission:	Automatic
Drive:	All-wheel drive
Number of doors:	2
Number of seats:	2+2

#### **Motors**

Type:	4x low voltage synchronous motors
Fuel:	bi-ION / fully electric
Maximum power kW (hp):	560 (760)
Maximum torque (Nm):	2,000 per wheel

#### **Flow Battery**

Type:	nanoFlowcell® (6 membranes)
Voltage (V):	48
Capacity (kWh):	300
Rated current (A):	max 9,000

#### **Consumption**

Energy consumption (100km):	<18 kWh
Tank volume (l):	2x 250
Range (km):	>1,000
Harmful emissions:	0

#### **Dimensions**

Length (mm):	5,257
Width (mm):	2,019
Height (mm):	1,357
Wheelbase (mm):	3,198
Kerb weight (kg):	2,300

## QUANTiNO 48VOLT

### E-mobility without compromises.

The QUANTiNO 48VOLT completed a 350,500 kilometres real-life endurance test. Its powerful nanoFlowcell® 48VOLT low-voltage drive is showing faultless, almost maintenance free performance during the entire testing cycle, making it the most advanced drive system for electric vehicles in the world.

QUANTiNO 48VOLT might be over-dressed for a test car, but it is an eyecatcher for a disruptive technology innovation that is about to change the way we consume mobile energy: nanoFlowcell® flow cell power.

The flow cell powered, fully road-legal EV prototype shows what responsible electric mobility could look like – no compromises in performance with regards to speed, range, comfort and safety. A true ambassador to represent the most economical and environmentally sustainable EV technology of today.

### Technical Data QUANTiNO 48VOLT (2016)

Body style:	Coupé
Top speed (km/h):	200
Acceleration (0-100 km/h):	5s
Gearbox:	Automatic
Drive:	Rear-wheel drive
Number of doors:	2
Number of seats:	2+2

#### Motor

Type:	Three-phase asynchronous motor
Maximum power (kW / hp):	80 / 108
Maximum torque (Nm):	200

#### Flow Battery

Type:	nanoFlowcell®
Voltage (V):	48
Rated current (A):	max. 300
Capacity (kWh):	85

#### Consumption

Energy consumption (100km):	<12 kWh
Tank volume (l):	2 x 95
Range (km):	>1,000
Harmful emissions (g):	0

#### Dimensions

Length (mm):	3,910
Width (mm):	1,930
Height (mm):	1,335
Wheelbase (mm):	3,198
Dry Weight (kg):	685

# NANOFLOWCELL: QUANT-CITY – OUR VISION OF THE FUTURE

*“QUANT-City will be the nucleus of a sustainable energy future!”*

## **QUANT-City Project Plan**

Our nanoFlowcell Innovation Center – internally named also QUANT-City – will be the international hub for flow cell research and applications development. QUANT-City will be a fully integrated science, research, development and production hub for flow cell technology. QUANT-City will serve as blueprint facility for similar nanoFlowcell flow cell innovation centers around the world. With QUANT-City, NFC is also piloting extensive service functions necessary to run such a facility – from complete supply and disposal management, to logistics services, as well as engineering and facility management. The experience with this project, from planning to operation, will help with the development and implementation of QUANT-City as an internationally compatible blueprint for plug & play facilities.

The entire construction costs for QUANT-City with all installations and productions is estimated to be around CHF 3.5 to CHF 5 billion. Operating QUANT-City requires an estimated staff of around 250 to 350 people – mainly developers, engineers and technicians, as well as administrative support.

At its final expansion stage, QUANT-City will comprise the following eight areas:

### **Research and Development**

- Research & Development (Digital Prototyping)
- Legal / Patents Lawyer
- Accounting & Controlling
- General Management

### **bi-ION® Production**

Production facilities for the for bi-ION® electrolyte liquids

- all materials used in the production of bi-ION® are toxicologically safe and freely available on the world markets
- over ten years research investments to develop bi-ION® from laboratory level to become suitable for mass production
- most modern industrial fittings with uniquely engineered production methods will be an industry-first in terms of scale of process technology; the pilot production alone could serve the bi-ION® need of around 1 million nanoFlowcell® powered vehicles
- eco-sustainable production methods throughout the entire processchain including on-site water purification and logistic
- bi-ION® production will surpass industry standards for toxicological safety and environmental pollution
- modular construction of complex production cycle provides utmost flexibility for any future technological requirements
- no contaminating waste or by-products as a result of the bi-ION® production
- production will be largely automated

### **nanoFlowcell® Flow Cell Manufacturing**

Production facilities for nanoFlowcell® flow cells with options for various performance levels and applications

- fully automated flow cell production line
- highest standards for safety, health and eco protection
- allows for different flow cell options: scalability for low-voltage and high-voltage system architectures



**Innovation Labs (application research)**

Innovation Labs for developing flow cell applications for a wide range of industries (illustrating the value chain from application research to application development)

- In those innovation labs the development, production and use of new flow cell applications can be simulated and tested.
- Innovation Labs will facilitate reproduction of the entire nanoFlowcell® technology value chain for individual industrial sectors.
- Innovation Labs like this will address the regional demands of flow cell applications or will conduct industry-oriented application research and development

**QUANT Pilot Production Center**

Construction of a sample production facility (CKD) for QUANT low-voltage electric vehicles; demonstration of standard quality processes as well as series-production methods for flow cell powered electric vehicles and further stationary / mobile nanoFlowcell® applications

- Pilot production / pre-production for various applications
- Production line optimisation and testing for various applications

**Logistics Center**

- Distribution center for production materials and finished products such as bi-ION®, nanoFlowcell® and parts as well as QUANT products

**QUANT Academic Campus / Training Center**

- Quant faculty for flow cell energy studies; academic campus for international scientists in the area of flow cell research and the education of high potential academics; training center for internal purposes

## NANOFLOWCELL: OUR BUSINESS PERSPECTIVES

nanoFlowcell® is shaping the world of tomorrow.

*“As an energy source for a diverse array of electrical applications, there is virtually no industry that cannot benefit from our nanoFlowcell® technology. The tandem of nanoFlowcell® as energy converter and the bi-ION® electrolyte as energy carrier is superior to all currently available battery technologies and will end our dependency on fossil energy.”*

QUANT is the brand for our prototype applications. Although the QUANT brand is initially appearing almost exclusively in the automotive sector, this should not detract from the fact that individual mobility represents just one small usage area for our nanoFlowcell® technology.

When it comes to innovative energy storage solutions for mobile or stationary applications, we think in holistic terms. We conduct our research with passion and develop without compromise from a sense of conviction. Our focus is on a high level of system competence and the networking of individual components. This results in product applications and system functions that make us what we are – R&D experts and partners of industry for innovative flow-cell based energy solutions on land, on water and in the air.

We assist manufacturers in the development of new product concepts, in the technical adaptation of our technologies and in matters relating to series production. It is important to us that technical innovations can also be transferred to series production.

### Enormous Market Potential for nanoFlowcell® Technology

To start with, nanoFlowcell is concentrating on energy intensive industries, which are attractive to flow cell energy such as automobile, maritime, aerospace (mobile energy) as well as energy providers and off-grid buildings (stationary energy). A quick exemplary look at the automotive market shows the business potential for nanoFlowcell® technology: we consider a non-linear market penetration of a total market of 1.1 billion vehicles and 90 million new vehicles annually. Gradually converting those vehicles to EVs powered by clean nanoFlowcell® energy technology is an attractive business proposition. Furthermore, with an average mileage performance of 8,000 miles annually, each vehicle would consume approximately 1,700 litres bi-ION® annually providing a viable business proposition to bi-ION® licensees (and subsequently bi-ION® gas station leaseholders).

But we are not looking at the automobile market only. As worldwide leading research and development company for modern flow cell technology and its applications, we are in the position to develop advanced flow cell energy systems for a multitude of mobile and stationary applications; the innovation research of ours is the material structure and composition of the nanoFlowcell® membrane as well as the chemical composition of the complementary electrolyte named bi-ION®. Outstanding features of this innovative flow cell energy technology are uncompromising health and environmental compatibility, inherent safety as well as high energy density and scalable power.

**Automobile & Transportation.** The social and political pressure on automotive manufacturers is increasing rapidly. Be it lithium-ion batteries or hydrogen fuel cells – the energies used in current electric vehicle concepts are far from being sustainable and environmentally compatible, neither in production nor in recycling and, furthermore, they are extremely costly or plagued by substantial safety concerns. However, we are not seeking to reinterpret electric mobility. The fact is that nanoFlowcell® will change electric mobility fundamentally. It is a vehicle drive that has zero harmful emissions, is environmentally compatible and harmless to health as well as cost-effective and sustainable to produce.

**Aviation.** Modern aircraft are equipped with a whole lot of batteries – the same lithium-ion batteries used in mobile phones and laptops. Experience shows that these types of battery have a tendency for thermal runaway – the battery overheats, melts and starts to burn. From an electrical standpoint, nanoFlowcell® would make aviation inherently safe. The bi-ION® electrolyte solution is neither flammable nor explosive and has an almost unlimited shelf life. nanoFlowcell® has virtually no self-discharge and its very nature makes thermal runaway impossible.

**Maritime.** Shipping has a major influence on our environment – with exhaust emissions, engine noise and water pollution caused by escaping fuel at the top of the danger list. According to estimates by the International Maritime Organization (IMO), the CO2 emissions caused by shipping – not including the substantial amounts of SOx/NOx/PM emissions – make up around 2.2 percent of all manmade CO2 emissions. IMO experts forecast that the proportion of CO2 emissions attributable to shipping will double or even treble by 2050. nanoFlowcell® supports efforts to achieve sustainable shipping without harmful emissions and with minimal noise pollution.

**Rail.** Railway travel and transportation is environmentally friendly, but only where trains are powered by electricity. However, many railway lines are not electrified, and running on them are diesel locomotives that generate noise and considerable amounts of harmful emissions. Using nanoFlowcell technology can deliver rail traffic that generates zero emissions and – electrically powered – less noise, too.

**Construction.** The need for mobile energy is constantly rising. Primary or secondary batteries or even diesel-powered generators are being used in many places as energy sources to supply electricity to mobile applications. To date, the downsides of these energy sources have had to be accepted as a compromise. nanoFlowcell® is a mobile energy source that offers an uncompromising alternative in many respects and that can be closely adapted to a wide range of requirement profiles.

**Stationary energy.** nanoFlowcell® is a compact power station that produces environmentally friendly electricity, is individually scalable and can be called on as required. nanoFlowcell® can be integrated flexibly into the domestic electric infrastructure – be it as a complementary energy supplier in a hybrid solution (together with solar or wind energy) or as a standalone solution to cover the electricity needs of a household, a community or even a whole town. Thereby, nanoFlowcell® can work as grid-integrated community solution as well as individual off-grid solution. As a redundant electricity source, nanoFlowcell® can be particularly useful for protecting critical infrastructure equipment in the event of a grid failure or power outage.

## nanoFlowcell's Business Proposition

*"As innovation partners with unique Know-how, we help companies to achieve higher performance in their markets by using our nanoFlowcell® technology."*

### Unique Know-how

We have sufficiently demonstrated the advantages of nanoFlowcell® technology with our QUANT electric vehicles (QUANT E, QUANT FE, QUANT 48VOLT, QUANTiNO 48VOLT) – mobile power stations and pioneers of modern e-mobility. Because of our in-house developed QUANT electric vehicles, we are often mistaken as car manufacturer. Instead, one should know that those EVs serve as unique reference projects for high voltage and low voltage applications of our proprietary flow cell energy technology.

Such advanced applications research provides us with complimentary technological and scientific know-how, from which our business partners benefit greatly as their specific application developments can be designed more efficiently, thus making our holistic approach a strategic driver for sustainable and continuous corporate value creation.

Advanced applications research strengthens our core competencies as leading research and development company for applied modern flow cell technology. We pass on these strengths to our research and development partners in form of know-how, upgraded products and improved services.

We prove ourselves as an innovation partner to companies from a wide range of industries, supporting them by uncovering new business and performance potentials, which are arising from the use of modern flow cell energy, namely nanoFlowcell®. A well working business case is important, especially when our overall aim with nanoFlowcell® and its complementary electrolyte bi-ION® is to improve energy efficiency and sustainable energy use, which both will contribute to a better environment and benefit society.

The bundling of competencies, i.e. professional know-how, specific personal as well as organizational and structural resources, is considered key for increasing efficiency and for performing complex tasks; hence, we will retain the project lead for all R&D projects that are assigned to us by third parties or which we carry out together with industry partners.

Important value drivers for our business are the international market development and expansion (through licensing, patenting and contract production), the development of new applications for strategic industry segments (together with selected industry partners) as well as contract research.

We will not necessarily produce or market nanoFlowcell® products or applications ourselves. The rationale behind that is, that we want to be a neutral business partner to businesses from a wide variety of industries. As such, we award licenses and patents to external partners for specific applications and/or market segments. However, with confirmed investor orders for 2,400 QUANT 48VOLT and 160,000 QUANTiNO 48 VOLT, we are assessing the options of contract manufacturing as well as company owned manufacturing. Besides the current order volume, an NFC-owned, but separately managed production company for QUANT vehicles and other nanoFlowcell® applications would accelerate market capitalization of nanoFlowcell® technology and corresponding excellency networks in the area of sales, services and after sales, etc. which in turn is beneficial for all our business partners. However, those manufacturing and sales businesses would be strictly separated from our R&D business for the latter to stay competition neutral.

## **Patents & Licenses**

Nunzio La Vecchia is holding all personal and property rights on nanoFlowcell® technology; patents are covering all major markets. There are no third-party rights affected. Nunzio La Vecchia has assigned all usage rights on nanoFlowcell® to nanoFlowcell IP AG. All patents, IP, design, and trademark rights are with nanoFlowcell IP AG, which itself is a fully-owned company of nanoFlowcell Holding Ltd.

NFC will use and market all its own developments and patents via joint ventures and licenses worldwide. The income generated by licensing patented product and process technology is a key element of NFC's business model and a major income stream to fund new research. The detailed licensing model for nanoFlowcell® and bi-ION® is currently under development.

The primary goal of NFC's licensing strategy is a swift and broad global market penetration. As the business potential is enormous, a thorough, detailed marketing strategy will be applied to rapidly develop all identified market segments. The involvement of industry partnerships (external licensees) is used to gain local market know-how and insights as well as to jointly develop the respective market / market segment.

## **Auxiliary NFC Business Service**

In order to facilitate its future market offer for stationary power supply in the area of grid-based and grid-supported energy, NFC has developed a unique business proposition that had been made possible due to the unique advantages of nanoFlowcell® technology. Alongside its scalable nanoFlowcell® power stations, NFC will offer services such as energy banking and energy leasing to private, industry and institutional partners.

Furthermore, with its culture of service-mindedness, partnership and innovation, NFC is planning to bring further value to its energy partners in form of an energy reinsurance service that will protect against the risk of energy black-outs.

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