

# The Sustainable Future of Production, Consumption and Work Best Practices in Competitiveness Strategy



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# **The Sustainable Future of Production, Consumption and Work** Best Practices in Competitiveness Strategy

2017

### **CHAIRMAN'S LETTER**



On behalf of the board of directors and members of the Global Federation of Competitiveness Councils (GFCC), I am pleased to present the 2107 report, *The Sustainable Future of Production, Consumption and Work: Best Practices in Competitiveness Strategy.* 

When the GFCC was formed almost eight years ago, it was predicated on the belief that sharing best practices among national competitiveness organizations and among nations would provide benefit to all. With the release of this year's report, we have again put that belief into practice and created what we hope will be a useful tool for competitiveness organizations and initiatives around the world.

GFCC members understand more than anyone that the nexus of sustainability, innovation, national competitiveness and economic prosperity can manifest into a higher standard of living for all.

It is the mission of the GFCC to actively promote debate and dialogue, competition and collaboration, and innovation above all else. This year's *Best Practices* highlights six outstanding examples of competitive strategies from Brazil, Ecuador, Qatar and the United States. We hope they can inspire action and open new opportunities for engagement.

*Best Practices in Competitiveness Strategy* is issued annually by the GFCC. I hope you enjoy the 2017 edition.

Sincerely,

**Charles O. Holliday, Jr.** Chairman, Royal Dutch Shell, plc Chairman, Global Federation of Competitiveness Councils

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## EXECUTIVE SUMMARY AND OVERVIEW

### Best Practices in Production, Consumption, and Work

The 2017 Global Federation of Competitiveness Councils Best Practices describe how different countries have implemented a diversity of policies, programs, technologies, and models addressing production, consumption, and work. These include efforts to increase the value created by production chains, reach customers through new models of consumption, increase workforce skills and the productivity of work, and leverage new technologies and models for advancing sustainability, innovation, and competitiveness.

**Brazil:** The Industry 2027: Risks and Opportunities for Brazil in the Scenario of Disruptive Innovations initiative is identifying the opportunities, challenges, and risks disruptive technologies present for Brazil's production systems in different industry sectors, providing inputs for a development strategy and public policy proposals.

Preliminary findings from the first phase of the project identified key technologies that could disrupt production systems and sectors important to Brazil in terms of generating products, jobs, exports, and innovation. For example, nanotechnology has the potential to make economically competitive electric vehicles and distributed energy generation possible, and will likely become a key tool for developing intelligent systems used in all industrial segments. Public policies suggested include training personnel, and adding a program for intelligent systems. Brazil's scientific community has fully mastered the techniques of biotechnology. The bottleneck for developing biotechnology products is in the science and technology management process, including low participation of the private sector in the R&D system.

Artificial intelligence (AI) technologies have the potential to increase the gross value added of the Brazilian economy by US\$432 billion by 2035. Opportunities for Brazil include machine learning, data analytics, and developing applications for cybersecurity. But the rate of AI diffusion in Brazil tends to be slower. Major threats posed by AI to industry in Brazil include: lack of skilled labor, insufficient data for industry, and unemployment due to automation. Greater investment in R&D and education, and promoting worker requalification are needed.

Other areas of opportunity include the Internet of Things, where Brazil could become a developer. In advanced materials, Brazil is challenged in converting research into innovations; technology development programs in research centers and startups are needed. Energy storage is another priority, but no organized programs currently exist to encourage research in this area. Programs needed include: sending professionals to overseas doctoral and postdoctoral research programs, and financing programs to support research groups set up in Brazilian universities. **Ecuador:** Coffee produced in the northwest of Quito has excellent potential as a specialty coffee. Yet, despite its high quality, the New York Stock Exchange has priced the coffee as conventional coffee. Lacking knowledge, producers managed their harvest as conventional coffee and did not seek a price differentiation. The lack of good agricultural practices, systematization, and traceability in the zone resulted in low production. In the city of Quito, the consumption of coffee was low, despite the high quality of coffee produced in the country.

CONQUITO, an institute of economic development, led a project to develop the specialty coffee production chain and position Café de Quito in the specialty coffee marketplace. The project began with a territorial coffee survey, and studies to obtain the information needed to help validate the coffee's high quality (a cup score of about 80), which indicates the coffee has the characteristics of a specialty coffee for which producers can seek a price differential. Coffee producers worked with the project to implement good agricultural and traceability practices, and to develop and disseminate a manual on good agricultural practices for producing specialty coffee in the northwest of Quito.

Efforts to promote specialty coffee and coffee consumption in Quito included: coffee tastings; Coffee Week; cafeteria training; and a report on the potential for cultivating specialty coffee in Northwest Quito. The study compared profitability of the production of coffee, sugar cane, and livestock, identifying areas with optimal conditions for producing specialty coffees.

Production levels and the cup scores obtained in the 2015 and 2016 Coffee Tastings reflect the adoption of the improved agricultural practices. Results from the 2015 coffee tasting were an average of 83.6 points in characterization, an average price of US \$180, and the volume of the sector was 1200 quintals. In the year 2016, the average rating was 86.2 points, the average price was US \$220, and the volume of the sector was 1500 quintals.

The market position of Quito's specialty coffee was improved by promoting the coffee nationally and internationally through the annual Coffee Tastings of Quito competitions. The coffee is increasing its position in the local consumer market, as the specialty coffee consumption culture gains momentum in the city of Quito. Three years ago, only three specialty coffee shops were managing the niche market in the city. Now there are around 40.

**Equador:** The Metropolitan Public Water and Sanitation Company (EPMAPS), which supplies water to approximately 2.5 million inhabitants of the Metropolitan District of Quito (MDQ), consumes a significant amount of energy, 31 MW, and the cost of energy has great impact on setting water rates. Sources of the water that EPMAPS treats and subsequently distributes to the MDQ population are far from the city. Its two main supply systems, Papallacta Integrado and La Mica, are located approximately 60 km from the city of Quito, and a third source, the Pita system, is at the base of the Cotopaxi volcano, which has frequent eruption alerts. The remoteness of water sources has forced EPMAPS to find extreme engineering solutions, such as designing large capacity pumping systems which consume significant amounts of energy.

EPMAPS's project took advantage of the geographic conditions and water resources where the company's drinking water and sanitation systems are located by developing small and medium hydroelectric generation projects that allow the "recovery" of the energy used in the pumping systems. Also, EPMAPS attained certification as a "Self-producer Agent" from the Electricity Regulation and Control Agency (ARCONEL), the country's first and only public company in the drinking water and sanitation sector to receive this certification. This certification saves the company between 60 and 70 percent of the monthly cost per kilowatt hour of electricity consumed, which otherwise would be paid to the Electricity Company of Quito.

In the absence of the project, the budget for the electricity needed to power the operation

of administrative and technical facilities in the drinking water and sanitation service would have reached US \$7 million per year. Therefore, the "Self-producer" qualification allows for approximately US \$4.5 million in savings annually. The management of energy under this model has allowed EPMAPS to attain energy self-sufficiency of more than 90 percent and provide water that is very competitively priced compared to other cities in Latin America. This effort exemplifies the concepts of Social and Environmental Responsibility, enhancing the sustainability of the company's practices, particularly with respect to energy efficiency.

**Qatar:** The Qatar Foundation Research and Development (QFRD) division has spent millions of U.S. dollars through its research fund to support investigator-led academic research in more than 50 countries since 2006. This increased Qatar's profile, and attracted scholars and students. However, it has not contributed similarly to bringing solutions to Qatar's priority needs or broader commercial markets, and resulted in little intellectual property.

To improve technology development and commercialization, QFRD revamped its research programming. Qatar's Ministries, state-owned companies, and private sector stakeholders identified national priority needs: water security, energy security, cyber security, and healthcare. Solicitations for research proposals permit only proposals that address these needs, and R&D proposals with cash and/or in-kind contributions from collaborations of industry and academia are ranked higher. Awardees and industry partners can own shares of resulting inventions. Kompass, a new software tool, was developed to identify topics within the national priority needs where there are possible "white spaces" and areas of global commercial interest. This permits funding solicitations to be further focused on both Qatar's needs and global commercial market potential.

The response to a focused solicitation in which industry collaborators and cost-sharing were treated with priority was overwhelming: \$30 million (USD) were committed in costshare contributions to the research proposals, and the number of proposals received in the first focused solicitation did not vary from the number received in earlier cycles before the changes.

To move QFRD-funded technology along the value chain, a Technology Development Fund invests in advancing inventions to higher levels of readiness, and small and medium-sized enterprise product development is encouraged through a new Product Development Fund. QFRD continued efforts to build capacity in entrepreneurship, and a start-up and venture capital ecosystem. These include launching a Research-to-Start-up program to bridge the gap between research projects and new start-ups, and an accelerator program. Ten new start-ups have been incorporated, nine new teams of entrepreneurs have participated in the accelerator program, and five agreements signed for the new Product Development Fund.

United States: The Council on Competitiveness Energy & Manufacturing Competitiveness Partnership (EMCP) brings together leaders from business, academia, national laboratories and the labor community to explore the distinct challenges critical sectors of the U.S. economy face at the nexus of energy and manufacturing, and how these industries can bolster the critical pillars of competitiveness-technology, talent, investment and infrastructure. Over the course of three-years, EMCP is conducting expert dialogues and sector studies. Based on the knowledge and insight gathered, the Council will develop an ambitious roadmap to focus national attention on the intersection of energy and manufacturing, and action-oriented recommendations to decision-makers at the highest levels of government and industry.

Bioscience and bio-product production is one of the sectors under study. The United States has pioneered much of the advancements in biosciences, with significant investment from the U.S. government. Its leadership in the technology of biology presents the United States with tremendous opportunity to build the world's preeminent bioeconomy by delivering novel products and processes to society more sustainably and efficiently.

However, challenges in infrastructure, technology, investment and talent must be addressed. For example, the United States lacks a unifying roadmap and its efforts are often uncoordinated and disjointed rather than strategic and long-term. Funding from different government agencies tends to favor components of bioscience rather than the entire industry. In addition, this approach tends to leave fundamental platforms that broadly enable bioscience research underfunded and underdeveloped. The biotechnology industry currently has a disconnected development pipeline, and there is a growing demand for biologists with multi-disciplinary backgrounds.

Based on the bioscience sector dialogue and study, recommendations to address these challenges include:

- Develop an annual strategic roadmap for advancing biosciences, biotechnologies and bio-production to meet energy, environmental, agricultural, national security and economic goals.
- Create tools and processes that capture and analyze basic and applied research data, private sector and governmentfunded activities, and community feedback on the Bioeconomy Roadmap's goals, objectives and milestones.

- Coordinate investments across government agencies, broaden disbursement to crossdisciplinary fields, and focus government investment in the development of research platforms that more quickly deliver solutions to society.
- Provide opportunities and incentives for stakeholders to determine next generation bio-targets that biotechnologists can use to reinvent products and make them marketable to consumers.
- Develop knowledge bases of principles, methods, processes, successes and failures to more quickly deliver helpful information to stakeholders.
- Enable bioscience research platforms to deliver novel capabilities to industry that would, otherwise, be cost prohibitive.
- Address the talent gap in multidisciplinary areas where bioscience has evolved to require frequent translation of information, updating of codes, and data management skills in high performance computing.

Webster University: With nearly 16,000 students in classrooms and online in the United States, Europe, Asia, and Africa, Webster University has long been a leader in the use of emerging technologies to connect its students and campuses across the globe. Over nearly 20 years, Webster's on-line course offerings have grown to more than 60 programs. Due to differences in time zones among Webster's campuses, Webster's programs have typically focused on asynchronous web-based approaches. Webster has innovated by installing a Global Wide Area Network and video-enabled classrooms, and launching the WebNet+ channel of live video instruction. Instruction can originate from specialist faculty at any campus and be delivered to students globally. Courses, certificates, and degrees can now function in synchronous and asynchronous modes.

In Fall 2015, the first set of WebNet+ classes launched. The pilot classes received positive reviews, while also generating requests for improvements in technology, pedagogy, and support. New cameras were sent to campuses, and Internet hot-spots were provided to campuses where the existing bandwidth was not sufficient for video conferencing. Live support systems and personnel were put in place to monitor the first weeks of class and resolve challenges as they arose. Improved training was offered to faculty, helping them become more comfortable on-camera and more effective as they engaged students who were not in the same room.

Growth was explosive over the first two years of WebNet+ delivery. By Fall 2017, nearly 100 faculty taught through WebNet+ and more than 800 students were served per term, attending from 40 different campuses, as well as some students attending from home. For some students, these classes allowed them to continue their graduate studies without interruption when they would not have been able to attend classes at their campus or via asynchronous online classes. Other students were able to access programs that they could not enroll in previously. For example, the Masters in Public Administration was a program delivered in only five campus locations via live classroom instruction. WebNet+ allows students who do not live near one of those campuses to enroll in the program. Likewise, Webster's Legal Studies and Paralegal programs have been available only in St. Louis at the main campus. These programs, accredited by the American Bar Association, cannot be delivered via asynchronous online modalities. WebNet+ has given students from outside the St. Louis area access to this program.

## BRAZIL

How Organizations, Cities, Regions, and Nations are Building a Sustainable Future for Production, Consumption, and Labor Brazil's Industry 2027 Initiative

### Introduction

The world is going through profound changes in competition, production, and consumption patterns, even in lifestyles. The engines of transformation have been active on both the demand side (population aging, emergence and expansion of new middle classes, search for solutions to the challenges of climate change, etc.) and the supply side (advances in science and technology, and new entrants in the arena of global competition).

The technical base of a large part of production activities is undergoing changes, paving the way for cost reductions, changes in work processes and in the qualification profile of the workforce, restructuring relationships along value chains, and launching new products and new markets. In addition to the emergence of specific innovations, one of the main differences between technological revolutions of the past and those of today is the convergence between technologies, leveraging sets of disruptive innovations; that is, clusters of interconnected innovations are emerging and deeply changing the business world and people's quality of life.

Disruptive innovations are not the result of natural processes. They are built through long and persistent interactive processes between the world of science and technology, the business world, and the public policy world, anticipating or responding to societal challenges, competition, or market demands.



Changes in technological opportunities for disruptive innovations largely depend on skills built over time, on competition between countries and companies to conquer new markets, and on pressures from society to overcome the economic, social, and environmental limitations of the current development model.

While advances in disruptive innovation clusters are still at an emerging stage, and therefore have not been fully understood, much less is known about their potential effects. Changes in the world of work will occur, but little is known so far about either their quantitative impacts—which depend on the diffusion of new techniques—or their qualitative impacts, and neither about workforce qualifications that will disappear, change, or emerge.

Despite these considerations and short-term budgetary constraints, public and private efforts are increasing worldwide to support innovations that could result in significant changes in the structure of the economy, giving rise to new, dynamic markets. Public and private actors around the world have presented lists of potentially disruptive innovations. For example, a 2013 McKinsey Global Institute report identified a dozen emerging technologies: global internet, intellectual work automation, Internet of Things, cloud computing, advanced robotics, standalone vehicles, next-generation genomics, energy storage, additive manufacturing, advanced materials, advanced oil and gas exploration, and renewable energy. In that same year, the French government listed seven technologies in which public and private investments should be concentrated: energy storage, rare metal recycling, seabed mining, green chemistry, personalized medicine, technologies to address the conseguences of aging populations, and technologies to explore large databases. Large-scale initiatives have been implemented to turn technological opportunities into disruptive innovations. In Germany, for example, initiatives to promote energy transition and the so-called "Industry 4.0" have been mobilizing academia, companies, and government agencies. In the United States, initiatives to promote "advanced manufacturing" have led to similar mobilizations.

Brazil is at an intermediate level of economic development. How should the country deal with emerging waves of disruptive innovation clusters? In a world where barriers to the circulation of goods, services, currencies, and information are falling, what investments should Brazil make to take advantage of emerging disruptive technologies and their convergence? Do these innovations present similar challenges, or do they have specific sectoral features? How can the private sector's responsiveness to risks and opportunities be strengthened? What should be the pillars for building public policies? What kind of institutional challenges should be addressed? What should be the constituent elements of a priority agenda for science, technology, and innovation in the short, medium, and long term? The initiative Industry 2027: Risks and Opportunities for Brazil in the Scenario of Disruptive Innovations, led by the National Confederation of Industry through the Entrepreneurial Mobilization for Innovation (MEI), proposes to engage in this debate.

In line with the topic of the annual GFCC meeting in 2017, we share in this paper how the initiative—which is still underway—was structured and how its products can be applied to Brazilian industry with the aim of building a sustainable future for production, consumption, and labor.

### Objectives and scope of the initiative Industry 2027: Risks and Opportunities for Brazil in the Scenario of Disruptive Innovations

The 12-month initiative is designed to identify for different production systems and disruptive innovation clusters: major domestic and international trends; associated processes of generating and disseminating their determinants; potential changes and impacts, mainly on the competitiveness of companies; and public and private strategies that should be adopted to improve the responsiveness of entrepreneurial, research, and professional training systems in Brazil.

The initiative has a five-year (2022) and a tenyear (2027) time frame. Its specific objectives for these two time frames are:

- Evaluating Brazil's ability to deflect risks, and monitor, absorb, and take advantage of disruptive innovations that will likely shape the economy and society over the next decade;
- Identifying key technologies for different production systems, and the socioeconomic development of the country;
- Evaluating the current and potential responsiveness of the system, considering elements at the corporate, industrial, and systemic levels; and
- Providing inputs for developing a production development strategy that drives public policy proposals.

This research effort will follow a line of investigation based on evaluations of the technology diffusion process, and building scenarios reflecting the potential impact of emerging technologies on production activities. To build this reference framework, it will be necessary to draw maps indicating the degree of maturity of the technological changes involved, the nature of their impacts, and the expected time horizons within the five- and ten-year milestones defined for the study. This analytical effort will, in turn, be structured at three different levels:

- At the level of companies: products, processes, and management models;
- At the level of industry: scale and scope, integration with suppliers and customers, and participation in value chains; and
- At the systemic level: innovation ecosystems; international flows of goods and services, capital and technology; labor and skill needs; and sustainability.

Along this line, a team will analyze clusters of technologies, production systems and, within the latter, specific sectoral foci (Figure 1). These clusters comprise a set of key technologies grouped according to their technological proximity, based on the expertise of the knowledge base involved. The production systems correspond to groups of industrial sectors selected for their importance to the Brazilian industrial framework. The main criteria for identifying specific sectoral foci were, by order of importance, the potential disruptive impacts of new technologies and the economic relevance of a sector in terms of generating products, jobs, exports, and innovation.

In the first stage, specialists in the different technological clusters who have experience in research institutes and companies produce analyses of trends and potential impacts on production systems. These analyses are then used as inputs for the second stage, when sectoral experts evaluate the process of developing and disseminating these technologies in each sector's production system and impacts on entrepreneurial competitiveness. Analyses of clusters and production systems are then used to promote reflections on public and private strategies.

### Figure 1.



PRODUCTION SYSTEMS	SECTORAL FOCI
Agroindustry	Processed food products
Basic inputs	Steel-making
Chemical industry	Green chemistry
Oil and gas	E&P in deep waters
Capital goods	Agricultural machinery and implements, machines, tools, electric engines and other serial engines, GTD equipment
Auto industry	Light vehicles
Aerospace/defense	Aeronautics
ICTs	Telecom systems and equipment, microelectronics, software
Pharmaceutical industry	Biodrugs
Consumer goods	Textile products and apparel

### Figure 2. How the initiative has been carried out in stages



# Criteria to evaluate disruptive innovations

The purpose of evaluating these eight technological clusters is to capture key technologies that tend to introduce disruptive changes in production systems, markets, and competition, which can change competition patterns and the elements that define market leaders. Within the time frames of the project (five and ten years), these technologies can pose major threats to established companies. However, the technologies also open a wide range of opportunities for new companies and established ones, as a result of the emergence of new market segments as well as new ways of producing and managing production chains. It should be clarified that, in view of increasing links between different key technologies for generating disruptive changes in different markets, this evaluation process is not intended to set rigid boundaries between the suggested technological clusters.

The analysis of technological clusters supports the analysis of production systems with information on trends in the process of generating and disseminating key technologies, potential impacts and expected changes in industrial activities, and opportunities and/ or threats to the sectoral foci. This process is expected to reveal implications for corporate planning and public policy for the sectors under study.

In particular, the following topics will be evaluated:

• Main disruptive technologies under development globally which make up the respective technological cluster. The technological developments identified must be qualified with regard to the time frame of actual use in the industrial sector; developments expected beyond the 10-year timeframe being studied are disregarded.  Production systems and sectoral foci with strong potential to be impacted by innovations resulting from the identified disruptive technology developments; importance of the relevant innovations of the technological cluster for each production system in Brazil; and opportunities and/or threats to sectoral systems and foci.

### **Preliminary findings**

Based on activities carried out in the first phase of the initiative, including field research applied to 437 large companies with operations in Brazil, the following are preliminary findings on the clusters of Nanotechnology, Biotechnology, Internet of Things, Artificial Intelligence, Advanced Materials, and Energy Storage.

### Nanotechnology

An impact survey identified two large groups of potentially disruptive innovations associated with new forms of energy generation and intelligent systems. The energy group includes innovations in batteries and solar cells that can make electric vehicles economically competitive and highly distributed energy generation possible. In the other group of disruptive innovations, nanotechnology will likely become a key tool for developing intelligent systems used in all industrial segments, such as the Internet of Things, autonomous vehicles, and in services and capital goods. The consequences of these disruptive innovations could be drastic for Brazilian industry, particularly because they require more high-tech content in any industrial sector for which Brazil is poorly prepared. To reduce risks for Brazilian industry, four public policies were suggested: i) training qualified personnel to develop or at least absorb new technologies; ii) placing priority on some industrial sectors in which Brazil can be competitive, such nanocosmetics, oil and gas, and the environment; iii) strengthening an existing program led by the Ministry of Science, Technology, Innovation and Communications, and adding a specific program for intelligent systems to it; and iv) intensifying the work being carried out to regulate nanotechnology through INMETRO's program with Europe's NanoReg project.

#### Biotechnology

Whether in the plant, animal, industrial or human realms, modern biotechnology depends on "omic" technologies (genomics, transcriptomics, proteomics, and metabolomics), on bioinformatics, and on a set of molecular and cellular biology techniques. These technologies have been fully mastered by the Brazilian scientific community. Hundreds of master's and doctoral theses are being produced annually using these technologies. Therefore, the bottleneck for developing biotechnology products of high economic and social value is not in the quantity and guality of human resources, but rather in the science and technology management process, including low participation of the private sector in the R&D system.

#### **Internet of Things**

Work addressing the Internet of Things (IoT) has focused on global public policy practices that will be used to inspire Brazil to be more than just a follower and to act as a developer as well.

To advance the IoT, governments of more developed economies have reinforced incentives designed to set up ecosystems and reduce the risk of innovation through direct investment, technological orders, financing instruments, deregulation, support programs for small and medium-sized enterprises, clustering, and consortia focused on overcoming specific challenges.

Key initiatives include: Horizon 2020, Startup Europe Partnership, and IoT European Platform Initiative (European Union); Smart Nation and High Performance Buildings Pilot Project (USA); Center for Creative Economy & Innovation (South Korea); Center of Excellence for IoT (India); Mittelstand 4.0 (Germany); and Tech City (United Kingdom).

### Artificial Intelligence

As in other countries, the impact of artificial intelligence (AI) in Brazil will be great. But the rate of its diffusion in Brazil tends to be slower, at least in the early stages. For example, the first AI movements in Brazil consisted of developing chatbots (in the financial, telephone, and retail sectors as the main markets) and applications of data analytics, mainly in the retail area. Several small startups are beginning to operate in Brazil's AI sector, as well as big companies, particularly IBM Brasil and Totvs.

According to Accenture, AI technologies have the potential to increase the gross value added of the Brazilian economy by US\$432

billion in 2035, an increase of 0.9 percentage points from the baseline scenario. Of this amount, US\$192 billion will be generated by the increased capacity of labor and capital, US\$166 billion by intelligent automation, and the remaining US\$74 billion will come from other structural and social transformations as AI diffuses throughout the economy. For example, driverless vehicles may create new opportunities for advertising and media as vehicle occupants spend time on mobile phones, or generate cost savings as traffic congestion and accidents are reduced. Major threats posed by AI to industry in Brazil include: i) lack of skilled labor; ii) insufficient data for industry to derive competitive advantage; and iii) unemployment due to automation, especially among less skilled workers.

On the other hand, opportunities are particularly available in the following areas: i) use of machine learning algorithms and data analytics in all segments of industry; ii) machine learning algorithms for predictive maintenance in manufacturing activities; iii) developing data analytics software applications for sectors such as health care, finance, automotive, and smart city applications; and iv) developing applications for cybersecurity.

The federal government will play a major role in developing AI in Brazil by stimulating investment in R&D, radically changing the philosophy and contents of basic education to prepare the population for the future, promoting worker requalification activities, and strongly encouraging long-term and more risky investment.

Two key objectives should guide the development and implementation of public policies in Brazil: i) investment and development of AI technologies due to the multiple benefits they can bring to the country, and ii) education and training of Brazilians for jobs of the future.

### Advanced Materials

Based on analyses and considering Brazilian production systems, the opportunities identified include: materials for functional packaging; light alloys reinforced with nanotubes; high-entropy alloys; nanocellulose; use of high-performance nanocomposites in petroleum production; and development of equipment for advanced materials, with emphasis on additive manufacturing and equipment for producing nanotubes, graphene, and nanocomposites.

With regard to public policies, the big challenge for Brazil in the coming years is increasing the conversion of advanced materials research into technological innovation. However, it is important to consider that the maturation period of advanced materials is very long (about 20 years), even in more advanced countries.. Therefore, it is imperative to create technological development programs in both research centers and startups, until new products are developed and the feasibility of transferring technology to larger investors is ensured.

### **Energy Storage**

Preliminary findings about this cluster indicate that no organized programs currently exist to encourage the development of fundamental and technological research in this area. The rapid progress made in electrochemical energy storage (EES) technologies and in applying them in different industries makes it necessary to adopt aggressive programs to stimulate the absorption of knowledge and development of technologies in the short term (within 10 years). According to experts consulted, program elements should include:

- Sending professionals from different areas to doctoral and postdoctoral programs in research groups abroad with solid capacity and knowledge in ESS, and strong links with manufacturers of ESS products; and
- ESS financing programs to support research groups set up in Brazilian universities that encourage their interaction with industries interested in technology transfer.

### **Final considerations**

The Industry 2027 initiative is evaluating the impacts of a set of technologies with high potential to improve the competitiveness of

Brazilian industry within 5 to 10 years, and will provide inputs for the corporate planning of companies and public policy-making with the aim of aligning industry with the best international practices.

The Entrepreneurial Mobilization for Innovation—the most important forum for dialogue between the private and public sectors on innovation in Brazil—will define many of its activities according to the outcomes of this initiative. The findings of the study will also include a proposal for measures recommended by CNI to candidates for the presidency of Brazil in the upcoming 2018 elections.

The study is being carried out in partnership with the University of Campinas (Unicamp) and the Federal University of Rio de Janeiro (UFRJ), and involves more than 40 experts from different areas with extensive experience in industrial innovation.

For more information on the project's methodology and more details about it, contact candida.oliveira@cni.org.br.

The **National Industry Confederation (CNI)** represents and defends Brazilian Industry's interests before federal, state and municipal governments through a nationwide network of private entities responsible for initiatives to support industrial development and competitiveness. Under the leadership of CNI, the Brazilian Entrepreneurial Mobilization for Innovation (MEI) is one of the most successful forums in regard to innovation that gathers the Founders and CEOs of the 120 biggest and most innovative companies in the country.

## ECUADOR

## CONQUITO ECONOMIC PROMOTION AGENCY

Café de Quito

# 

### What was the challenge?

Despite its high quality and potential as a specialty coffee, the New York Stock Exchange has priced coffee produced in the northwest of Quito as conventional coffee. Lacking knowledge, producers managed their harvest as conventional coffee and did not seek a price differentiation. The producers did not see coffee as a profitable crop because its production is labor intensive, its geography does not allow for automation of the process, and lack of investment made it an expensive crop. A price differentiation was necessary to encourage coffee cultivation in Quito and position it globally, since the presence and quality of coffee in the area was not well known. In the city of Quito, the consumption of coffee was low, despite the high quality of coffee produced in the country. Creating a culture of coffee consumption was a first great step to create cyclical economies in the area.

The area has excellent potential and a variety of microclimates that make this coffee unique. But the lack of good agricultural practices, systematization, and traceability in the zone resulted in low production of specialty coffee. In addition, the production of conventional coffee did not consider the social and environmental pillars of sustainability; working toward more sustainable agriculture was needed.

### How was the challenge overcome (or the problem solved)? What was the solution adopted?

The project Café de Quito began with a territorial coffee survey. Studies obtained the information needed to validate the coffee's high quality—a cup score of about eighty which indicates the coffee has the unique characteristics of a specialty coffee for which producers can seek a differentiated price, and move into a niche market that seeks quality coffees that are environmentally friendly and agriculturally responsible.<sup>1</sup> Achieving price

ANECAFE, "Concurso Taza Dorada", http://www.anecafe.org.ec/documentos/ rueda\_de\_prensa\_taza\_dorada\_2010(1);pdf. CONOUITO, http://www.cafedequito.com/ premios/.

differentiation led to the development of the area, increasing the coffee plantations, and improving economic and employment opportunities for its inhabitants as several people are required to manage a crop. The city has been working in conjunction with coffee shops that offer high quality coffee to contribute to the cyclical economies. Three years ago, only three specialty coffee shops were managing the whole niche market at the city level. Now there are around 40.

Coffee producers worked with the Café de Quito project to implement good agricultural and traceability practices, and to develop and disseminate a manual on good agricultural practices for producing specialty coffee in the northwest of Quito. This manual helped systematize and facilitate the implementation of sustainable practices that are appreciated by the specialty coffee market worldwide.

# Who were the stakeholders were involved?

Actors in the coffee production chain were the main stakeholders in Café de Quito. These different actors have special characteristics and interests, and play different roles in the project. Direct stakeholders include coffee producers, association leaders, trading companies, and consumers. Indirect stakeholders are state officials, an NGO, and the technicians of CONQUITO. **Producers:** About 200 families of producers in the area of Nanegal, Nanegalito, Pacto, Gualea, and San Jose de Minas in the Quito Metropolitan District cultivate specialty coffee. These are the main actors in the production chain that benefitted from the project's support, exchange of knowledge, observation tours, technical assistance, and supplies, all with the objective of increasing the quality of coffee produced in the area and quality of life for the producers.

Associations: In the area, there are four producers associations that work for the benefit of their members. They have 20-30 members, the average age of their members is 53 years and the association has 1-3 years of existence.

**Trading companies:** Producers sell their coffee to two trading companies in the area, Café Velez and Café Galletti. Both trading companies support producers with some assistance and feedback for harvest and post-harvest handling. Another trading company, Virmax, is an international specialty coffee buyer that works in different countries. These companies have an important role for the producers as they buy their production depending on demand and offer.

**Public institutions:** In the territory, there are three State institutions: the Ministry of Agriculture (MAG), which is the director of public policy at the national level; the Decentralized Autonomous Government of the Province of Pichincha, which promotes the strengthening of production chains in the agricultural, agro-industrial, associative, commercial, and tourism sectors; and CONQUITO, the Economic Agency for Development. These three institutions make up the Coffee Table, formed in 2015, which holds meetings one or two times a month to coordinate coffee agendas in the area.

**NGOs:** VECO Andino is a Belgian non-governmental organization that has worked in Ecuador since the 1980s. VECO's objective is to support family farmers to reduce rural poverty; it specializes in coffee production, and applies a production chain approach. VECO highly values the coordination of actions in the territory by state institutions, a result of establishing a joint agenda developed in collaboration with producers.

**Coffee experts:** CONQUITO is an institution of economic development. Its team includes experts who are passionate about the world of coffee; specialists in agribusiness, competitiveness, and finance; and professional tasters. Team members have provided technical advice and contributed to carrying out important studies in the area.

# Who were the leaders, catalyzers, and enablers?

To achieve success and have an impact on the coffee industry, it was necessary to encourage different actors to work collaboratively toward a common objective. CONQUITO proposed and led the project, working with the different actors in the coffee production chain. CONQUITO worked as a catalyst, coordinated project efforts among actors across the value chain, and served as a mediator. Enablers helped make the project happen, including technicians, anchor companies, and specialists who helped implement the project. The most important enabler was the Inter-American Development Bank, which contributed funds to implement the project.

### What types of barriers were faced in implementation? How were they overcome?

One of the biggest barriers was the lack of institutionalism in the area, the lack of efficiency of the associations, and the lack of teamwork. Small producers are not accustomed to working together. As a result, individual producers are forced to sell under buyers' demands, since a single coffee producer's offering is not important for the buyer that always seeks to maximize its monetary benefit. But if producers, together, bargained for a higher price, coffee buyers would consider their demands. Another great barrier was getting producers to understand the benefit of participating in the specialty coffee market and getting out of price setting by the New York stock market. The fear that this could not be achieved led some producers to distrust the project. Also, hard work and

several steps were needed to achieve the recognition needed to differentiate the coffee as a specialty coffee of Quito and position it in the global market.

### What results were obtained?

CONQUITO had several achievements in the 2015-2016 phases. Below, we detail some of the main results and how these correspond to the four components of the IBD (Inter-American Bank of Development)-funded project.

One of CONQUITO's main achievements was helping organize the institutions and public entities—such as MAG that provides agricultural assistance; the Provincial Council that works in infrastructure, local capacity building, and promoting the Coffee School; and CONQUITO as economic promoter—and strengthening their efforts by taking an integrated approach in the territory.

Another important achievement, not only of CONQUITO, but of all the involved institutions present in the area, has been producers' greater awareness of the quality of the coffee they grow in the Northwest. The training and technical assistance provided by the project institutions help develop the commercial and productive capacities of the small coffee producers. The technical assistance, capacity building, and training provided by CONQUITO fully respond to the specific needs of small-scale producers to improve coffee quality and increase productivity.<sup>2</sup> This action changed the lives of producers since, before, they had to rely on their buyers to know the quality of coffee they sow. Now these small producers have technical tools to better manage their plantations and fertilization, and they no longer need anyone to measure the quality of the coffee they produce.

The project seeks to increase rural producers' access to public agricultural planning and decision making. For this reason, CONQUITO facilitate the participation of producers' associations in the Coffee Consultative Council created by Ministerial Agreement 081 of April 2015. Producers, along with other actors, will actively consult and advise the Ministry of Agriculture, not only to obtain knowledge of how to link to business opportunities, but to contribute in the formation of public policies for the development of the different actors in the coffee production chain.

Another CONQUITO achievement is the manual Agricultural Practices, Traceability, Registration and Beneficiation of Special Coffees of the Northwest of Quito. The manual provides producers with guidance on applying

<sup>2</sup> CONQUITO-Triplei, "Informe de la Caracterización Física y Organoléptica del Café de Noroccidente de Quito en función a 3 variables: variedades, altura y localidad", diciembre 28 de 2015, Pág. 6, http://www.cafedequito.com/publicaciones/. CONQUITO-Triplei, "Análisis químicos y físicos de una muestra representativa del café de la zona", marzo de 2015, Págs. 4-5, http://www.cafedequito.com/publicaciones/.

and standardizing practices and processes of production and transformation of the coffee until it reaches the final consumer. With great success, the manual was developed in a collaborative manner with the producers and associations of the Northwest of Quito, and was informed through interviews with the main marketers of the area. The manual supports project goals by providing lessons and knowledge on good practices and production processes to be disseminated and implemented among producers.<sup>3</sup>

Hosting two Catas of the Café de Quito (coffee tasting competition) was a success, exceeding the expectations of the organizers because it help to positioning the name of Café de Quito in the local and international market, and showcased the excellent physical and organoleptic characteristics of the area's coffee. CONQUITO also promoted the leading role of associations of coffee producers. Each of the tastings gathered more than 400 people who had the opportunity to learn how to host a coffee tasting, visit the coffee farms, listen to lectures, and hear the verdict of the international experts of the Coffee Quality Institute (CQI), whose views are highly regarded due to their experience in coffee tastings.

# What was the impact of the solution implemented?

The project's solutions have had impact at different levels. At the production level, implementation of good agricultural practices began to benefit producers, consumers, and the environment. Average production of the area was increased in annual guintals, and the average qualification score in cup was raised.2 the project's studies and the collection of information and data helped establish a basis for price differentiation, impacting the economy of producers and the sector. Producers could seek a higher price for their coffee due to the demand for this product validated as being of high value. The social impact was also great, because the project sought to integrate young people into the economy and empower women in this area. In the labor market, the number of jobs increased due to the high demand for labor associated with this crop. The market position of Quito's specialty coffee was significantly improved by promoting the coffee at the national and international levels. through the annual Coffee Tastings of Quito competitions. Also, the coffee is increasing its position in the local consumer market, as the specialty coffee consumption culture is gaining momentum in the city of Quito. The

<sup>3</sup> CONQUITO-VECO Andino, "Análisis de la influencia de prácticas agrícolas y del manejo post-cosecha del café en la calidad organoléptica de la taza", febrero de 2016, Pág. 8, http://www.cafedequito.com/publicaciones/.

training and development of other links in the coffee production chain have also had a positive impact.

# How much was invested? How long did it take?

Launched in the Northwest area of the Metropolitan District of Quito in 2014, implementation of the project lasted about three years. The project invested about US \$300,000 for studies related to cultivation, information surveys, consulting, and training.

# Were there any innovative elements in the solution implemented?

The project objectives were to strengthen capacities to: (i) improve and increase the interaction between anchor companies and small agricultural producers, so they could access the market on fair terms, and (ii) identify and capture new, higher value-added business opportunities. Throughout the intervention process, CONQUITO implemented three strategies on an ongoing basis:

- Improvement/maintenance of coffee quality;
- · Associativity; and
- Positioning the coffee in the marketplace.

CONQUITO's intervention sought to respond to the reality and needs of the small producers of the Northwest of Quito. To meet these needs, CONQUITO developed its own form of technical assistance in five key areas:

### 1: Characterization of the zone

Studies and analyses were carried out to characterize the zone and create a baseline of knowledge for the project:

- Coffee Census, Process of Georeferencing of Coffee Plantations in Northwest de Quito<sup>4</sup>;
- Report on the Historical Background and the Process of Colonization and Development of Agricultural Activities in the Northwest of Quito during the last decades;
- Report on coffee production systems in the Northwest;
- Report of the Physical and Organoleptic Characterization of the Coffee of the Northwest of Quito in three variables: varieties, elevation and locality; and
- Chemical and physical analysis of a representative sample of coffee in the area.

<sup>4</sup> CONQUITO-Triplei, "Informe del proceso de georreferenciación de las plantaciones de café en la zona", febrero 2015, Pág. 2.

### 2: Analysis of best practices

The Study of Costs of Production and Profit of Coffee<sup>5</sup> analyzed the influence of agricultural practices and post-harvest management of coffee on the organoleptic quality of the cup. The report of the Organoleptic and Physical Characterization of the coffee samples taken in May, June, and July 2016 in the Northwest of Quito generated data for the Manual of Good Agricultural Practices developed by CONQUITO and Triple i. CONQUITO plans an international study tour to Honduras.

### 3: Implementing Best Practices

Improving and maintaining the quality of coffee is one of the three strategies CONQUITO has worked with producers on an ongoing basis. The scores obtained in the 2015 and 2016 Coffee Tastings reflect the adoption of these good practices, as measured in cup quality in these public events. Results from the 2015 coffee tasting were an average of 83.6 points in characterization, an average price of US \$180, and the volume of the sector was 1200 quintals. In the year 2016, the average rating was 86.2 points, the average price was US \$220, and the volume of the sector was 1500 quintals.<sup>6</sup>

### 4: Associativity

Increasing associativity is still a challenge in Northwest Quito, for strengthening both coffee growers 'capacities and their organizational processes for negotiating in an associative way for better prices and conditions. CONQUITO's second strategy seeks to enhance associativity through organizational strengthening workshops, accompaniment, visits to the farms, specialized talks to overcome the organizational difficulties that impede associative commercialization with business vision. CONQUITO has also provided legal and administrative advice to producer associations so they can establish themselves, obtain legal status, establish their internal regulations, and register with institutions such as the Superintendency of Popular and Solidarity Economy (SEPS).7

### 5: Marketing and consumption

There were different strategies for promoting specialty coffee and coffee consumption in Quito, including Coffee Tastings; Coffee Week; Cafeteria Training; and a report on the identification, description, and mapping of the potential for cultivating specialty coffee in the rural parishes of the Metropolitan District of Quito (Pacto, Gualea, Nanegal, Nanegalito,

<sup>5</sup> CONQUITO-Triplei, "Informe de Costos de Producción y Beneficio de Café en las Parroquias Rurales del Noroccidente de Quito en Tres Niveles de Intensificación", febrero 2016, Pag.3, Http://www.cafedequito.com/publicaciones/.

<sup>6</sup> Resultados oficiales de la Cata de Café de Quito 2015 y 2016. Elaboración: Francisco Enríquez. CONQUITO 2016.

<sup>7</sup> CONQUITO, "Términos de Referencia para la Capacitación para la implementación y ejecución de un programa de fortalecimiento asociativo", diciembre 2016, Pág. 2.

## Conquito's Intervention for productive chain projects

#### Phase 1. Characterization of the zone

- Coffee Census.
- Plantation Georeferencing.
  Historical and productive Background Report
- Report and analysis of physical and chemical characteristics of coffee in the area.

#### Phase 2. Analysis of best practices

- . Study of costs of production and implementation of good practices for a better quality.
- Manual of good agricultural practices.

#### Phase 3. Implementation of best practices and traceability system

 Improvement and maintenance of coffee quality.

#### Phase 4. Associativity

- Organizational strengthening workshops.
- Accompaniment.
- Farm visits
- Creation of control and management system.

## CAFÉ≌QUITO ()

#### Phase 5. Marketing and consumption

- Coffee Tasting.
   Coffee Week.
   Capacitation and training for cafeterias and other actors in the chain value.
   Strengthening of management and control
- systems.

and San José de Minas). In a study, Triple i made an objective quantitative comparison between the profitability of the production of coffee, sugar cane, and livestock, identifying areas with optimal conditions for producing specialty coffees in the parishes of Nanegal, Nanegalito, Pacto, and Gualea.

### What went wrong?

Success was not achieved in the associative strengthening process. The disparity of producers, idiosyncrasy, and unclear reasons limited their strengthening, even with the potential for reducing production costs and improving financial returns. However, we worked on implementing management and

control systems, with the purpose of achieving support and progress in training and institutional development.

# What was learned? What should be done differently in the future?

Fostering institutional collaboration is not always an easy task, particularly when there are different institutional competencies and specific mandates of public entities. However, when it is possible to establish optimal levels of coordination in the territory, the accompanying processes are very rewarding and mutually beneficial for all actors, especially for producers.

Knowing how to listen to people and make them responsible for their own development process is one of CONQUITO's greatest achievements. Their "ownership" of the development process encourages them to invest time, economic resources, socially, and emotionally. There is nothing more fruitful and sustainable for an economic development project than to have strengthened the capacities of its beneficiaries, and given them sufficient skills to know that they do not need more from the institutions. The anchor companies that were incorporated into CONQUI-TO's intervention process as potential drivers of the development of the area became rather a distractor and, unfortunately, were not willing to pay what the coffee produced in the rural parishes of the Northwest is worth. Associativity is one of the weakest links in the Northwest, and has strengthened only slightly as a by-product of CONQUITO's other main activities. Organizational processes or associative marketing cannot remain in the hands of individuals. But the social fabric of collaboration must be generated and strengthened, so that organizational processes and productive development rest in associations and their communities.

### What comes next?

After about five years of intervention to develop and strengthen the specialty coffee production chain in the rural parishes of the Northwest, CONQUITO has been able to elevate and position the Café de Quito in the marketplace, and positively change the lives of people. However, there are still a number of challenges facing all the actors involved in the production chain: public institutions, marketers, producers, and associations.

One challenge is encouraging producers to conduct an in-depth analysis needed to obtain a designation of origin or geographical indication for their specialty coffee. This decision must be made autonomously without the influence of the institutions present in the area.

The niche for specialty coffee still has no local acceptance; consumers do not yet recognize the effort involved in growing gourmet coffee. Therefore, a huge challenge is generating local demand and promoting a coffee culture in certain circles, and not just a greater appreciation of the Café de Quito, but more generally of the good coffees produced in Ecuador.

Inadequate management of water waste from the coffee industry in the post-harvest coffee process continues to be a problem that adversely affects the environment, contaminating water, soil, and air in the areas dedicated to this activity. Therefore, one of the challenges is promoting innovative ideas and developing strategies to avoid environmental deterioration, improve the quality of life of the population, and promote sustainable coffee production in the Northwest.

This economic process is not always very inclusive of women. It is therefore essential to create favorable conditions to promote and strengthen women's leadership. Moreover, there are women entrepreneurs from the Northwest who have won prizes for the quality of their coffee and actively participate in all links of the production chain.

It is necessary to work on establishing more public-private partnerships. Although efforts have been made to promote the participation of producers in the Coffee Consultative Council and the Technical Coffee Table, there is still a need to involve other institutions of the state in the strengthening of coffee production in this area. The promotion of entrepreneurship and the acquisition of credit for coffee growers is an ongoing need to strengthen the production of specialty coffee, as well as other initiatives in different links of the production chain.

#### Who to contact for more information

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#### About the organization

**CONQUITO** is an Economic Promotion Agency that impulses economic growth in rural areas of Quito-Ecuador, and the Multilateral Investment Fund of the Inter-American Development Bank (IDB-MIF), in 2015, signed a No reimbursable Technical Cooperation Agreement to promote the project "Café de Quito".

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## ECUADOR

**METROPOLITAN PUBLIC WATER AND SANITATION COMPANY** Self-Generated Energy

### The Challenge

The Metropolitan Public Water and Sanitation Company (EPMAPS) consumes a significant amount of energy, 31 MW, which exceeds the demand from several small provinces in the country. The cost of energy required is substantial and has great impact on setting water rates.

EPMAPS's project focused on addressing two challenges. The first challenge was incorporating hydroelectricity generation within its business, on the basis that electricity generation is a complementary process to the management of drinking water and sanitation. This addressed the high level of energy consumed by EPMAPS for the efficient provision of its service. This strategy is considered by Michael Porter as "backward integration," since it entails business moves to increase control of a priority input to its production processes. Moreover, the project significantly optimized the use of its funding, creating a more efficient and sustainable financial environment, without compromising the company's social and environmental responsibility.

The second challenge was attaining certification as a "Self-producer Agent" from the Electricity Regulation and Control Agency (ARCONEL). EPMAPS would be the country's first and only public company in the drinking water and sanitation sector to receive this certification. Attaining certification was



an important project milestone and a good business practice, since this certification would save the company 60-70 percent of the monthly cost per kilowatt hour of electricity consumed, costs which otherwise would have reached US \$7 million per year paid to the Electricity Company of Quito.

EPMAPS currently supplies a population of approximately 2.5 million inhabitants of the Metropolitan District of Quito (MDQ). Thus, the substantial savings mentioned above would allow the company to reallocate these financial resources to new water and sanitation system projects, particularly for inhabitants in remote and rural areas of the city, while reinforcing the operations management and maintenance of company facilities. By taking advantage of the geographic conditions and water resources where the company's drinking water and sanitation systems are located for electricity generation, the company could reduce costs, make efficient use of renewable resources, and improve energy efficiency.

The support of the company's leaders and work teams that allocated the time and resources needed to carry out activities related to the project was essential for success. For example, achieving the ARCONEL certification was a time-consuming and challenging process that lasted several months, and required responding constantly to the different requirements of the governing body that includes SENAGUA and the Ministry of the Environment, each with its own procedures. However, the understanding that water and energy management are complementary activities underpinned the company's commitment to devote the time, resources, and coordination needed to respond to the regulatory, control, and administration entities' requirements.

The qualification of EPMAPS as "Self-producer" and its energy management in the framework of the electricity market set a precedent for future public sector actors in the country who have water resources available and are willing to replicate this good practice in the efficient use of resources, which also achieves significant economic benefits.

### Solution

Sources of the water that EPMAPS treats and subsequently distributes to the MDQ population are increasingly far from the city. Its two main supply systems, Papallacta Integrado and La Mica, are located approximately 60 km from the city of Quito, entering the Amazon region, crossing the central Andes Mountains. A third source, the Pita system, is at the base of the Cotopaxi volcano, which has frequent eruption alerts.

The remoteness of water sources has forced EPMAPS to find extreme engineering solutions, such as designing large capacity pumping systems (i.e., flow rate of 3,000 l/s with a pumping height of 650 mca). However, the energy and electric power needed (24 MW for the nominal flow) exceed the requirements of several of the small provinces of our country. This large demand for power and energy has a significant cost that affects the company's operating expenses for this functional stage in the water process and, consequently, has an impact on the cost per cubic meter of water distributed. The process EPMAPS developed makes the price of water delivered to the end user in the city of Quito very competitive compared to other cities in Latin America.

Due to the particular topographic conditions of Quito in the areas from which EPMAPS draws and transports raw water, it is possible to develop small and medium hydroelectric

generation projects that allow the "recovery" of the energy used in the pumping systems, and technical processes and administrative functions carried out by the company. In this context, the company has a comprehensive view of the use of water resources, as it uses the same infrastructure of drinking water and sanitation systems, in many cases already built, to develop small and medium hydroelectric generation projects. For this reason, the company has built small and medium-sized hydroelectric generation plants in virtually all stages of the water process: Recuperadora (14.7 MW), El Carmen (9.0 MW), Noroccidente (250 kW), and Microcentral Carcelén (60 kW). Chalpi (7.6 MW) and Tanque Bellavista (212 kW) are in the process of being built. This portfolio of generation projects adds up to approximately 50 MW, especially those that are part of the Quito River Decontamination Project (PDRQ) which will contribute 43 MW of power.

Optimizing the use of available water resources for both human consumption and power generation is an Energy Efficiency (EE) process based on Social and Environmental Responsibility principles, responsibly managing a resource considered to be renewable but becoming scarcer. Clean energy is generated which reduces the effect of global warming. And, finally, it contributes to the financial leverage of the company by contributing revenues or savings that the energy management produces in the framework of the Wholesale Electricity Market (MEM), which EPMAPS has been a co-founding partner since 1999.

The EE process in the EPMAPS has driven the construction of hydroelectric plants in the different functional stages of the water process, including sanitation, taking advantage of the hydraulic infrastructure built to supply the water or discharge it to receptors or purification plants.

The second activity related to the EE process has been EPMAPS's certification as a "Self-producer Agent" in 2012; since that year, the company has acted in the MEM under this designation. Since obtaining the "Self-producer" certification, the company has achieved an energy self-sufficiency rate of 93.5 percent, which varies depending on the use of the Papallacta pumping system, conditional by the climate and the consequent availability of water in the different sources. This positions the company as energy-sustainable, not only generating cost benefits but also process efficiency, and contributing to an environmentally and socially responsible business strategy.

### **Stakeholders**

Stakeholders in the project include: the Metropolitan Public Water and Sanitation Company (EPMAPS), its General Management and Support Management, in particular Operations Management with the Sub-Management of Hydroelectricity, which is responsible for energy management in the EPMAPS; ARCONEL (Agency of Regulation and Control of the Electricity) from which permits are obtained; CENACE (National Electricity Control Corporation); SENAGUA (National Water Secretariat); MAE (Ministry of Environment); and the Electricity Company of Quito (EEQ). The consultants who designed the power plants, and the suppliers of electromechanical equipment, controls, and automation have also been important players in the process.

Implementation of the Energy Efficiency process has been led by the Hydroelectricity Sub-Management and its officials, which has also included disseminating information on project results and training in the areas where projects are located. In addition, several multidisciplinary EPMAPS groups have participated in different stages of project implementation.

### **Implementation Barriers**

Due to the large amount of investment needed to develop electricity generation projects, limited financial resources have been a barrier. Another barrier has been the significant time it takes to do the paperwork required by the governing bodies of the electricity sector to obtain the qualification and authorization for development and subsequent operation of the generation projects, as well as the "Self-producer" certification needed to participate in the MEM. Extensive paperwork also had to be prepared for the regulating agencies related to water and environmental management, SENAGUA and MAE respectively, and the public procurement portal (SERCOP).

The consultants who carried out the designs of the electricity generation systems were not particularly familiar with the development of microgeneration projects. Although the engineering concepts in the different fields are the same, the technology usually used was not appropriate for the size of the facilities, the type of water (treated) with which hydroelectricity would be generated, the site of evacuation of the generated energy, and the management of these projects in the MEM. Constant monitoring from EPMAPS personnel, and internal and external knowledge management were necessary to generate specific solutions to each particular need presented.

### **Overcoming Barriers**

The use of financial resources for projects was optimized. Particularly for microgeneration projects installed at the entrance of treated water distribution tanks, some of the designs by employees of the Hydroelectric Sub-Management and the Studies and Design area of EPMAPS held down project costs. Hydraulic, electrical, control, and automation equipment was built in the country (hydraulic turbine); control and automation software was developed by a local company; and the pipeline assembly was run by EPMAPS.

Regarding the appropriate technology used, in the Carcelén micro-central, a standard asynchronous electric motor was used as an electric generator, avoiding the need for auxiliary control equipment such as speed and voltage regulators and synchronizer. That equipment would have taken up too much space and been too costly, given the size of and total budget for the installation. Instead, the use of equipment was optimized, placing both the control system and automation in the same space. The equipment used allows selection of different functions to be regulated such as inlet flow rate, tank level. generation power, and position of the turbine injectors. The equipment used for generation, not only allows counting the value added of the energy produced, but also uses the latest technology for operating the treated water distribution system.

### **Results Achieved**

With the ARCONEL Resolution of 2012, EPMAPS acts in the MEM as a "Self-producer Agent." This means that EPMAPS uses the energy produced in its own plants to power its treatment plants, wells, pumping stations, warehouses, administrative buildings, etc. The management of energy under this model has allowed EPMAPS to save approximately US \$4.5 million per year and attain energy self-sufficiency of more than 90 percent.

The degree of automation developed for the generation projects is high. These are unattended stations, optimizing the use of human resources.

Optimizing the use of available water resources holds down operating costs, resulting in a more sound budget structure for EPMAPS.

The use of micro-centrals at the entrance of treated water tanks, allowing control of different functional variables—flow, level, power, and position—should be a trend in the company itself, and as an example of good practice at the regional level.

Information on these practices has been disseminated locally and internationally, receiving positive feedback. Recognition of the company's energy efficiency innovation has come from Ecuadorian organizations and from abroad, where the projects have been presented in specialized forums and applauded.

### Impact of Implemented Solution

The economic impact is one of the most relevant. In the absence of generating its own electricity, EPMAPS would have to pay the local distributor approximately \$7 million per year to purchase the energy it consumes.
The level of energy self-sufficiency is unprecedented in the country, and perhaps in the region, for a company that provides such basic services. This level of energy self-sufficiency guarantees the availability of electricity to power EPMAPS drinking water and sanitation systems, regardless of conditions in the electricity sector or at the external electricity supplier, reducing the risk of insufficient energy supply to power EPMAPS operations.

The projects exemplify the concepts of Social and Environmental Responsibility, enhancing the sustainability of the company's practices, particularly with respect to energy efficiency.

The "Self-producer" energy project can be replicated in other public companies, particularly those located in the highlands. Other municipalities and provincial governments have the potential to develop similar programs and use the energy for administrative buildings, recreation areas, traffic signaling, transportation, and education centers, among others.

The high cost of energy in the country has been due to the use of polluting thermal generation, high levels of technical losses, and lack of automation. The Self-Producers process in EPMAPS addresses this high cost of energy by optimizing resources, automating processes, and using appropriate technology.

## Investment

The average internal rate of return in these projects is greater than or equal to 12 percent. The economic values described above have been invested over a period of five years. It should be noted that the operations of the

Since 2012, the year EPMAPS obtained the	"Self-producer"	certification
by ARCONEL, investments include:		

Self-producers Phase I	US \$272,500 + VAT (Acquiring Energy Meters)
Self-producers Phase II	US \$265,000 + VAT (Acquiring Energy Meters)
Micro-central Carcelén	US \$102,571 + VAT
Mini-central Bellavista Tank:	US \$583,000 + VAT (under construction)
TOTAL	US \$1,223,071

Recovery Center of 14.7 MW, the micro-central Noroccidente of 250 kW, and the power station El Carmen of 9.0 MW were implemented in 2012, and finally, in 2014, the micro center Carcelén of 60 kW was implemented. These investments were considered as part of previous projects the company executed since 1990 and represented an investment of approximately US \$150 million.

## **Innovation Approach**

The use of appropriate technology in the development of generation micro-plants can be considered an innovation. The "synchronous generator" is, in fact, an asynchronous motor running as a generator, without requiring voltage and speed regulators, and synchronizer.

This innovation did not endanger people or undermine the integrity of the facilities, the water supply, or the operation of these generation systems but, instead, makes optimal and efficient use of equipment in meeting EPMAPS's needs. The human-machine interface (HMI) developed in a micro touch screen displays user friendly and transparent options for control of the system based on external variables.

This technological tool's high-level of flexibility in the operation of drinking water systems is far from traditional control over a single valve with limited functions. Many innovative components and engineering have been incorporated into the different phases of the projects such as: design, hydraulic turbine manufacturing, software development, and HMI.

Finally, the model for managing this type of project in a drinking water and sanitation company is totally innovative and unheard of in the country. A rating of this type in the electricity sector, an energy self-sufficiency rate of more than 90 percent, can be replicated by other national and international industries and companies.

## What Went Wrong?

Ecuador's public procurement model for micro generation projects through electronic reverse auctioning, and the limited budget allocated to the projects, present some restrictions that do not allow for the selection of construction firms with guaranteed solvency, which has repercussions on compliance with contractual deadlines and difficulties with the ARCONEL, the regulatory agency that supervises the execution of the projects. These problems were solved by having the EPMAPS team assume responsibility for carrying out more project activities which, in turn, has led to more of the project work being accomplished as planned due, in large measure, to the skills and abilities of the professional staff of the Sub-management of Hydroelectricity.

## Learned Lessons

Large and small projects must be tackled with the same rigor in the construction phase, with close supervision and rigorous control of contracts and contractors, and assigning experienced personnel to carry out technical and administrative tasks.

In the future, the drinking water and sanitation systems operation and maintenance groups should be more involved at all stages of generation project development.

Provide more time for personnel to become adept in operating and maintaining the new facilities and reinforce the training.

Allocate more economic resources to allow the selection of firms with greater solvency and experience to supply equipment and construction.

## What Comes Next

Develop new EPMAPS micro generation projects, as determined by the Sub-Management of Hydroelectricity, in the different functional stages of water treatment and distribution, including sanitation, to achieve the so-called total optimization of available water resources.

Incorporate the "Self-producer" model into the company's new facilities, through administrative management with ARCONEL and installation of energy meters with communications capability. Incorporate this model in other projects of the Municipality of Quito: Quito Subway, Cable Car System, Trolley, and particularly in the Quito decontamination project that generates 43 MW, which is equivalent to the energy demand of medium-sized cities in our country.

Establish Public-Private Partnerships that will allow EPMAPS to develop the small generation projects as part of its portfolio.

### Who to contact for more information

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### About the author

Antonio Villagómez is currently an Assistant Manager for the Metropolitan Public Water and Sanitation Company (EPMAPS) where he has worked for over 20 years in the strategic areas of drinking water and energy efficiency. His academic background as an Electrical Engineer and his MBA from the Simón Bolívar University combined with his work experience has given him ample and comprehensive knowledge in the strategic management of water resources. Additionally, he has participated in training courses in countries such as USA, Japan, Israel and Venezuela and he also has been an key note speaker at the "Latin America Small Hydro" event in Medellin and the Seminar "Electric Power Operation Specialists" in Brazil.

## QATAR

## **QATAR FOUNDATION RESEARCH AND DEVELOPMENT**

Toward an Impactful R&D Collaboration Among Industry and Academia in Qatar

## Background

Qatar seeks to diversify its economy, grow foreign direct investment, and build knowledge jobs to create resilient and sustainable ecosystems. Within this context, the vision of Qatar Foundation is to enable research and development excellence in Qatar to achieve a knowledge-based economy through the advancement of research and education by funding original, competitively selected research and development at all levels and across all disciplines, with an emphasis on the four following pillars of the Qatar National Research Strategy (QNRS):

- Energy and Environment;
- Computer Science and ICT;
- Biomedical and Health; and
- Social Sciences, Arts and Humanities.

These priority themes were identified through a consultation between Qatar Foundation Research and Development (QFRD) and the main stakeholders in Qatar (ministries, companies, and academic institutions) in 2012. The themes are aligned with the QNRS 2013 and 2014 Grand Challenges, and take into account Qatar's local R&D capacities and the global R&D landscape. The objectives of the priority themes are to focus and optimize QFRD's efforts according to the following main strategic principles:



- Diversify and develop Qatar's industry and services towards a knowledge-based economy.
- Support the development and implementation of public policies, governance, and public services in Qatar.
- Invest in a number of hotspot R&D fields in which Qatar could take some leadership, and create its own competitive advantage in the region.

## The QFRD Challenge

Within this context, QFRD has challenged itself to focus vigorously on building a strong economic ecosystem by:

- Funding targeted R&D projects aligned with national priorities and global markets;
- Encouraging and facilitating industryacademia and public-private sector collaborations and co-funding;
- Driving IP creation, technologybased product development and commercialization, and technology entrepreneurship; and

• Encouraging technology startups, and collaborating with international venture capital entities through mutual investment to attract startups to Qatar.

Collaboration between industry and academia is a critical component of efficient national innovation systems. In particular, such collaboration in R&D has been the main driver for the development of innovative technologies.

The focus on collaboration in R&D is based on the fact that industrial investments in R&D are a major driver of economic growth, and the development of capabilities in innovation, product development, and manufacturing. In addition, this collaboration is an important strategic vehicle to increase the efficiency and effectiveness of such investments.

There is strong evidence in the academic literature that suggests, on one hand, universities are more likely to collaborate with industry if the business is engaged in exploratory internal R&D, the business is mature and large, and there is a lack of intellectual property issues between the business and the university.

On the other hand, this collaboration is a source of significant R&D benefits to a company, such as the productivity of business R&D increases with university participation in the R&D process. The probability of an R&D project being commercialized increases when a university is an R&D partner, and the business's economies of technological scope increase with university involvement.

Despite these proven win-win relationships, there are still significant challenges associated with bridging cultural and communication gaps between industry and academia. For instance, the conflict between industrial trade secrecy and traditional academic openness is a major impediment to such collaborations.

In the following sections, we describe the QFRD strategy and action plan that were developed to positively deal with this challenge.

## The QFRD Response to this Challenge—Strategy Formulation

The Qatar Foundation and QFRD tackled this challenge in two distinct phases by first building on a strong foundation (2006–2015) and then focusing on impact (2016+).

# Phase 1: Laying R&D Foundation (2006-2015)

- Creation of Qatar National Research Fund
- Creation of Branch Campuses
- Founding of Research Institutes
- Creation of Qatar Science and Technology Park

- Establishment of QFRD
- Establishment of Office of Intellectual Property and Technology Transfer
- Initiation of Qatar National Research Strategy 2012 and articulation of the Grand Challenges
- Launching Arab expatriate scientists forum to attract top elite experts to Qatar

During this period, QFRD spent millions of US dollars through its research fund to support investigator-led academic research in more than 50 countries. This increased Qatar's profile, and attracted scholars and students. For instance, from a limited initial pool in 2006, the number of researchers has been multiplied by 25, and the number of publications in referenced journals has been multiplied by 40.

However, these efforts have not contributed similarly to bringing solutions to Qatar's priority needs or broader commercial markets and resulted, generally, in Technology Readiness Levels (TRL) on the order of 1-3 with little identified intellectual property (IP).

### Phase 2: Focus on Impact (2016+)

- Identify subjects and sectors where Qatar can have a competitive advantage
- Focus funding on these priority areas
- Promote participation of private and public sectors

- Drive and enhance innovation, commercialization, and entrepreneurship
- Focus capacity building programs on priority areas

These shifts are driven by the following six (06) QFRD strategic objectives:

- Lead the effort to update the R&D strategy, in conjunction with stakeholders;
- Fund targeted R&D projects which are aligned with national priorities and global markets;
- Encourage and facilitate public/private sector collaboration and co-funding;
- Drive IP creation, technologybased product development and commercialization, and technology entrepreneurship;
- Contribute to enhancing internal capabilities, sustainability, and synergy across Qatar Foundation; and
- Support the creation of an enabling environment for R&D.

Consequently, QFRD is laying the foundation for the value chain to move research to markets, with a clear emphasis on the "D" in "R&D". This is illustrated in the following diagram.



### The QFRD Response to this Challenge—Strategy Implementation

The action plan consisted of three distinct steps:

# Step 1: Stakeholders Engagement and Research Funding Revamped

Qatar's Ministries, state-owned companies, and private sector stakeholders identified national priority needs. A solicitation for research proposals permitted only proposals that addressed those needs and solutions at a higher TRL level with industry participation. QFRD encouraged the private sector to co-fund the R&D projects. Proposals with cash and/or in-kind contributions from collaborations of industry and academia (to ensure relevance) were ranked higher. Awardees and industry partners could own undivided shares of resulting inventions jointly with the Qatar Foundation.

## Step 2: Hot Spot analysis

Kompass, a new software tool, was developed to identify specific topics within the identified priority needs where there were possible "white spaces" and areas of global commercial interests. This enables proposals to be further focused on both Qatar's needs and global market potential. It consists of a database of every patent and publication submitted globally in each of the four areas of national need, and accompanying market analyses. Kompass users can interrogate this data on 43 parameters, for example, to identify the most recent advances in hundreds of specific areas, or find "white spaces" where connections are still needed to fill gaps in knowledge. More than 99 percent of submitted research proposals are aligned with the priority themes identified.

Kompass is now used by research institutes to help them set their research agenda by focusing on areas where "breakthroughs" are possible (the white spaces) and commercial interest is high.

### Step 3: New programmatic Reviews

New programmatic reviews were added to the funding decision process. These reviews, which consist of panels of industrial experts, academics, and researchers, are an essential component of the industry-university collaboration.

## Performance of the Revamped Stakeholder Engagement and Research Funding

In spite of the arguments that no entity would respond to such a focused solicitation in which industry collaborators and cost-sharing were treated with priority, the entities of the "triple helix" in Qatar (public, private, and academia) have become more united and reliant on each other, and the results are overwhelming and extremely positive. For instance, for the first time in the existence of R&D in Qatar, \$30 million (USD) were committed as in-cash and in-kind cost-share contributions to research proposals. The number of proposals received in this solicitation did not vary from the number received in earlier cycles before the changes. QFRD also undertook efforts to drive IP creation, and technology-based product development and commercialization. These include launching a Technology Development Fund to move inventions to higher levels of readiness to enhance their value, and encouraging small and medium-sized enterprise product development through a new Product Development Fund.

QFRD also continued efforts to build capacity in entrepreneurship, and initiated the creation of a start-up and venture capital ecosystem. These include launching a Research-to-Start-up program to bridge the gap between research projects and new start-ups, and an accelerator program. Qatar Foundation signed an agreement with the Silicon Valley-based 500 Start-ups investment fund, a global venture capital seed fund with a network of start-up programs.

Ten (10) new start-ups have been incorporated, nine (9) new teams of entrepreneurs have participated in the accelerator program, and five (5) agreements have been signed for the new Product Development Fund.

## Barriers to Industry-Academia Collaboration

In embarking on this new strategy, we know from literature and practice, there are many barriers to university-industry collaboration, such as:

• The research objectives of companies and universities are often misaligned, with a major focus on fast commercial results in companies and on basic research in universities. Therefore, each sector has a different approach and incentives to measure and improve performance.

- In terms of outputs, companies are usually interested in how quickly new patents can be obtained or new products developed, and want to delay publications to avoid disclosing information. In contrast, researchers are typically motivated to publish research results as fast as possible.
- There can be a mismatch in expectations about intellectual property (IP). While academia often prefers more openness with regard to research results, industry is concerned about secrecy and making a profit from IP. Therefore, contracts need to be established in a commercially timely manner that ensures the ability to commercialize with appropriate returns.

Beyond those barriers, QFRD has experienced additional hurdles, including resistance to transitioning from "investigator-led" solicitations to requiring that proposals address specific research with impact. Development and demonstration projects have created resistance among the academic research community, who alone had been the recipients of prior grants. In industry, commercialization strategy is a crucial component of the business plan as it drives the process.

## Conclusions

The enthusiastic response of industry to this collaboration and co-funding has been very successful. It has resulted in the drafting of a new solicitation for specific technological solutions to Qatar's needs, in which industry will be allowed to serve as the lead program investigator as long as the company has a certified Research Office. Qatar's state-owned and private industries have come to appreciate what academia has to offer them. In addition, entrepreneurship is becoming a major component of our R&D ecosystem.

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### About the Organization

Qatar Foundation for Education, Science and Community Development (QF) is a private, non-profit organization founded in 1995 by His Highness Sheikh Hamad Bin Khalifa Al-Thani, the Father Amir. Chaired by Her Highness Sheikha Moza bint Nasser. QF is guided by the principal that a nation's greatest resource is the potential of its people, and aims to develop that potential through a network of centers devoted to progressive education, research, and community development.

Qatar Foundation Research and Development is leading the effort to make Qatar in international center for research and development excellence and innovation. It is home to the Qatar National Research Fund, a globally renowned scientific research funding organization, and the Qatar Science & Technology Park, a world-class hub for technology innovation and commercialization.

## **UNITED STATES**

## COUNCIL ON COMPETITIVENESS

Leverage: Advancing U.S. Bioscience Production

## Introduction

U.S. leadership in the technology of biology presents our nation with tremendous opportunity to build the world's preeminent bioeconomy by delivering novel products and processes to society more sustainably and efficiently. Many nations around the world, however, are acting fast to build their bioeconomies and surpass U.S. scientific and technological dominance to reap the national security and economic benefits of leadership.

Advances in biological sciences hold tremendous promise for realizing solutions to today's challenges, from protecting the population from biological threats and securing access to affordable, sustainable energy to realizing the promise of precision therapies, achieving dramatic improvements in agriculture and materials, and maintaining the health of people and the planet.

Biomanufacturing and production can transform existing industries and create new ones that are more profitable, sustainable and efficient than the status quo. Similarly, smart and modular manufacturing offer significant benefits in terms of customization, precision therapies, more powerful healthcare instruments, and more nutritious food products and sustainable food production.

The United States has pioneered much of the advancements in biosciences. Foundational work in biology, from the **Human Genome** 



**Project** to early advances in synthetic biology, benefitted from significant U.S. federal investments.

These investments directly led to current assets like the U.S. Department of Energy's **Environmental Molecular Sciences Laboratory** and its **Joint Genome Institute** that have extended the progress in biological sciences beyond human health to advance research in plants, microorganisms and ecosystems.

These are innovation engines for the nation's leading scientific research experts, not just with bioscience technology, product and material design, but also with advanced manufacturing and data management. Public-private partnerships in smart manufacturing and digital manufacturing are offering enabling technologies that can ignite scientific discoveries and technological advancements for the future.

Groundbreaking innovations in biology are already happening in American companies, universities and national labs. For example, the **Joint BioEnergy Institute**, a government funded partnership among national laboratories and universities, is leading the way in the development of advanced biofuels and bioproducts from U.S. biomass—a market potentially worth more than \$700 billion for the United States. Jets are already flying with cleaner and more efficient fuels based on discoveries at the institute.

But other countries are investing much more aggressively and more strategically in supporting the growth of their bio production economies. Dozens of countries around the world, from China and the United Kingdom to Thailand and the Netherlands, have published well-defined bioeconomy roadmaps that identify opportunities, potential bottlenecks and roadblocks, and strategic areas of investments. The United States has yet to identify a similar set of strategic investment priorities.

To take full advantage of the potential in biosciences for the United States, and to capitalize on the advancements that have been realized, there must be a seismic shift in the way policymakers approach funding and regulating biosciences and biomanufacturing. Likewise, academia and industry must demonstrate to the American public the current and future value of advanced biosciences to U.S. prosperity.

We cannot hope to make advances without a strategic, aggressive, focused and coordinated effort to reduce silos and identify synergies among federal agencies, industry, universities and our national laboratories. Cross-sector collaboration to advance this key sector of the U.S. economy is critical. Organizations such as the Council on Competitiveness are bringing together leaders from these groups to pave the path forward for competitiveness in bioscience and its manufacturing potential. But more must be done at the federal level. The Council recently published a report that calls on policymakers in the Trump Administration and Congress to take action in the following ways.

- First, develop an annual strategic roadmap for the advancement of bioscience and biotechnologies to meet energy, environmental, agricultural, national security and economic goals.
- Second, coordinate investments across agencies, broaden disbursement to cross-disciplinary fields and focus federal investment in the development of research platforms that more quickly deliver solutions to society.
- Third, enable bioscience research platforms to deliver novel capabilities to industry that would, otherwise, be cost-prohibitive.
- Finally, facilitate the nexus of biology, engineering, and manufacturing technology and training.

Significant progress must be made. With continued cross-sector partnerships, a coordinated effort, and a renewed faith in the promise of science for a better future, bioscience-based production and manufacturing can transform our economy and position America as a global leader in technology and innovation.

## **Takeaways & Recommendations**

Develop an annual strategic roadmap for the advancement of biosciences, biotechnologies and bio-production to meet energy, environmental, agricultural, national security and economic goals. The Office of Science and Technology Policy (OSTP), research agencies, industry, national laboratories and academic experts should partner for the purpose of creating a Bioeconomy Roadmap to be implemented as a top economic priority for the Administration.

Create tools and processes that capture and analyze basic and applied research data, private sector and government-funded activities, and community feedback on the Bioeconomy Roadmap's goals, objectives and milestones. With the 2012 White House National Bioeconomy Blueprint as its foundation, a performance indicator document is needed to review the progress of various aspects of bioscience research on a yearly basis. Information pertaining to the success of policy and science programs such as data analysis, workforce development, regulatory barriers and future federal activities will leave researchers better equipped to establish areas of improvement and increase public awareness of the importance of the bioeconomy.

Coordinate investments across government agencies, broaden disbursement to cross-disciplinary fields, and focus federal investment in the development of research platforms that more quickly deliver solutions to society. The diversity of bio-based products cuts across multiple industries like medicine, food, renewable energy, agriculture, and many more, creating challenges when coordinating investments. A lack of investment among cross-disciplinary fields or in a diverse collection of industries may inhibit promising advancements, therefore hindering forward movement for bioscience as a whole.

Address the issue of public distrust of science and regulation by raising awareness, and increasing education and outreach efforts to the public and policymakers. The public perception of bioscience as a whole is incredibly important to moving forward, and scientists must remain ethically grounded to gain public trust. Combatting uninformed, negative perceptions requires improving U.S. scientific literacy through an education and outreach program that includes STEM education and progress metrics.

Provide opportunities and incentives for stakeholders to determine next generation bio-targets that biotechnologists can use to reinvent products and make them marketable to consumers. The notion of using biotechnologies to recreate products with next generation applications, such as chemicals and fuels that release fewer toxic gases into the atmosphere, simply do not have a strong enough economic value that will appeal to the consumer. Biotechnologists need a target with both next generation properties and next generation values to succeed in the market.

Develop widespread and easily accessible knowledge bases of principles, methods, processes, successes and failures to more quickly deliver helpful information to stakeholders. Industry access to central scientific and technical resources will help experts develop and deliver new, innovative products to the market. This will improve the maturation and impact metrics of the bioeconomy and assist in the technology innovation pipeline from development in the laboratory to scaling-up in manufacturing plants on to consumer outlets.

Enable bioscience research platforms to deliver novel capabilities to industry that would, otherwise, be cost prohibitive. From start-ups to large companies, academic and agencies' scientists, federal and industry investments in research platforms and bioscience knowledge bases will help overcome the steep barriers to entry for biomanufacturing and product development.

Address the talent gap in multidisciplinary areas where bioscience has evolved to require frequent translation of information, updating of codes, and data management skills in high performance computing. The bioscience talent pipeline has significantly transformed and now demands non-traditional biologists who have trained skills in multidiscipline areas. There must be a frank dialogue among industry and academic leaders about workforce development so we can reestablish training and employment opportunities for graduating students and continue to expand science beyond its current capabilities.

## Setting the Stage

Research and development in bioscience plays a current and active role across many industries. From improving U.S. manufacturing competitiveness to advancing technologies for energy, the environment, human health and agriculture, advances in bioscience are vital to remaining on the cutting edge of technological development and to enhancing American prosperity.

In recent years, policymakers have consistently demonstrated support for efforts to better coordinate, and strategically plan and invest in bioscience opportunities across agencies, industry, national laboratories and academia. The White House Office of Science and Technology Policy (OSTP) has been a strong advocate for the potential of this field as evidenced by a number of programs and initiatives, including:  The National Bioeconomy Blueprint, which signaled to researchers, industry and policymakers the important role of bioscience research for American innovation as a major driver for



economic growth, job creation, a healthier environment and stronger communities;

 The Precision Medicine Initiative (PMI), which seeks to revolutionize modern medicine to improve health and effectively



treat disease through innovative medical treatment methods tailored to a patient's genetic makeup, environment, lifestyle and other key characteristics;

 The Brain Research through Advancing Innovative Neurotechnologies (BRAIN) initiative, launched in 2013 to



pave the way for biological discoveries and future scientific achievements in the way we prevent, treat and cure brain disorders; and • OSTP announcement for a new National Microbiome Initiative (NMI) to foster the integrated study of microbiomes and support interdisciplinary research, develop platform technologies and expand workforce in this key area.

These initiatives identify some of the opportunities and benefits to the nation that bioscience may deliver with better integration, collaboration, sharing, the building and exploiting of existing competencies among stakeholders, and new investments in people and resources. They are not necessarily, however, roadmaps that can guide policymakers, as they make funding and programmatic decisions across the larger breadth of bioscience and biotechnology development.

The nation's siloed approach to research and development among multiple agencies and departments, and among multiple Congressional committees makes the development of a common and useful roadmap across the government very difficult to develop and implement. Unfortunately, this gap has international competitiveness implications, and stymies U.S. economic activity and growth.

## A Global Competition

Bioscience already plays an integral role in the U.S. economy. It has the potential, however, to play an even larger role in enhancing U.S. competitiveness if the nation undertakes a more sophisticated and integrated approach to strategic planning and collaboration that includes increasing targeted investments and developing clear goals and objectives.

A number of countries have recognized the importance of undertaking such an approach and have developed strategic plans and detailed roadmaps with the clear goals, objectives and milestones needed to strategically advance the bioeconomy. One such example is China's 12th Five Year Plan, which calls for hundreds of billions of dollars in funding for research and development in biopharmaceutical, bioengineering, bioagriculture and biomanufacturing R&D. The plan aims to strike the right balance between the seed corn of basic science and the technology development needed for commercial application.<sup>1</sup>

The United Kingdom has also invested resources in building a world-leading bioeconomy. The U.K.'s roadmap *Annual Energy Statement 2012*, issued by the government, looks at the opportunities and challenges of biotechnologies from basic



science challenges to real world applications,

1 Full Translation of China's 12th Five-Year Plan, The CBI, 2011.

regulatory considerations, and health, safety and environmental issues.<sup>2</sup> Although funding allocated to these efforts in the U.K. is significantly lower than in China, the U.K.'s access to top talent, focused approach and clear deliverables are helping to build a strong foundation of scientific leadership and entrepreneurial progress.

In comparison, the United States lacks a unifying roadmap and its efforts are often uncoordinated and disjointed rather than strategic and long-term. The absence of a clear and coordinated approach leaves individual agencies, companies and researchers uncertain about which investments and which lines of inquiry may bear the most fruit.

### Stakeholder Dialogue

### Advancing U.S. Bioscience-Infrastructure

As a global leader in engineering biology and biotechnology development, the United States has developed extensive infrastructure to support development in bioscience. One of the foundations of this infrastructure has been the U.S. Department of Energy's national scientific user facilities, which act as creation hubs for the nation's leading scientific research experts, igniting scientific discoveries and technological advancements for our future. By bringing together multi-disciplinary researchers, these facilities enable a

<sup>2</sup> Annual Energy Statement, 2012, U.K. Department of Energy & Climate Change, November 29, 2012.



The third fastest supercomputer in the world, Titan, is in Oak Ridge, Tennessee, USA. Photo courtesy of Oak Ridge National Laboratory.

level of scientific research that goes beyond the means of most individual corporations or universities.

U.S. advanced capabilities in high performance computing (HPC) are another key component of the bioscience infrastructure. Modern day bioscience research is increasingly dependent on the accumulation and manipulation of huge sets of data, rendering HPC the backbone of bioscience infrastructure in the United States. The Department of Energy's Office of Science Advanced Scientific Computing Research (ASCR) program funds high-end computing centers at U.S. national laboratories. Also known as "supercomputers," these world-class scientific user facilities support researchers from around the country, from academia and industry, by providing cutting edge computing and computational resources, as well as expertise in data management and analytics, modeling and simulation essential to building the bioeconomy.

Despite the extensive infrastructure available to support innovation in the bioeconomy, partnerships must continue to grow and mature across the board, and ensure quicker and more robust facilitation of the exchange



The fourth fastest supercomputer in the world, Sequoia, is in Livermore, California, USA. Photo courtesy of Lawrence Livermore National Laboratory.

of information, not just among industry and government partners, but among and within agencies of the federal government. The Obama Administration's 2012 National Bioeconomy Blueprint highlights various aspects of bioscience research that must be improved including workforce development, better transitioning breakthroughs from lab to market and addressing regulatory challenges.

Progress on infrastructure development must also include strengthening the entire technology innovation pipeline from research and development in the laboratory to scaling-up in manufacturing plants and on to consumer outlets. The biotechnology industry currently has a disconnected development pipeline in which the many stages within the development-deployment cycle often include multiple destinations or transportation of materials, unnecessarily lengthening the overall process.

Developing and maintaining the relevancy and leadership of the nation's infrastructure for bioscience and other research disciplines requires a multi-stakeholder approach that includes input from the scientific community, industry, academia and government. Sustained, long-term investment in this field, however, is the key to ensuring the nation's



The fifth fastest supercomputer in the world, Cori, is in Berkeley, California,United States Photo courtesy of National Energy Research Scientific Computing Center.

bioscience infrastructure is accessible to users and robust, reliable and relevant to today's science and technology development challenges. This requires a strategic roadmap for the bioscience community, federal agencies and other partnering entities detailing the status of current initiatives, providing feedback on performance, drawing incentives for future funding opportunities and influencing the direction of future innovations.

## Advancing U.S. Bioscience— Technology

The ideal future of biotechnology is one in which bio-based products are designed with a greatly accelerated research and development process with less trial-and-error, generated from renewable materials and developed into final products complete with advanced properties like self-repairing capabilities or easy recyclability. If the United States can manage to transcend persistent barriers including misinformation, regulatory hurdles, siloed research and development,



Bioscience Area equipment at Lawrence Berkeley National Laboratory

and underinvestment, biotechnology has the potential to advance scientific innovation and human knowledge in ways unimaginable.

In general, biotechnologists face a number of challenges that complicate their ability to remain innovative. One of the most significant challenges to product development in biomanufacturing is designing for utility while also allowing for continuous improvements in performance. For example, new molecules designed with emissions reductions as the primary consumer benefit are unlikely to see long-term market success without also holding the potential to improve or enhance the product's performance. The economic driver or financial incentive is often insufficient without a concurrent enhancement in utility. Unlike consumer electronics such as cell phones or computers in which innovation and performance enhancement are often visible, simply replacing a petrochemical with a biobased, similarly priced version is not likely to draw the attention required to drive market adoption. Biotechnologists need to design new products not only with these next-generation properties, but also with next-generation value required to succeed in the market.

One way to better align priorities and capabilities of new bioproducts is through the development of a comprehensive, open database for scientists to share solutions in a common space. Design outline templates are needed to build products, modeling and data analytics are needed to turn a design into a realistic product and, more importantly, there is a common need for automation along the molecular biology pipeline. Availability of a computer-designed molecular application could reduce the margin of error and make dissemination of new, innovative products widely scalable and automatic.

The competitiveness of U.S. biotechnology could also benefit significantly from the development of sensor and detection technologies that allow researchers to better understand the properties of microbiomes and their potential benefits. The same sensor and detector technologies could also allow researchers to understand and engineer new, sustainable bioproducts with greater precision and effectiveness by monitoring biological production. These technologies will be critical to developing bioproducts that provide real-world solutions to challenging issues in sustainability and drive American competitiveness.

## Advancing U.S. Bioscience— Investment

The bioscience industry has the potential to become an even larger player in the U.S. economy than it is today. With an influence on energy, modern medicine, the food industry and many other sectors of our economy, the diverse bio-based products discovered and invented affect various areas of our daily lives. Unfortunately, this wide diversity leads to challenges in coordinating and collaborating investments. Despite the obvious benefits to U.S. competitiveness of investing in the bioeconomy, there are a number of challenges that stifle investment. Accelerating the pace of the bioeconomy requires incentivizing potential investors who may be reluctant to finance research and development in this area due to the long time horizons for return on investment compared to other fields. There is also the persistent question of whether to solely fund large, notable institutions or smaller, start-up entities.

In addition to these barriers, funding from different government agencies tends to favor specific components of bioscience rather than the entire industry as a whole. This method may be beneficial for specific industries; however, a lack of disbursement among cross-disciplinary fields or a diverse collection of industries may leave some promising areas under-resourced. This approach also tends to leave fundamental platforms that broadly enable bioscience research, such as technological development, disproportionately underfunded and therefore underdeveloped. Investment in technology development can drive the development of technological platforms that can be multi-purposed across the entire bioscience spectrum to create standard processes for biological engineering.

Coordinating investments across agencies to finance cross-disciplinary initiatives could distribute the costs associated with area-specific

research and disrupt the current stakeholder fragmentation. A key challenge with coordinating investments include maintaining an agency's mission such that the types of research and development funded do not significantly overlap with another agency's mission space. Agencies also face challenges in collaborative funding because legislation mandates the funding mechanisms agencies can use, such as grants and cooperative agreements, and prevents pooled funding for large-scale challenges. While some of these challenges will need to be overcome through legislation, agencies can be encouraged to coordinate funding to address common goals. Additionally, agencies can be encouraged to fund the development of platform technology solutions that are broadly enabling in addition to the mission-specific research they already fund.

## Advancing U.S. Bioscience—Talent

In an age in which biomarkers are now being used to detect disease in humans and animals, and disruptions in plants and ecosystems, both of which have major implications for the future of society, attracting and retaining the right talent for the bioscience field is crucial. The talent pipeline for this field is one that has significantly transformed in recent decades. With that comes a high demand for trained biologists with multi-disciplinary backgrounds capable of navigating a broadened knowledge base. Many of the challenges to expanding expertise in this field circulate around the idea of providing the platform for college students to transition effectively from the classroom to the industry under cross-disciplinary leadership. Students with combined knowledge make for more well-rounded professionals who are skilled in operating at intersections of biology such as bioinformatics. Traditional laboratory biology on its own is no longer an effective model as the demand for computer-savvy biologists trained with the computing skills necessary to develop data management and analysis tools continues to grow exponentially.

There are a number of reasons for the persistent skills gap in areas such as biomanufacturing and bioprocess engineering, including previous shifts in federal funding which left bioprocess engineering faculty at universities across the nation without the means to continue researching and developing breakthroughs. Consequently, in recent years there have been few students trained in bioprocessing technology and even fewer experts in the field. Of the few who currently major in this area and move on to the profession, most of their career training takes place inside the companies they go on to work for, leaving significant gaps in this talent pool and a negative impact on development in biotechnology overall.

The current state of industry is not reflective of the changes that need to take place to encourage incoming talent. The translation of information, updating of codes and the communication of data between biologists, engineers and physicists are currently disrupted, making it difficult to attract students to work at this nexus of biology, engineering and manufacturing.

Of all the challenges that exist around finding the talent to fill jobs in bioscience, perhaps the most important is that science is not often hailed as a heroic or public service profession, a serious issue for U.S. competitiveness. Without science, individuals such as nutritional scientists who study to fight world hunger may never exist, biologists who research rapid diseases may not be successful in creating cures, and engineers who manufacture renewable energies may not be able to help preserve our environment. Advancing the current talent pool and drawing interest from multi-disciplinary backgrounds would enable the expansion of a diverse collective of professionals needed to discover and innovate in the area of bioscience for generations to come.

## About the Energy & Manufacturing Competitiveness Partnership (EMCP)

The bioscience and production sector study is part of a larger initiative of the Council on Competitiveness known as the Energy and Manufacturing Competitiveness Partnership (EMCP). The EMCP unites Council members



to focus on the shifting global energy and manufacturing landscape, and how energy transformation and demand is sharpening industries critical to America's prosperity and security.

The EMCP taps into a diverse membership of leaders from business, academia, the national laboratories and the labor community to understand the discrete and distinct



challenges critical sectors of the U.S. economy face in the energy-manufacturing convergence and how decision-makers can bolster the critical pillars of competitiveness—technology, talent, investment and infrastructure.

Over the course of the three-year EMCP, the Council will develop an ambitious roadmap to focus national attention on the intersection of energy and manufacturing. Through a range of activities and dialogues such as the EMCP water and manufacturing sector study workshop, the EMCP will deliver action-oriented recommendations to decision-makers at the highest levels of government and industry.

#### Who to contact for more information

Mr. Chad Evans Executive Vice President, Council on Competitiveness cevans@compete.org

#### About the Council on Competitiveness

For more than three decades, the Council on Competitiveness (Council) has championed a competitiveness agenda for the United States to attract investment and talent, and spur the commercialization of new ideas.

While the players may have changed since its founding in 1986, the mission remains as vital as ever—to enhance U.S. productivity and raise the standard of living for all Americans.

The members of the Council—CEOs, university presidents, labor leaders and national lab directors—represent a powerful, nonpartisan voice that sets aside politics and seeks results. By providing real-world perspective to Washington policy, the Council's private sector network makes an impact on decision-making across a broad spectrum of issues, from the cutting edge of science and technology, to the democratization of innovation, to the shift from energy weakness to strength that supports the growing renaissance in U.S. manufacturing.

The Council's leadership group firmly believes that with the right policies, the strengths and potential of the U.S. economy far outweigh the current challenges the nation faces on the path to higher growth and greater opportunity for all Americans.

## GLOBAL

## Webster University

## The Challenge

Throughout Webster University's history, it has innovated to meet unmet educational needs. Over more than one hundred years, Webster has expanded its student population in increasingly inclusive ways. From its 1915 beginnings as a Catholic women's college, Webster's population has grown to nearly 16,000 students, including men and women in classrooms and online in the United States. Europe, Asia, and Africa. An early innovator in taking education to students, Webster has developed campuses across the United States and in Europe since the 1970s. The challenge then and now is to use emerging technologies to connect diverse students and campuses across geographies and borders, promoting education and innovation at the local level (GFCC 2016 edition of Competitiveness Principles). As a result of Webster's changing geographies, and evolving community needs and demands, the technologies employed to address this challenge have expanded and become increasingly sophisticated

## The Practice

By the 1990s, Webster had established campuses at military bases and metropolitan sites in the United States, as well as American-style residential campuses in Europe and Asia. While faculty, staff, and students could interact with individuals at the other



campuses by physical travel and study abroad, uses of technology to engage students across the campuses had not yet been explored.

In January 1998, Webster launched the Collaborative Teaching and Learning Pilot Project, which offered five courses to students at all of Webster's European campuses and six U.S. campuses. These courses were designed to "use internet technology to link students and faculty so they can share perspectives through discussion groups, case studies and small group assignments" ("World-Wide Collaborative Learning Project: What the Project Is and Is Not"). Participating students enrolled in multiple face-to-face sections across state and international borders, collaborating in online exchanges. The following year, 1999, Webster offered its first six online classes in either the MBA or the MAT programs to any Webster student. Soon afterwards, a completely online MBA degree program and two fully online majors in the MAT-multidisciplinary studies and education technology-were launched ("Webster

University A Century of Defining Moments" 98). Online offerings have since grown to more than 60 programs, serving thousands of students. Thus, Webster, the leader in establishing global campuses to meet local needs of international students and U.S. service members, led again in establishing fully on-line courses and programs. Due to differences in time zones among all of Webster's campuses, Webster's programs have typically focused on asynchronous web-based solutions and approaches.

Within the past five years, Webster has again innovated with emerging technology solutions by installing a Global Wide Area Network (WAN) and video-enabled classrooms, and launching the WebNet+ (Webster Networked) channel of live video instruction. Technology innovations make it possible for instruction to originate from specialist faculty at any campus and be delivered to students distributed globally. Courses, certificates, and degrees can now function in synchronous and asynchronous modes. These technologies support academic programs, collaborations, presentations, and operations.

This best practice case focuses on Webster's evolving use of emerging technologies to meet the challenge of strengthening the education and ongoing connections of a globally diverse community in substantive and engaging ways. Webster is currently ranked first in the State of Missouri and sixth among all private institutions in the United States for the quality of our online programs (Accredited-SchoolsOnline.org).

### Leaders, Enablers, Innovators, Investors

Faculty at Webster University have always been key stakeholders in pioneering teaching strategies using technology. The early adopters of the mid-1990s were primarily faculty members in the School of Education and the School of Business and Technology. Their early enthusiasm for meeting the needs of students at a distance and remaining competitive in an increasingly technologically connected world evolved into strong asynchronous online degree programs, with those in business the most ubiquitous. Faculty members' ownership and focus on quality was supported by administrators who saw the value of technology to serve Webster students completing their degrees in sites across the United States and on Webster's European campuses. Faculty and administrators recognized that students needed to gain comfort with advanced technologies to contribute to an increasingly connected world. Online education was tapped for "the benefits it could provide to working adults, military personnel and even faculty members" (Schlereth 10). Faculty enthusiasm for new technologies continues to be strong.

HUMBLE

### Webster UNIVERSITY Timeline of Events

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Webster was founded and opened with five students in St. Louis, Missouri

#### MEETING Global Needs

Webster celebrated its 75th anniversary, offering programs in 11 urban education centers and 37 military bases in the United States, Bermuda and Iceland as well as American-style residential campuses in Europe and Asia.

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1990

#### NATIONAL SCIENCE

The National Science Foundation grant funded Internet connectivity to the U.S. extended campuses to move from dial-up modem to a managed wide area network.

### 1999

ONLINE

Webster University offered its first six online classes in the MBA or the MAT programs to any Webster student. Soon afterwards, a completely online MBA degree program and two fully online majors in the MAT or multidisciplinary studies and education technology were launched.

### 2011

#### CONSISTENT Network Connectivity

Webster entered a new \$12 million partnership with AT&T in 2011. This partnership provided more robust and consistent network connectivity and services across the Webster global system of campuses, and further strengthened our desire to build a global community.

## 2015

WEBNET+

The first set of WebNet+ classes launched, primarily connecting campuses across the Eastern United States. A total of 14 campuses were involved as hosts and satellites, serving 92 graduate business and management students.

#### EXPANSION Outside St. Louis

An early innovator in taking education to students, Webster developed campuses across the United States and in Europe.

### **1996**

1970

#### UNIVERSITY Library Passports

Provided a virtual library of research tools and journal access to Webster students worldwide who needed campus library support for instruction at more than 60 extended sites.

1998

COLLABORATIVE Teaching & Learning Pilot

Offered five courses to students at all of Webster's European campuses and six U.S. campuses. These courses were designed to "use internet technology to link students and faculty so they can share perspectives through discussion groups, case studies and small group assignments"

2000

#### WORLDCLASSROOM

Webster University's Online Campus, with more than 500 enrollments in online programs. WorldClassRoom is fully online, asynchronous certificates and degrees at both the graduate and undergraduate levels.

### **2012**

#### WEBSTER NETWORK of Campuses

Webster adopted a new website that aligned Information Technology, Global Marketing and Communications, and recruitment in a mobile-optimized web environment. These changes accompanied a new VOIP-enabled telephonic system.

2017

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WebNet+ Past Two Years.

Growth was explosive over the first two years of WebNet+ delivery. By Fall 2017, more than 800 students were served per term, attending from 37 different campuses, as well as some students attending from home. More than 200 different faculty have been trained and taught via WebNet+ Critical to Webster's capacity for offering high quality online programs are the University Library, the Online Learning Center, and the Information Technology Division. While each of these units is housed at the St. Louis campus, they serve the Webster worldwide community of faculty, staff, and students. The University Library Passports access system first became available in 1996. This system provided a virtual library of research tools and journal access to Webster students worldwide who needed campus library support for instruction at more than 60 extended sites. While this distribution of students in faceto-face classes predated the development of distance education programs, the transition that Webster made from "decentralized. library collections to centralized, integrated library collections and services" (Rein and Staley 196) was important for online instruction. Today, the Webster Library offers an entire suite of resources and services for online students (library.webster.edu). The library now spends 85 percent of the \$1.5 million materials budget on electronic resources and always selects an online format if available.

In 2000, Webster University created an entity called WorldClassRoom, Webster University's Online Campus, with more than 500 enrollments in online programs. Initially, WorldClassRoom enabled graduate courses, in-service workshops, and an undergraduate program in web site development. While the learning management system and the ways students access our online portal have changed over the almost 20 years of implementation, the mainstay of WorldClassRoom is fully online, asynchronous certificates and degrees at both the graduate and undergraduate levels. These courses follow a weekly schedule, are taught by the same distinguished faculty as those who teach face-to-face, and result in the same accredited credentials.

Webster's Online Learning Center (OLC) provides the leadership, direction, and a range of support services to faculty, staff, and students. The OLC coordinates support and information for online students with various offices such as admissions, registration, and advising. In addition to administering the daily operations of WorldClassRoom, the OLC works with academic departments to develop plans and strategies for the delivery of online courses and programs. With a cadre of in-house specialists, the OLC assists faculty in the development and delivery of online courses, including training, instructional design, course development, and online technical support. This investment in Webster's talent and capacity has grown over time, now totaling 27 full-time Online Learning Center administrators and staff members.

In addition to providing support for faculty in the form of course design and delivery, Webster University compensates faculty members who create a new course. As faculty perfect courses over time, these models are then used as "clones" for multiple sections. Class size for online sections is purposefully managed to mimic the small class size for face-to-face classes at Webster, typically between 15-20 students per section.

Investments in technology have accompanied the growth in Webster's capacity for high quality online learning that bridges state, national, and continent borders. In 1997, a National Science Foundation grant funded Internet connectivity to the U.S. extended campuses to move from dial-up modem to a managed wide area network. With growth in the Webster network of campuses, increased usage by our community, and advances in technology, further investments were needed. In 2012, Webster adopted a new website that aligned Information Technology, Global Marketing and Communications, and recruitment in a mobile-optimized web environment. These changes accompanied a new VOIP-enabled telephonic system. Recognizing the need for greater network bandwidth, increased speeds, and the desire for new technologies including videoconferencing, Webster entered a new \$12 million partnership with AT&T in 2011. This partnership provided more robust and consistent network connectivity and services across the Webster

global system of campuses, and further strengthened our desire to build a global community.

In the years leading up to the 2015 creation of the WebNet+ live video class model, several campuses and faculty had experimented with video using existing classroom technology and WebEx conferencing software. St. Louis faculty engaged with students in Europe via WebEx during a series of business seminar classes. Campuses in Florida connected distant students with professors in Orlando when a class they needed did not run on their local campus. In each of these cases, faculty were self-motivated, self-taught, and received mostly ad-hoc technical support. Yet, faculty and students saw value in live video interaction.

## WebNet+ Campus to Campus + Online



Due to their early successes and expressed interest in expanding offerings and support, Webster's leadership assembled a cross-functional team to investigate and systematically implement a pilot of live video-enabled classes connecting students and faculty across the global network of campuses. This kind of delivery introduced complications for the student information system, student billing, financial aid, student scheduling, faculty staffing, and support. Therefore, the pilot leadership team included faculty from multiple colleges and campuses, as well as staff members who would facilitate the faculty training, class scheduling, technical support, back-end technical modifications, as well as student registration and billing.

Recognizing that the introduction of this new technology into a distributed network of campuses would be challenging, the leadership group used a form of Agile project management to rapidly design, pilot, evaluate, and improve processes and technologies. New designs were tested each term, resulting in iterative improvements over time.

In Fall 2015, the first set of WebNet+ classes launched, primarily connecting campuses across the Eastern United States. A total of 14 campuses were involved as hosts and satellites, serving nearly 100 graduate business and management students. These early classes served students who did not have a required class delivered at their local campus and who preferred the live experience over asynchronous online delivery. One of the business classes connected St. Louis students, fully-online students, and students in Leiden, Netherlands and Geneva, Switzerland in a Business Communications seminar. offering rich international perspectives to all students

Pilot classes received positive reviews, while also generating requests for improvements in technology, pedagogy, and support. The entire system needed to be adapted to this new learning environment. Students and faculty offered feedback on the video and sound quality, and the teaching techniques that faculty employed. As a result, new cameras were evaluated and selected to be sent to campuses. Dedicated Internet hot-spots were provided to campuses where the existing bandwidth was not sufficient for video conferencing. Live support systems and personnel were put in place to monitor the first weeks of class and resolve challenges as they arose. Improved training was offered to returning and new faculty, helping them become more comfortable on-camera and more effective as they facilitated engagement among students who were not in the same room with them.

Growth was explosive over the first two years of WebNet+ delivery. By Fall 2017, more than 800 students were served per term, attending from 40 different campuses, as well as some students attending from home. Nearly 100 faculty taught in Fall 2017, and more than 200 different faculty have been trained and taught via WebNet+ over the past two years.

This rapid growth trend has introduced challenges in scaling up technologies, training, and support. New versions of cameras and conferencing software were introduced. Initially, three specialists provided training and support. As enrollments grew, additional staff were added to the Online Learning Center, and support was improved to offer live and asynchronous options for faculty and students. The IT Service Desk and staff members at all campuses were trained in how to support students in their classrooms and at home. Thus, with centralized, agile management and the development of geographically distributed, local support, students were served more effectively over time, and their evaluations of the experience likewise improved.

The impact of WebNet+ for Webster University has been significant, especially in terms of giving access and support to students in their preferred live, interactive modality. For some students, these classes allowed them to continue their graduate studies without interruption when they would not have been able to attend classes at their campus or via asynchronous online classes.

Students who prefer the live classroom experience sometimes struggle when they are first introduced to asynchronous online classes. Webster's historical data indicate that graduate students who self-select into fully online programs succeed in online classes at a higher rate than those who take their first online class out of necessity. In contrast, the student success rate for WebNet+ classes is greater than 95 percent for this same population. Live video classes provide better support for students, and deliver higher rates of success for students who prefer the classroom experience.

The introduction of WebNet+ delivery offered additional students access to programs that they could not enroll in previously. For example, the Masters in Public Administration was a program delivered in only five campus locations via live classroom instruction. WebNet+ allows students who do not live near one of those campuses to enroll in the program of their choice. Likewise, Webster's Legal Studies and Paralegal programs are accredited by the American Bar Association,



and have been available only in St. Louis at the main campus. This specially-accredited program cannot be delivered via asynchronous online modalities. WebNet+ has given students from outside of the St. Louis area access to this high-quality program. These newly available programs have served a student need and provided the university with new avenues of growth.

Even as the university has seen growth in WebNet+ courses and programs, and overall positive reviews from faculty and staff in the first two years, the iterative evaluation and improvement process continues. Challenges remain in coordinating class schedules across multiple time zones in Webster's global campus network. Additional academic programs will be added to a centralized scheduling process so that a student anywhere in the world can access a class that they need, in the live learning modality they prefer. Video conferencing technologies continue to improve rapidly, as does the demand for Internet bandwidth globally, requiring the university to revisit hardware and software standards for campuses and students attending from their homes. Along with new technologies, faculty develop new best practices for teaching in this modality. New faculty are added to WebNet+ courses every term, requiring additional training, monitoring, and updates to faculty development.

## **Barriers Faced and Lessons Learned**

Throughout this journey of employing emerging technologies to strengthen an education community, Webster has addressed barriers by making strategic investments; collaborating with global industry partners; attracting and developing expert talent; and focusing on building our own capacity to learn, innovate, and meet students' changing needs. The barriers have sometimes been a product of the sheer number of programs and locations necessary to coordinate for effective use of technology and talent. Changing market conditions and increasingly sophisticated technologies available in the workplace have prompted Webster to pursue synchronous delivery options. Not only are these changing conditions a threat to existing strategies, they can represent an initial barrier to entering new markets due to the costs of implementing new technologies and new modes of offering programs.

Since 2000, online programs offered by for-profit institutions have proliferated in the United States. They have varied widely in guantity and are often associated with the perception and reality of a business model that relies on recruiting large numbers of students who qualify for federal financial aid to programs that are not well suited to meet the promised outcomes (McMillan Cottom). During the past eight years, these programs and related practices by for-profit institutions have come under increased regulatory scrutiny. These new regulations have touched all who offer programs at a distance. The results are increased institutional costs for obtaining state by state licenses for offering programs within their boundaries, increased staffing to meet regulatory requirements, and increased attention to marketing Webster's programs to differentiate them by their quality.

While online programs are attractive to working adults and particularly working mothers, who prize their convenience, they are still viewed by some as lower quality programs because of the perception of a lack of interaction and substance. Earlier acquaintanceship with "correspondence courses" feeds this skeptical perception on the part of potential students, employers, and even faculty. Some accrediting agencies have been unwilling to view online, asynchronous delivery of a program as having equivalent quality to in-person classes. In Europe, Webster experiences limitations by in-county approvals for program quality; Austria and Switzerland are examples where the synchronous modes of delivery may well gain approvals where fully online asynchronous modes are viewed less favorably.

In each of these instances, the lessons learned are the need to continue innovating in ways that increase substantive interaction among students and with faculty members. Further, providing evidence of quality to decision-makers and advocating with opinion leaders are critical to establish the place for online programs within the range of ways students seek an education and institutions wish to respond. Investments in time, money, true collaboration with faculty members, and building the institution's internal capacity as an institution are assets we greatly value. The most important lesson learned is that as students' needs evolve, so must our practices evolve. Asynchronous must give way to synchronous. Graduate only offerings must make room for undergraduate programs, including degree completion. Degrees must be supplemented with certificates and with non-credit offerings, and industry partners must be able to match Webster's global footprint.

### About the authors

Dr. Elizabeth (Beth) J. Stroble is president of Webster University, private nonprofit university serving nearly 16,000 students in 8 countries on 4 continents. Her leadership has strengthened Webster's global impact and academic standing, as well as attracting significant external funding and expanding the universities net assets.

Dr. Michael E. Cottam is Dean of Military Campuses and Online Education at Webster University. Prior to joining Webster, he led education innovations as a faculty member and administrator with Rio Salado College, and with MyCollege Foundation. Dr. Cottam holds a BA and MA in Spanish and a Ph.D. in Educational Technology from Arizona State University.

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## GFCC

## Foundational Global Competitiveness Principles

Build cross-sector coalitions and publicprivate partnerships to drive future and sustainable growth. Public and private sector collaboration is critical for scaling sustainable future production and consumption systems, as well as for developing the future workforce. Technologies, standards, regulations, investments, policies and initiatives need to be coordinated through consultation, cooperation and joint investment mechanisms. Establishing buy-in on opportunities, challenges and common goals from government, academia, business and civil society will be critical for creating a common sustainable future.

Make innovation the centerpiece of sustainable growth strategies. Innovation is a fundamental driver for sustainable production systems and a key factor for creating new businesses. To drive sustainable future growth, countries, regions and cities need to combine: world-class STEM, business and creative capabilities; favorable regulatory regimes; openness and trust; top-notch infrastructures; capital availability; smart finance; and effective business connectors and knowledge brokers.

Invest in developing the skills needed for future production, and in transitioning the workforce and society to a new economic paradigm. The transition to future production systems will require a massive adaptation in the workforce, powered by STEM and social sciences. New skills will be needed; jobs that do not exist today will emerge; many jobs will disappear. Government, academia, businesses and civil society will need to come together to effectively develop future workforce, respecting local cultures and values. They will need to work to ensure citizens will have opportunities to adapt and access future economic opportunities regardless of race, gender, religion, age or economic status.

# Enhance local capabilities and leverage local assets to build global competitive-

**ness.** Cities and regions have become the cornerstones for today's economy—they concentrate: manufacturing, consumption of goods and resources, innovation capabilities, finance and economic activities in general. The emergence of future sustainable production-consumption systems will primarily take place in cities and their surrounding regions. It will be essential to mobilize local actors in government, business, academia, non-profit, international organizations and financial institutions and leverage local innovation capabilities to create new sustainable technologies, businesses, jobs and production systems.

Implement functional, fast and forward-looking IP regimes to unleash innovation and global deployment. New technology solutions and business models will make future production systems possible. They will emerge and deploy in places were innovators and businesses are sure they will receive rewards for their efforts. Speed is critical for IP regimes as technology and global competition continue to accelerate. Bridge technology development, investment and sustainable business models with infrastructure development. Sustainable, resilient and secure physical and cyber infrastructures will be essential to address global challenges in areas such as water, energy, climate, mobility, food, housing and natural resources. Investments in these infrastructures will also have the potential to turbocharge innovation capabilities and capacities. Countries, regions and cities should tap into the potential of infrastructure investment as a key accelerator for sustainable technologies, businesses and production systems. Innovative finance and regulation will be essential.

# Scale sustainable technologies and business models through global markets.

Future competitiveness will result from local innovation combined with global perspective and scale. Global flows of goods, capital, information and ideas will be essential for future production systems. Stakeholders should support open and transparent markets as drivers for economic growth around the world.

Use advanced technologies to boost resource productivity, create sustainable value chains and decouple natural resource pressures from economic growth. New, disruptive, emerging technologies open up enormous opportunities to increase the efficiency and productivity of energy and other natural resources—from minerals to water. In order to maximize this potential, these advanced technologies should be combined with smart regulation and systemic business, production and urban networks concepts. This mix can help decouple economic growth from natural resources depletion, while combatting biodiversity loss, desertification and land degradation.

Implement forward-looking, seamless and efficient regulations that create favorable conditions for the emergence of new business models and sustainable technologies. Efficiency, transparency and predictability are key attributes for functional and innovation-positive business environments. A fastpaced, changing global scenario also requires flexibility, adaptation, speed and accelerated learning. The emergence of future production and consumption systems will require experimentation and institutional learning.

Turbocharge local and national sustainable development through systematic business, regulation, policy and strategy global benchmarking. For countries, regions and cities to compete and cooperate in building sustainable production and consumption systems, it will be essential to track key metrics and constantly assess new solutions and practices implemented globally. Learning and adapting will only be possible with systematic global engagement and benchmarking.

# GLOBAL FEDERATION OF COMPETITIVENESS COUNCILS MEMBERSHIP

## SUSTAINING AND GENERAL MEMBERS

Argentina Business Foundation for Quality and Excellence—FUNDECE

Australia

Department of Industry, Innovation and Science

Brazil National Confederation of Industry— CNI/SENAI/SESI/IEL

Brazilian Innovation Agency—Finep

**Canada** Go Productivity

**Ecuador** Quito Council on Competitiveness

**Greece** Delphi Economic Forum

Federation of Industries of Northern Greece

India India Council on Competitiveness

Japan Japan Science and Technology Agency—JST

**Kazakhstan** Kazakhstan Competitiveness Council

National Chamber of Commerce

Korea Economic Research Institute—KERI (on leave) Malaysia National Council of Professors— MPN

Malaysian Industry-Government Group for High Technology—MIGHT

**New Zealand** BusinessNZ

**Qatar** Qatar Foundation R&D

**Russia** Eurasia Competitiveness Institute

Saudi Arabia Saudi Arabian General Investment Authority—SAGIA

**United Arab Emirates** Competitiveness Office of Abu Dhabi

United Kingdom Centre for Competitiveness

Unites States of America Council on Competitiveness

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**Finland** University of Helsinki

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Hong Kong University of Hong Kong

Italy University of Bologna

**Korea** Ajou University

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University of Malaya

Mexico Monterrey Institute of Technology and Higher Education

**New Zealand** University of Auckland

**Norway** University of Oslo

**Portugal** Catholic University of Portugal

University of Minho

**Qatar** Qatar University Weill Cornell Medicine—Qatar Saudi Arabia King Abdullah University of Science and Technology

**Singapore** Singapore Management University

**Switzerland** University of Zurich

Taiwan National Taiwan University

United Kingdom Imperial College London

King's College London

Ulster University

University of Sheffield

University of Southampton

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**Colombia** Consejo Privado de Competitividad

Denmark Monday Morning Global Institute Sustainia Foundation

**Ecuador** Centro de Competitivad y Innovación

Egypt Egyptian National Competitiveness Council Global Trade Matters

Ireland National Competitiveness Council **Japan** Council on Competitiveness— Nippon

**Mongolia** Economic Policy and Competitiveness Research Center

**Morocco** Kingdom of Morocco Competition Council

Nigeria National Competitiveness Council of Nigeria

Panama Centro Nacional de Competitividad

Phillipines National Competitiveness Council

**United Arab Emirates** Federal Competitiveness and Statistics Authority

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