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Supporting Innovation in Energy Sector: the SMEs Role and DIGIFED Success Cases

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Abstract: This paper aims to discuss the peculiarities of innovation approaches in the energy sector and examines success stories on how alternative sources of funding (such as cascade funding deriving from EU-financed projects) can effectively promote the role of SMEs in this environment. As digitalisation and smartification of the energy sector are key goals of the European Commission (EC), relevant legislative packages like the European Green Deal and other initiatives are actively promoting these priorities as enablers of the green transition. However, while large energy companies can afford to make substantial innovation investments, the SMEs innovation scenario is often characterised by a selected portfolio of start-ups and SMEs that get funded by large players only when functional to their business, leaving a significant portion of innovative SMEs out of this investment trend.

In this context, the EU-funded DigiFed project's approach, supporting Application Experiments (AEs) for innovative products development, seems relevant to showcase alternative ways to support innovation in the energy sector. Indeed, in 2 years of implementation, DigiFed has structured and launched 3 Open Calls for AEs (cascade funding), succeeding in funding 71 companies and 46 AEs in several sectors, for an overall investment budget of € 3.6 M.

The present paper focuses on two successful cases of TWIN AEs related to the energy sector, i.e., DYNAGRID and REDUXI. DYNAGRID aims at demonstrating an affordable, wireless and battery-free solution to digitise the New Caledonian electric grid, reducing maintenance and increasing grid capacity, representing a peculiar case of successful implementation with a long-distance collaboration. On the other hand, REDUXI is focused on developing a smart, plug & play building management system box, capable of forecasting energy consumption and its further redistribution, with high chances to quickly reach the market. Eventually, based on these success cases, the paper discusses the support provided by DigiFed and its benefits with respect to other forms of innovation financing.

Keywords: energy, EU funding, SMEs, cascade funding, DigiFed, cyber-physical systems (CPS)

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1. Introduction

Energy has been a core sector of the European economy, shaping its financial, societal and political structure since the birth of the first European Community in 1951, when six countries decided to share the production of coal and steel to achieve economic stability and strengthen the post-war efforts (Painter, 2002). Since then, the European Economic Community (EEC) first and now the European Union (EU), guided by the non-always homogeneous agenda of the Member States, have achieved a gradually more integrated structure of the energy market that still determines the current dynamics for producers and consumers.

Today, thousands of energy companies exist in Europe, including producers, retailers, grid operators and related energy services companies. Considering the full panorama of the companies involved in the energy sector in Europe, this figure can exceed the number of 200,000 entities (D&B Hoovers, 2022). However, according to Eurostat (2019), the total number of electricity-generating companies representing at least 95% of net electricity generation at a national level is 4,730 in the EU, and 5,688 are the electricity retailers with the equivalent sum of national market shares.

Out of this amount of companies, only 86 are large companies with a market coverage higher than 5% of the total national net electricity generation in Europe, and 114 for the same share of the big retailers. In this context, it appears evident the enormous quantity of smaller companies, SMEs and start-ups that work, innovate and grow behind the spotlights, facing the numerous challenges of the traditional energy market.

In this paper, the authors therefore aim at discussing the peculiarities of innovation approaches in the Energy sector, also providing success stories on how alternative sources of funding (such as the so-called cascade funding deriving from EC financed projects) can effectively promote the role of SMEs in this sector, providing them with the necessary tools to enter the market next to the large and dominant companies.

The main research question arises from the need of understanding why it is important to support innovation and small actors in the Energy sector given their main characteristics, discussed below, and how innovation can be effectively fostered via alternative sources of funding (e.g. cascade funding) in this sector. The paper will aim to show the correlation between the main priorities of the EU regulations in terms of innovation, support to SMEs and energy, and the objectives of DigiFed project, and how this shared vision has a practical impact in bringing funded success cases close to the market, breaking the “experience paradigm”. Indeed, as shown by the success cases discussed in the fourth section, this paradigm arises when, on the one hand, it is necessary to have the most mature solution to obtain customers but, on the other, in a vicious loop scheme, it is also required to already have customers to receive the investment asset from investors in order to develop the solution.

2. Context

2.1 EU innovation targets and objectives in the energy sector

If SMEs and start-ups dedicated to the development of innovative solutions for the energy transition aim at becoming competitive in comparison with already established actors, they will need to play a major role in the achievement of a sustainable and resilient European economy. To achieve this goal, they will need to stay up

to date or one step ahead on the main legislative and regulatory novelties that the EC has set. Atop of these, the *European Green Deal* is the cornerstone of the upcoming years' policies and financial efforts (EC, 2019), with the goal of transforming the European Union into a just and prosperous society with a modern, resource-efficient, and competitive economy by 2050, and each European company can be a small piece of this bigger puzzle. Moreover, in such a delicate moment, in which the entire world finds itself under the burden of skyrocketed energy prices due to increased primary resource prices, and of a more recent dramatical geopolitical turmoil in energy critical production and transit areas, the energy sector acquires an even more strategic and essential connotation. To carry out its heightened ambition, the EC delivered the first set of adopted papers under the *Fit-for-55* package already in July 2021, with the goal of unifying the efforts aimed at reducing net greenhouse gas emissions by at least 55% by 2030 compared to the 1990 levels (EC, 2020a). The package includes legislative proposals to update the whole EU 2030 climate and energy framework. Inside it, more specific regulatory measures take place, and other relevant initiatives like the European Innovation and Technology Platforms (ETIPs) are actively promoting these priorities as enablers of the green transition.

For many years and through different innovation plans, the EU has mostly advocated for a research-led innovation policy based on a linear model of innovation, relying on a well-defined set of sequential stages: research and science, then development, production and marketing (Barbosa de Oliveira, 2014). Increasing R&D expenditure of Member States (MS), set as a policy goal at 3% of each MS's GDP by the Lisbon Strategy in 2000 (EC, 2010) has remained a core goal across the years. This goal was reaffirmed by Europe 2020, the EU's plan for the 2010–2020 decade to address the economy's structural weaknesses and increase overall competitiveness and productivity (Hervás-Oliver *et al*, 2021). More recently, with the publication of *A Europe fit for the Digital Age* (EC, 2021), the European Commission established that the EIC, along with relevant clusters and a new wave of public-private partnerships, will further boost innovative sectors, with a special support to SMEs as veritable backbone of European innovation. A performance indicator that will monitor this objective, particularly relevant for this paper, is the percentage of SMEs introducing innovative products and processes (EC, 2020b), which is also one of the goals of the DigiFed project, and both the cases analysed in the fourth section are noteworthy examples. At EU level, the EC primarily finances SMEs' innovation in the energy (and many other) sectors through grants within European funding programmes like the Framework Programmes, the EIC accelerator, Eurostars, Innovation Fund, Erasmus+, LIFE, CEF and Interreg among others.
Currently, Horizon Europe is the leading programme for R&D, lasting from 2021 to 2027 with a budget of € 95.5 billion spread over seven years. Horizon Europe was preceded by Horizon2020 (2014-2020, € 79 billion), the programme to which the DigiFed project belongs. As is the case for several SMEs instruments of the EC, one of the goals of DigiFed is to ensure that all the participating companies can focus on the development of their prototypes being financially covered until they can reach a successful product or service and then enter the market. However, as DigiFed more widely addresses Cyber-Physical Systems (CPS) and IoT (Internet of Things) applications, it is worth reducing the scope of the present paper to the energy funded AEs, analysing the main characteristics, trends and needs of the SMEs and start-ups involved.

2.2 Peculiar dynamics in the energy sector innovation landscape

Fostered by policy objectives and allocation of economic resources as described above, green innovation has become a main trend in the innovation ecosystem, hence driving opportunities for SMEs to create new business models, offer new services and products and cooperate with major players. Indeed, digital technologies encourage further players to profit from these opportunities, by allowing agile development (i.e. with low investments in assets and infrastructures) of IoT-based solutions, AI-based predictions, maintenance and performance optimization models. Hardware-related developments in relation with batteries optimization, renewable energy-related innovation, energy efficiency sensors for buildings and industrial facilities are other possible opportunities. As such, challenges posed by green transition offer significant opportunities for SMEs to develop new offers, both in the B2B and in the B2C domain. Yet in both cases, the major role played by big private players in the energy sector as distribution or transmission system operators (DSO/TSO), energy network operators, generators and retailers and equipment manufacturers, affects the dynamics of SMEs' innovation. Indeed, these large entities can play different roles in relation to SMEs, such as incubators or innovation ecosystems or as end-user or final customers.

In the first case, in order to address internal needs or emerging market trends not yet consolidated, big energy players can act as SMEs incubators or innovation ecosystems, and several major energy groups have created their own innovation ecosystems, such as the *EDF Pulse Croissance* (https://www.edf.fr/pulse), created to

incubate SMEs and start-ups that contribute to achieve carbon neutrality, or *OpenInnovability* of Enel (https://openinnovability.enel.com/it/startup-ecosystem), that crowdsources talents, ideas and technologies in the domain of energy transition and sustainability. In these cases, the interaction can vary from pure incubation to direct investment or acquisition in the group, depending on the interest of the firm in object.
In the second case, operators of major infrastructures or providers of different energy services often represent a priority customer for the SMEs, as well as the provider of concrete requirements for the creation of ready-to-use products and services. This interaction can be mediated via open innovation initiatives (*hackathons*) or created during demonstration activities, often as an investment from the SME itself, in order to break the "experience paradigm" in which having initial results is usually required by clients.

In this ecosystem, the purpose of managers to maximize utility and minimize costs can be hard to reach, in particular for SMEs and start-ups, due to different positioning and negotiation power, as well as to other information asymmetries. Hence, while substantial innovation investments are still made by large energy companies, they mostly end up affecting and involving only a selected portfolio of start-ups and SMEs, that get to collaborate with the main players as functional to their business, or that are directly incubated within their economic control. Needless to say, this trend leaves a significant portion of innovative SMEs out of this investment trend (Franklin-Mann, 2021). Yet, collaboration is essential if a higher degree of innovation is to be achieved (Taurino, 2018). In order to create products and solutions with higher opportunities for market success, alternative solutions are therefore needed, to enable peers' collaboration beyond traditional circles.
In this context, the EU-funded DigiFed project's approach to support AEs for innovative products development seems relevant to showcase alternative ways to support SMEs innovation in the energy sector, and the next section will provide more details on the support to SMEs and the approach of DigiFed.

3. DigiFed approach supporting AEs to develop innovative products and services

In the scope of the Digitising European Industry strategy in 2016, the Smart Anything Everywhere (SAE) initiative was launched to test innovative tools to support start-ups, SMEs and midcaps digitisation across Europe, fostering cross-border collaboration between small and medium companies, research centres, universities, and large enterprises with the support of DIHs (SAE, 2018). The Financial Support to Third Party (FSTP), also called cascade funding, is the core tool that has been first tested, then widely implemented by the SAE initiative. The DigiFed project (*Digital Innovation Hubs (DIH) federation for large scale adoption of digital technologies by European SMEs*), started in January 2020, is one of the 16 SAE projects, and it has deployed the FSTP tool in three innovation pathways, the Application Experiment (AE), the Generic Experiment (GE) and the Digital Challenge (DC), in order to propose different services to boost European companies' competitive advantage by fostering their adoption of the latest digital technologies. Whatever service, the support provided by DigiFed is not limited to FSTP, but combines it with technical expertise provided by research organisations (RTOs) and large industrial providers, and innovation management and business support. In that respect, DigiFed has developed a tailored tool with customized support in order to address the wide diversity of companies in terms of size, need, digital maturity, sector of applications, etc.

Having distributed a major part of FSTP funding to innovative companies, the AE pathway has been the main instrument for DigiFed implementation. It is divided into the TWIN pathway (below) and the SINGLE one, in which a company applies alone, facilitates the collaboration with either a DigiFed research institute or a DigiFed technology supplier, granting up to € 55,000 to the company for a 12-month maximum implementation. On the other hand, by supporting the collaboration between European companies of complementary expertise, the TWIN AE pathway fosters the collaboration of transnational companies with innovative digital SMEs (up to € 110,000 and 12 months of implementation). To incite low digital company digitisation, a third AE pathway is also proposed to low digital maturity companies within the TWIN AE where additional technology expertise can be provided by a DigiFed partner.

DigiFed has also designed the GE to test new collaborations between research institutes and companies, and to develop new co-financing mechanisms between European and regional funding to foster European industry digitalisation. Each of the four GE builds a community of SMEs and Mid-caps (between 8 and 20) around a specific technical topic proposed by a DigiFed research centre. The community members have direct access to the institute's experts, share their requirements and use-cases and contribute to the technology roadmap of a leading research centre. Overall, the four DigiFed GEs account for 51 members in 15 members states and leverage € 280,000 of regional co-funding.

Thirdly, the DC is a match-funding opportunity where advanced digital technology SMEs are selected to solve sectorial industry challenges set by corporate businesses. A challenge is proposed by a large European organisation, who serves as early adopter of the accelerated innovation developed by the selected SME, and provides additional support to the programme in the form of co-funding, innovation support and pilot sites.

In two and a half years of implementation, through its three innovation pathways, DigiFed is supporting 117 start-ups, SMES and Mid-caps located in 23 EU and associated countries. In particular, it has structured and launched 3 Open Calls for AEs, succeeding in funding 71 companies and 46 AEs in most of the industrial sectors, for an overall budget of € 3.6 M investment. Within the three pathways, the energy sector is one of the most addressed with eight projects supported, five of which belonging to AE (*Touch&Heat, DYNAGRID, REDUXI: Smart Building Management System, Ovon boiler controller, MyEVCharger*) and three to the DC (GEHydro - Catie, EDF Hydro - ISYmap, ACCIONA-Instrumentation technology). After having detailed how the DigiFed project is structured, the next section provides space for describing two of its most successful and peculiar use cases, both funded under the AE pathway.

4. Success stories from the energy sector within DigiFed

In DigiFed, after the selection of the most promising AEs along the 3 AE open calls, the process of implementation and monitoring is set to follow a regular and efficient pathway. Indeed, the methodology undertaken to monitor the implementation of each AE consists in a monthly monitoring meeting, organised by the responsible DigiFed partner in charge of the selected project. The meeting aims to assess the main progresses achieved, the help required (if any) and business, IPR and market access issues encountered. All the high and low points of implementation are then reported to the Monitoring Partners Monthly Meeting, where the advance of each AE is assessed and discussed. As reported by the interviewed AE partners after the implementation of their projects, the monitoring meeting structure was particularly “appreciated”, and the attitude of the monitoring partner considered effective as “an in-between” among “rules and [ad-hoc] adaptation”, that ensured the steady advancement of the projects.

The two AEs described below have been thus considered as valuable examples from the consortium partners of how DigiFed-funded projects can have a tangible impact on innovative applications for the energy sector.

DYNAGRID and REDUXI’s stories of successful early implementation make up the central subject of this paper, highlighting their special features of early-commercialisation, wider-than-EU impact and an interest from clients higher than forecasted. In short, DYNAGRID aims at demonstrating an affordable, reliable, wireless and battery-free IoT solution to digitise the New Caledonian electric grid, reducing maintenance and increasing grid capacity, representing a peculiar case of successful implementation with a long-distance collaboration. REDUXI is instead focused on developing a smart, plug and play building management system box, more user-friendly and capable to forecast energy consumption and its further redistribution, with high opportunity to quickly reach the market.

4.1 DYNAGRID - Optimising smart grid application for a more sustainable planet

The inception of Dynagrid arises from a significant economic challenge related to the existing state of the art of power grids: indeed, over 20% of the electricity paid by customers is due to distribution and transmission costs (Prettico *et al*, 2019). This is mainly due to the fact that the grid operators, or DSO/TSO, usually have to guarantee a supply of clean, affordable, and secure energy at any time. However, they face costly challenges in order to handle the shifting conditions caused by decarbonization and decentralization of power generation, and to prevent power outages or damages caused by unforeseen meteorological events or wildfires, especially in isolated or remote areas. DYNAGRID applied as a TWIN AE to the DigiFed project foreseeing a potential for current IoT solutions that could thus help operators to dynamically monitor their assets' conditions to predict power faults and improve maintenance and operation. However, these solutions are still limited given their upfront costs, as they are still based on batteries or current transformers.

Aware of the challenge ahead for innovating IoT devices, Energiot and ELEMENT decided to unify their working capabilities and jointly access EU cascade funding. Their profiles seemed perfectly matched for a TWIN AE as Energiot is a high-tech startup company founded in 2017 in Barcelona (Spain) and a spin-off of the most significant innovation laboratory in the country (CSIC). It has developed a battery-free IoT device that harvests energy from the residual magnetic field of power lines using piezoelectric technology. This device uses a set of sensors such as temperature, current, vibrations, acceleration, humidity, and light to deliver a smart monitoring solution. On the other hand, ELEMENT is a startup company founded in 2018 in Nouméa (New Caledonia, France), focused on IoT solutions and integration with several types of applications, including providing analysis systems and cloud computing, and it has been working with grid operators in New Caledonia since its origin. The research background of the two companies includes the involvement for research purposes in several EU-funded projects on energy harvesting and IoT technologies for Energiot, and the development of IoT solutions for different clients from banks and industry for what concerns ELEMENT.

The two companies joined forces forming the Dynagrid project to deliver a solution to help grid operators optimize their operation and maintenance.
Its main objective was to demonstrate an affordable, reliable, wireless, and battery-free solution for massive deployment of IoT to digitize the grid that could lead to a 20% of maintenance and operation costs reduction. The following applications can be applied to grid operators:

- Detection of events, such as power faults, accidents, forestal fires, and others
- Increase the grid capacity by using Dynamic Line Rating (DLR)
- Predictive maintenance of critical asset
- Balance and integration of renewable sources on the grid

Along with the devices, the project also developed an IoT platform to manage the devices and use analysis models to deliver the use cases for the clients. The project started in May 2021 and will be concluded during the summer 2022. Nevertheless, Enercal, the main DSO/TSO in New Caledonia, has already agreed to pilot this project with Dynagrid, given the promising early-stage implementation and the stable support provided by DigiFed. The project seems thus entitled to be a successful case of self-sustainable project, also provided that New Caledonia is a smaller and isolated region which facilitates the validation and the need of the Dynagrid solution. Implementing the project in New Caledonia, a French Overseas Territory, therefore fully part of the EU, also included the peculiarity of seeing a tangible impact of EU funding for innovation broadly out of the European continent, in a country in which ad-hoc hardware modifications of the solution needed to be brought. In addition, Energiot and ELEMENT are in want of testing the use cases of the Dynamic Line Rating (DLR) and power fault detection to manage the power congestion due to the increase of renewable energy sources on the island. A more efficient grid will finally come out of the application of these two use cases, enduring the impact of the funded solution and of the scope of the DigiFed project itself.

4.2 REDUXI: changing the way we use electricity

The second Application Experiment successfully implemented, already concluded during Spring 2022, is called REDUXI. Its starting challenge took place from the awareness that electricity is becoming an increasingly valued and expensive resource and that, in order to maintain the comfort of our lifestyle, a change in the way we consume electricity is needed.

The problem REDUXI aimed to solve, comes from the increasing consumption of electricity during peak hours in industry, households and cities, which is posing serious challenges and constraints for energy distribution related to the stability of grids. In the forthcoming scenario, without extremely high and time-consuming investments aimed at improving the capacity of the power infrastructure, it will be almost impossible to meet the needs of electricity supply in peak hours, caused by the growing number of electric vehicles (EV), heat pumps and other devices in need of electricity. REDUXI thus positions itself as the answer to the question of how to meet the increased electricity consumption on the existing electricity infrastructure and thus maintain the stability of electricity grids, changing the perception and raising awareness on the use of electricity. Indeed, by activating cooperation between suppliers and customers of electricity, the REDUXI system:

- Contributes to balanced electricity use
- Reduces electricity consumption

- Increases electricity efficiency
- Encourages the use of green energy
- Reduces costs

The development of REDUXI comes from the collaboration of two companies, AMIBIT and PES. AMIBIT is a high-tech start-up company from Slovenia that addresses the increasing trend of digital transformation in the energy sector with its self-developed innovative hardware and software solutions. PES is an Austrian start-up engineering company with extensive experience from planning to construction of electricity and power infrastructure in the energy industry, households and urban spaces. AMIBIT and PES have joined forces to develop the new version of AMIHUB (an AMIBIT hardware) to be tested by PES on pilot cases with potential clients. AMIHUB was a modular controller that served as a base design in the development of REDUXI as well as for the identification of relevant shortcomings and potential improvements that brought to the final product realised within DigiFed.

Describing the solution in its technical aspects, REDUXI is an energy management system (EMS) that includes a REDUXI controller and a REDUXI application. On one side, REDUXI modular controller is the central unit of the system. The design of the controller is based on the flexibility. Thus, the input/output part of the controller can be adjusted to individual requirements without adding external units. The controller communicates with all connected electrical devices via various protocols (LAN, Wi-Fi, RS485, etc.). Due to its modular design, REDUXI provides numerous functions for electricity efficiency, and it only needs to be connected to electricity and the internet to be used.

On the other side, the installation is user-friendly, based on "Plug & Play" approach and does not require any technical skills. The solution is highly innovative as it can be connected to various users (EV charging stations, heat pumps, washing machines, etc.), electric energy producers (solar cells) and accumulators (batteries). To ensure the largest possible number of electrical devices connected to REDUXI, special converters have been produced by AMIBIT. Moreover, the ability of REDUXI to forecast the electric production of solar power plants is crucial for suppliers and customers, and it strengthens the confidence of all actors in the stability of electricity from renewable sources.

Funding such a solution within the DigiFed project has allowed REDUXI to develop a new HW solution for Energy management, allowing AMIBIT to successfully receive ISO27001 certificate, while ISO9001 certificate is in progress. 100 units of REDUXI have already been produced and two pilot projects are in progress: one in Slovenia, and the other one in Austria (private house and business premises). 10 REDUXI units have been sold within few months from the end of the project implementation and five new potential clients are interested in REDUXI, also from the automotive sector. Large scale commercialisation is now expected during the second half of 2022, beginning with Slovene and German-speaking market and a EU-wide promotion within the DigiFed project, that will disseminate the most prominent results, as commercial and business support goes in parallel with the cascade funding provided.

5. Conclusions: lessons learnt and specific needs in the energy sector

When entering the energy sector for developing innovative solutions, before reaching a market dimension most SMEs and start-ups require significant time, several investments, and connections to navigate the complexities of bureaucracy. Given the limited resources (in terms of time, money, decision-making, connections), the constraints become even more impacting once new ideas arise in terms of the development of a product or a service. Moreover, a further limit that prevents effective innovation in smaller companies includes an already-established market activity requirement from the clients, often resulting in what has been defined above the "experience paradigm". However, as discussed throughout the paper, aside from these barriers, SMEs and innovative startups that want to enter the energy services market today also feature peculiar traits that can project them in an advanced position compared to other market's players. Among these are flexibility, agility, fast decision-making, and consequential shorter time to be ready for entering the market are the most prominent.

The successful early-stage implementation cases of DYNAGRID and REDUXI have attempted to show how SMEs and start-ups – in both cases with two transnational companies joining forces to achieve alternative paths of

growth – can more directly access significant sources of funding, fostering the execution of innovative solutions that project the four companies involved one step closer to the energy services market.
In the two cases analysed, the two TWIN AEs have both been able to obtain up to € 110,000 in cascade funding, with the 50% paid as prefinancing at the kick-off of the project, and the remaining when all deliverables and results were submitted. This implies that SMEs had liquidity upfront, allowing them to develop their prototypes without the need of making their own investments, which can hamper SMEs' effectiveness in implementing innovation. The projects also received innovation management and business support from DigiFed DIH and business partners, which further fostered their opportunity to grow.

According to the DYNAGRID developers, *"a program like DigiFed incredibly helps a startup to take a first step, as it offers the investment without collateral and assumes the risk allowing the creation of innovation"*. Moreover, as soon as DigiFed approved this grant, it was much more receptive for Enercal [the energy operator in New Caledonia] to agree to contribute and receive the pilot project. This support and push from DigiFed and Enercal were the reasons why they chose to be part of this program, adding that *"trust and risk bring innovation forward"*. Similar feedbacks come from the REDUXI team, which considers the H2020 cascade funding *"fair for small companies"* as *"if you have a good product, presented in the right way, you will be heard out and recognised"*, faster and with a higher success rate than a direct jump to the market.

For all these reasons, within DigiFed, cascade funding has proven to be a highly effective funding method given the characteristics of the sector (energy) and the dimensions (SMEs and start-ups) of the companies involved, allowing them to achieve the full development of their innovative idea, as it has been the case for several other products and services funded by DigiFed, now readier to face the market.

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