

Evaluation of the National Innovation Program Hydrogen and Fuel Cell Technology Phase 1

(2006 bis 2016)

On behalf of



Federal Ministry
of Transport and
Digital Infrastructure



Federal Ministry
for Economic Affairs
and Energy

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Carried out by McKinsey & Company, Inc.

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Summary of the evaluation results

Overview

The National Innovation Programme Hydrogen and Fuel Cell Technology (NIP) was founded in 2006 as a joint effort of German policymakers, industry leaders, and the research community. It has three objectives:

- Secure Germany's position as a technology leader in hydrogen and fuel cells
- Accelerate the development of the hydrogen and fuel cell markets
- Strengthen the industry along the whole hydrogen and fuel cell value chain.

Between 2006 and 2016, the Federal Ministry of Transport and Digital Infrastructure (BMVI) and the Federal Ministry for Economic Affairs and Energy (BMWi) have granted funds totaling about EUR 710 million to approximately 750 research and development (R&D) projects. The grant recipients, in turn, have invested an additional EUR 690 million of their own resources into these projects and raised an additional EUR 20 million in third-party funding. The NIP encompasses a range of application areas – hydrogen production, transportation sector applications, building heating and power applications, industry heat and power applications, as well as specialized markets. It also funded several cross-cutting projects that span the

Figure 1: ~EUR 1.4bn was invested in the course of NIP

Scale, EUR m

	10	50	100	150	200	250	300	350	400
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Total volume and grant proportion

	Basic research ¹	Applied R&D ¹	Demonstration projects ¹	Market activation ²	Support activities ¹	Total
Transport	44 (46%)	471 (49%)	238 (49%)	-	0 (41%)	754
Household power	4 (49%)	165 (48%)	33 (49%)	13 (39%)	9 (48%)	223
Special markets	4 (46%)	109 (53%)	40 (48%)	3 (45%)	-	152
Industry	8 (46%)	32 (60%)	76 (46%)	-	1 (46%)	120
Transversal topics	6 (88%)	67 (60%)	1 (43%)	-	8 (43%)	83
H ₂ production	5 (86%)	18 (59%)	30 (50%)	-	2 (100%)	55
Total	71	863	418	16	21	1,415³

¹ Estimate of innovation stage based on self-assessment of grant recipients

² NIP CHP grant guidelines

³ Contains 18 additional BMWi programs subsequently designated to NIP but not designated within this matrix – see appendix 8.5

SOURCE: Database NOW GmbH NIP I (professional excerpt, as of February 2017); Survey of NIP Grant Recipients 2017

five areas of application. Overall, approximately 240 industrial companies have received NIP funding, including about 90 small and medium-sized enterprises (SMEs) as well as 50 research and educational institutions and as public sector bodies.

In addition to funding, the NIP has provided coordination, networking, and public relations assistance to support the development of the hydrogen and fuel cell industry. A separate program organization, NOW, was established for this purpose and managed by an advisory board of representatives from politics, industry, and research. "Lighthouse" projects were set up for the four main application areas: road transportation, building heating and power, shipping, and uninterruptible power supply applications. Within these lighthouse structures, stakeholders were connected, concepts for research projects were developed, and public relations work was coordinated.

With the NIP and the European Union's Fuel Cells and Hydrogen Joint Undertaking (FCH JU), Germany has the world's third-largest funding program for hydrogen and fuel cell technologies, surpassed only by those in Japan and the United States. Due in part to the program's public-private structure, international experts and funding programs consider the NIP to be a role model. However, Japan, the US, and the Scandinavian countries have been able to develop their (nascent) markets more rapidly, owing mostly to regulatory activities such as quotas and high premiums for buyers.

Methodology

Phase 1 of the NIP, which took place from 2006 to 2016, was evaluated between February and September 2017 on behalf of the BMVI in collaboration with the BMWi. The evaluation focused on the funded projects (what was funded and what was achieved as a result?), program implementation (how was support provided?), and the program context (where does Germany stand today in terms of hydrogen and fuel cell technology?).

The evaluation was conducted based on indicators developed ex post. This approach was necessary because the NIP's targets were not broken down by application area (transportation, building energy, industry) and overall measurable indicators were not defined for all of them ex ante. Wherever possible, the values measured for the indicators were compared against relevant national or international targets, e.g., indicators of technology development were compared against technology development targets of the US Department of Energy (DoE).

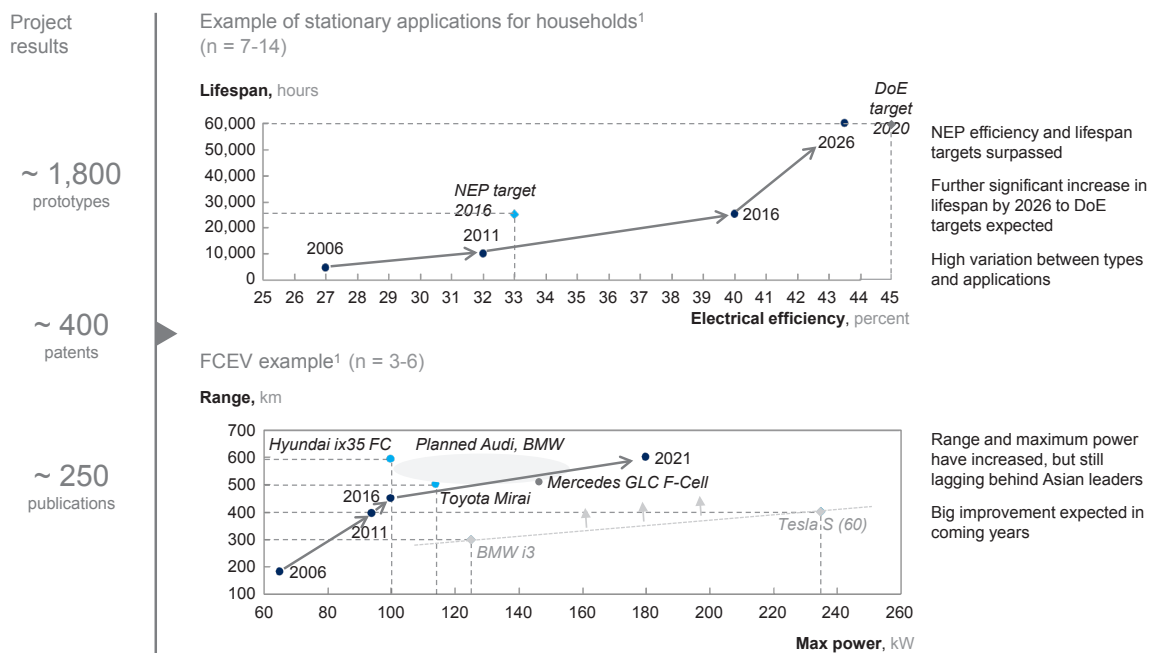
Assessments of the indicators were based on an analysis of funding data, an evaluation against technical and financial targets performed by Projektträger Jülich (PtJ), and an online survey of funding recipients, as well as detailed interviews with the heads of selected projects, program managers, international partners of the NIP, and experts from industry and research. Furthermore, publicly available data on industry and market development in 12 countries was examined. The online survey was sent to 537 projects at 244 organizations. By May 19, 2017, the submission deadline, 274 responses to the project-specific section (51%) and 94 responses to the organizational section (38%) had been received. Since not all questions were answered completely in every survey, separate sample sizes have been provided for the relevant questions in each analysis.

Evaluation against program objectives

The NIP has made a significant and measurable contribution toward achieving the program objectives set out in 2006. After ten years of program support, Germany's hydrogen and fuel cell industry stands at a threshold to commercialize and scale. In this case, the

technology has the potential to significantly reduce carbon emissions of the transportation, residential, and industrial sectors. The following section lays out the evaluation findings for each of the three program objectives.

Figure 2: Safeguarding Germany's position as a technology leader



Question on technical features: Please estimate the state of the art and the expected development based on the following indicators in real conditions
¹ Median of survey responses per area of application

SOURCE: Survey of NIP Grant Recipients 2017; National Development Plan for NIP, Version 3.0, 2011; McKinsey

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Objective 1:

Securing Germany's position as a technology leader

Germany is among the top five global technology leaders in both stationary and mobile applications for fuel cells. In simplified terms, the level of technological development of fuel cells can be measured in three dimensions: efficiency, lifetime, and cost. According to information provided by funding recipients in the survey, clear progress has been made in all three dimensions since 2006. However, the ability to commercialize and scale the technology will require further improvements, especially in terms of lifetime and costs. For most fuel cell types and applications, **efficiency** has reached levels that experts and funding recipients consider **sufficient for commercialization**. In

stationary applications, median electrical efficiency is 40 percent for low-temperature polymer electrolyte membrane fuel cells (LT-PEMFCs) and solid oxide fuel cells (SOFC), and 30 percent for high-temperature polymer electrolyte membrane fuel cells (HT-PEMFCs). Given these values, the 2016 efficiency target of 33 percent for home energy applications set in the national development plan has been achieved. The median overall efficiency level relevant for combined heat and power, which includes thermal efficiency, is 85 to 90 percent. For industrial applications, however, the target of at least 60 percent electrical efficiency for SOFCs has not yet been reached.

In terms of mobile applications, LT-PEMFC have come to be the most common type of fuel cell. In this technology, an electrical efficiency of 55 percent was achieved over the course of the NIP. This still contrasts with the US DoE targets of 60 percent peak electrical efficiency for 2015 and 65 percent by 2020.

Since 2011, the median lifetime of fuel cells in stationary applications has doubled to approximately 25,000 hours for PEMFCs. For SOFCs, it has increased four times, reaching about 40,000 hours. At the same time, leading Japanese fuel cells already reach lifetimes of 70,000 hours (for PEMFCs) and 90,000 hours (for SOFCs) today. **Funding recipients continue to see fuel cell lifetime as an ongoing barrier to commercialization.** In mobile applications, service life for HT- and LT-PEMFCs increased from 1,000 hours in 2011 to about 5,000 hours today. This suggests that the DoE target for 2020 has already been met, meaning that these fuel cells provide a sufficient lifetime for use in passenger cars.

Many types of fuel cells now **cost less than half** to produce in Germany compared to 2006. In stationary applications, fuel cell costs have fallen by 60 to 80 percent. This impressive development is essential to remaining internationally competitive: during the same period, leading Japanese manufacturers – who produce fuel cells at much higher volumes – were able to bring down costs by up to 85 percent. Costs for mobile applications decreased as well, but larger savings will only be possible in mass production. As of now, costs for both fuel cells and mobile applications continue to hinder market activation, prompting efforts to **further reduce costs by 50 to 80 percent** in the next ten years.

Most funding recipients believe that their NIP projects and the NIP overall have **contributed to Germany's leading technological position.** One way to verify this impression is to look at the number of publications, patents, and prototypes that have resulted from the NIP¹: since 2006, about **250 publications**

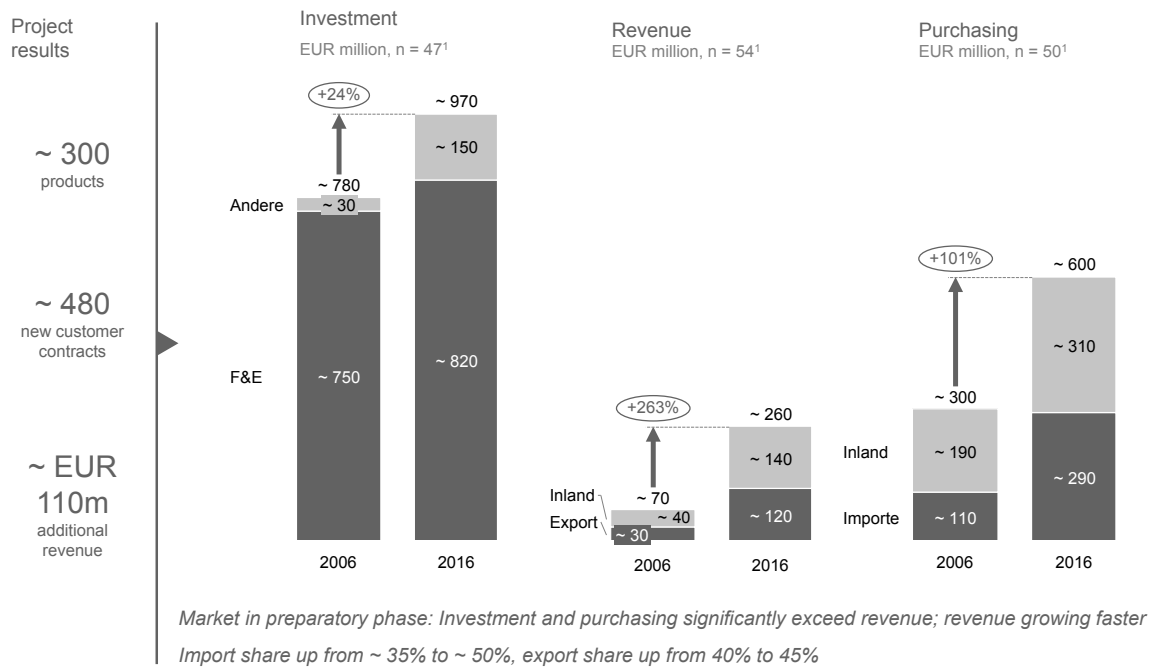
have been published, 410 patents submitted, and 1,830 prototypes and units (products and components) have been **developed for testing purposes** within and as a consequence of NIP projects.² If these publication and patent figures are considered in the overall German context (1,620 publications and 9,100 patents related to hydrogen and fuel cells from 2007 to 2016), the NIP accounts for approximately 15 percent of publication activity and 5 percent of patent activity. These results indicate that companies and institutes are engaging in research beyond their immediate NIP activities.

Germany leads all European countries in patent and publication activities. Internationally, it accounts for roughly 6 percent of publications and 8 percent of patents, earning a spot in the top five countries along with Japan, the US, South Korea, and China.

1 Publications, patents, and prototypes can be indicators of technical development, but do not provide a full picture of the extent of a country's technology leadership.

2 Average figures from the survey responses were extrapolated in each case for the total amount of funding provided to recipients who were asked to participate in the survey. Outliers were eliminated from the extrapolation calculation. Only publications by research institutes were counted.

Figure 3: Accelerating the market's development and building up value chains



Question: Please indicate your investments in and revenue from H₂/FC technologies; investments in H₂/FC/thereof R&D; revenue from H₂/FC/thereof exports; purchases from suppliers in H₂/FC/thereof from suppliers outside Germany

¹ Average values were extrapolated to 205 companies (large corporations and SMEs) that received the survey

SOURCE: Survey of NIP Grant Recipients 2017

2

Objective 2: Accelerating the market development

Despite the technological progress that has been made over the course of the NIP, **hydrogen and fuel cell technology has not achieved broad market acceptance**. The program has, however, accelerated its development: from 2006 until 2016, sales of hydrogen and fuel cell technologies by companies supported by the NIP increased fourfold, reaching approximately **EUR 260 million p.a.** A significant share of this increase, about EUR 110 million, is linked to NIP projects. Components and equipment account for the largest share of these sales.

Especially in **stationary home energy applications, first marketable products are being developed and sold**. All German manufacturers of such applications were supported by the NIP. Germany is Europe's leading market for fuel-cell-powered residential heating systems, with 2,000 installed micro-CHP systems by 2016. In addition, the BMWi's new program to support the technology's introduction (KfW program

433) was prepared during the NIP. Globally, however, **Japan remains well in the lead with just under 200,000 installed systems**. This success is partly due to the high subsidies that Japan has provided over the last ten years to support the purchase of fuel-cell-powered heating systems. A similar development is apparent in South Korea: buyer premiums for micro-CHP systems add up to about EUR 20,000 per unit; in Germany, a subsidy of about EUR 10,000 (for 1 kW systems) has been provided for such purchases since 2016.

In mobile applications, market development in Germany remains modest despite the fact that the bulk of NIP funding was invested in this application. Small-series production of the first German fuel cell electric vehicles is not anticipated until 2017/18. Japanese and South Korean car manufacturers are already offering models on the market today. Currently, about 240 fuel cell cars and 16 fuel cell buses are registered in Germany. **In both Japan and the US**, in turn, **more than 1,400 fuel cell cars** have been registered.

Furthermore, fuel cell cars account for a significantly higher share of all cars on the road in **Norway** and **Denmark** than they do in Germany. Countries that strongly subsidize these purchases are in the lead here, just as they are in terms of stationary applications. Norway, Denmark, and Japan each provide subsidies of EUR 15,000 to 20,000 to buyers of fuel cell cars; in Germany, this subsidy is EUR 4,000.³ Germany does have a success in **hydrogen fueling station infrastructure** to its credit: the initiative H2 Mobility was founded with NIP support during Phase 1 of the program. This joint venture of several companies now operates the existing stations that resulted from demonstration projects and has agreed to expand the network to 100 stations by 2018/19. After this point, further expansion will depend on the growth in the number of fuel cell vehicles in operation and targets 400 stations by 2023, creating one of the densest such networks worldwide.

Objective 3: Building up the required value chains

The industry's **value chains** and the **share of value creation** in Germany **developed favorably** between 2006 and 2016. The industry, however, remains relatively small. As a result, the scale and extent of industrialization is still limited.

Compared with other countries, Germany is one of the **three countries with the largest supplier and manufacturer landscape** (the others being Japan and the US) in fuel cells. Germany's 20 manufacturers and 12 sellers of fuel cells and components are active along the value chain.⁴ In some areas such as PEMFCs, however, the majority of manufacturing takes place in Asia.

In terms of stationary applications, Germany has 14 manufacturers (including nine that produce heating applications) and thus the highest number worldwide, although Japanese manufacturers produce a far high-

er number of units. In terms of mobile applications, there are no commercial offers by German manufacturers yet. Japan's Toyota and Honda and South Korea's Hyundai are the only automakers to have mass-produced fuel cell vehicles so far. Daimler plans to launch a model by 2020 and BMW – as a small series – by 2021. The situation for hydrogen fueling stations is more encouraging: Germany's Linde is one of the world's top three manufacturers.

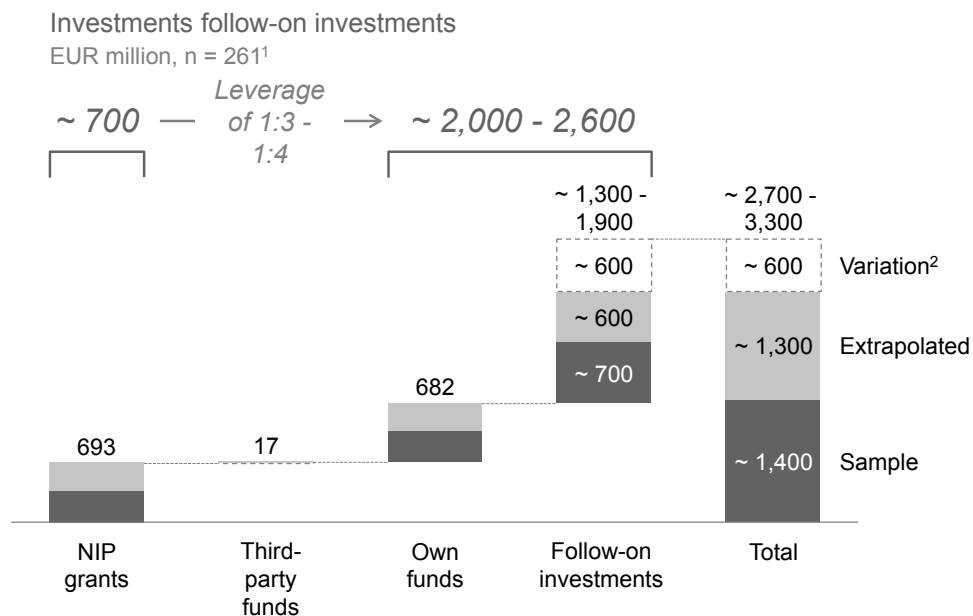
Due to the focus of the NIP on technology applications, only few suppliers were among the direct beneficiaries of the program. Yet, **each NIP-supported project conducted by an industrial company has indirectly reached an average of ten suppliers**. Furthermore, one out of four industry projects has led to **new supplier and customer contracts**. About 90 percent of new supplier contracts are with German suppliers, while about 40 percent of the new customers are with foreign customers. Since the import and export share in the fuel cell industry are each approximately 45 percent, the NIP has played a role in building up Germany's supplier industry while strengthening the German sales market.

Extrapolations also show that **approximately 1,500 jobs have been secured and close to 800 have been created** as a result of NIP projects. However, it is likely that some of these jobs are project based and therefore temporary.

³ Fuel cell vehicles are also exempt from the fuel tax, which – assuming a Golf as a reference – amount to EUR 60 annually.

⁴ Manufacturers of fuel cell components and/or stacks are, e.g., BASF, balticFuelCells, Daimler, Elcore, ElringKlinger, ENERCON, Enymotion, Evonik, FCES, new energyday, Proton Motor Fuel Cell, Proton Power Systems, SGL Carbon, SFC Energy, Siemens, Sunfire, thyssenkrupp, Ulmer Brennstoffzellenmanufaktur.

Figure 4: An overall leverage of between 1:3 and 1:4 was reached



¹ 261 responses to question: Have follow-on investments resulted from the project? 110 yes, 151 no. Of the 110 positive answers, 84 included an indication of the volume of follow-on investment. For the remaining 26 positive answers, the average value for the 84 responses was assumed

² The upper boundary of the leverage was calculated directly from the raw data, the lower boundary from a version adjusted for potential double-counting. The double-counting adjustment was made for volumes in excess of EUR 10 million at organizations with multiple projects

SOURCE: Survey of NIP Grant Recipients 2017

3

Review of cost effectiveness:

Ratio of input to direct results and impact

The survey data and interview results indicate that a large part of NIP funding supplemented existing funding sources rather than replacing them. Because guidelines specified that no more than 50 percent of funding could be provided, 50 percent of investments were covered by private sources by design. In addition, survey responses from funding recipients indicate that **additional private investments** were made as a result of the NIP projects. These investments totaled an estimated 200 to 300 percent of NIP funding. Overall, this means that NIP funds of EUR 0.7 billion stimulated further private investment of **EUR 2.0 to 2.6 billion** – a leverage ratio of 1:3 to 1:4. Compared with the target for the FCH JU (1:1.7), this is a very good result and comparable to the outcome of the Clean Technology Fund (1:3.3).

In total, funding recipients invested approximately EUR 1 billion in hydrogen and fuel cell technology during 2016. This figure includes investment unrelated to the NIP. Roughly estimated, annual NIP funding accounts for about 5 to 10 percent of invest-

ment in the industry, while related and subsequent investment from recipients and other sources makes up an additional 20 to 30 percent.

A comparison of funding input to project output shows that approximately **0.7 patents were registered, and 0.5 commercial products and components were developed for each EUR million in funding**. In addition, about **2.4 jobs were secured, and 1.3 jobs were created** per each EUR million in funding. Since market development is still at an early stage, it will only become evident in the coming years to which extent the NIP's economic benefits are sustainable.

The question also arises of how direct funding of individual projects can be supplemented with further instruments to spur demand and strengthen market dynamics. Many funding recipients said that **instruments such as infrastructure expansion, purchasing incentives, and increased public sector procurement** of fuel cell technologies have been missing in Germany and would help the market in its current stage of development. Accompanying political action is also

necessary to support funding effectiveness by putting the right legal frameworks in place. Such legislative action has been used successfully worldwide for comparable purposes, such as encouraging battery-electric mobility (including in Germany). Based on this experience, a similarly positive effect on fuel cell technology seems likely. Although the legal framework during the program period was fundamentally supportive of renewable energies and alternative drive systems, hydrogen and fuel cell technology was not explicitly covered in some areas (e.g., in terms of the ability to count hydrogen towards CO₂ reduction targets).

Climate protection potential

Estimating the potential contribution of hydrogen and fuel cell technology toward reaching climate protection goals is difficult because the technology has many different new areas of application. The greatest impact through 2030 is expected to come from the adoption of stationary residential heating systems. Assuming a ramp-up to approximately 4 million systems by 2030 – a figure based on funding recipients' expectations and the projection of targets from the National Development Plan – would reduce household emissions by 4 to 5 percent. Due to the slower market ramp-up in the road transportation sector, the majority of transportation-related impact is only expected to take place after 2030. This is also true for other future applications of hydrogen, e.g., in industry or as storage for (renewably produced) power.

Evaluation of program implementation

The NIP was set up as a joint program of the BMVI and the BMWi. Within this umbrella, the BMWi focused on encouraging applied research and development and the BMVI on supporting demonstration projects and developing the market.

To implement the program, a special structure was put in place: an **external program organization**, the National Organisation Hydrogen and Fuel Cell Technology (NOW) provided overarching coordination and management, handled networking and public relations, and acted as a central point of contact. A project management firm, Projektträger Jülich (PtJ), awarded and managed program funding. Between the two involved ministries, tasks were allocated differently: at the BMVI, NOW not only handled overarching activities but also supported applicants before they submitted their applications and evaluated funding requests. At the BMWi, in turn, NOW was responsible for overarching activities only, and the ministry and the PtJ handled all funding applications.

The overwhelming majority of funding recipients and experts evaluated the program implementation positively: 35% of funding recipients ranked it "highly satisfactory", an additional 62% "satisfactory". Some criticism was offered regarding the funding application process. The most salient points of the evaluation of the key functions were:

- **Design of overall program, including management of those involved.** The dual structure with overarching coordination of the program by NOW was considered a valuable contribution both by funding recipients and experts. For example, about 70 percent of funding recipients said that the program helped to coordinate policymakers, researchers, and the business community, leading to a stronger commitment to the technology within their own organizations.
- **Approval, reporting, and evaluation processes (project funding).** Funding recipients provided very positive feedback on the support they received when applying for NIP funding: 80 to 90 percent considered the support "good". However,

the award process was lengthy in some cases: for about 10 percent (BMW i) or 30 percent (BMVI) of projects, it took more than a year to receive funding approval. To speed up the process, PtJ issued nonbinding letters of intent (UIAs) for BMVI projects. Nonetheless, only about one-third of funding recipients felt that the process was "short". Recipients also criticized the amount of effort needed for a funding application and progress reporting, as well as the sometimes unclear interface between NOW and PtJ for BMVI-funded projects. From the program's perspective, the interim and final reports submitted by the projects did not always succinctly present the achieved results. As a consequence, this information was not recorded or used for managing and steering the overall program.

- **Networking and public relations.** The program deployed so-called "lighthouse" structures to coordinate the stakeholders within an application area. In total, four lighthouses were funded: the Clean Energy Partnership (CEP) for road transportation applications, Callux for residential heating and power applications, e4ships for maritime applications, and the Clean Power Net (CPN) for an uninterruptible power supply. Survey respondents provided highly positive assessments of this aspect of the program. More than 80 percent said that they formed new business relationships that continued after the project was over. About 70 percent believed that the technology is now the focus of increased attention in professional circles, and 50 percent see similar impact among the general public. Other European and international funding programs confirm that the NIP has played an important international role, especially by driving the establishment of international standards for hydrogen refueling station infrastructure.

In Phase 1, administration costs equaled 3.6 percent of requested funding for the BMW i and 4.1 percent for the BMVI – in line with that seen at other funding programs and below the target of 5 percent. The difference between BMW i and BMVI is due to the fact that NOW also handled activities for the BMVI beyond pure project funding.

In the course of Phase 1, two partial evaluations and two partial audits by the Federal Court of Auditors⁵ took place. The report from the Federal Court to the BMVI specifies shortcomings in the program's early years, especially relating to requirements under EU law and funding regulations. Central points of the recommendations, such as the differentiation of funding ratios, were addressed during the later years of the program.

Recommendations for the design of phase 2

On September 28, 2016, the Federal Cabinet decided to continue the National Innovation Programme Hydrogen and Fuel Cell Technology as a government initiative from 2016 to 2026 (Phase 2).

The insights from Phase 1 should be used to improve the implementation of Phase 2. From this evaluation, the following recommendations can be derived:

Focus of Phase 2

1. **Funding for R&D** should continue, but support should extend to **market activation measures**. Additional R&D work to improve the technology is both possible and necessary, but hydrogen and fuel cell technology will only become internationally competitive if the industry reaches scale. Both priorities are already part of Phase 2 – the task now is to rigorously put them into action. Recommendations 6 and 7 describe some options to do so.
2. The program should continue to take a **cross-application approach**. Coordination among sectors and ministries should be further strengthened in order to drive development of an integrated energy system and take advantage of synergies.
3. In Phase 2, the NIP should specify concrete **strategic focus areas** and communicate these more openly to the public. The focus areas should be derived from the overarching program strategy, but be more specific than the overall funding guidelines. Examples could be the development

5 (Bundesrechnungshof, 2016)

of a cost-competitive supplier industry for fuel cell stacks or of large electrolyzers for integrating renewables into the energy system. The program does not need to specify particular technical solutions – it suffices to set a goal and allocate funds to projects that will make a measurable contribution to reaching it. Competitions could also play a role in realizing such strategic goals, with awards going to concepts that could be further developed into solutions. Focus areas make it possible to actively manage funding and research activities while sending positive signals to industry members and the broader public.

4. **SMEs and suppliers** should be involved more closely in the program. One way to do so – beyond continuing the SME bonus – would be to simplify the application process for SMEs (or even all applicants). One example of this approach is the “SME instrument” in the EU’s Horizon 2020 program, which provides a simplified application process with a maximum duration of two to four months and enables SMEs to apply for funding for projects in a concept phase.⁶ SMEs that participate in the Horizon 2020 program can also take part in coaching and networking activities designed to support them in commercializing their developments. It would also be possible to favor the participation of SMEs and suppliers in funding applications and request projects to contribute and describe their contribution to the creation of value chains. Furthermore, suppliers and industry associations could receive a stronger role on the NOW advisory board.
5. The involvement of **research institutions** in the NIP should also increase. Extending the higher funding ratios for research institutions to BMVI projects – a step taken at the end of Phase 1 of the NIP – was a start. In addition to program research, Phase 2 could also specifically support prenormative research projects, international technology benchmarks, or studies on market design by research institutions.
6. To support the upcoming market ramp-up, Phase 2 should expand the palette of **funding instruments and activities** to the extent possible under funding regulations. Approaches could include investment subsidies and buyer’s premiums to simulate private and business demand, funding to build and operate infrastructure, funding for direct investment to build production capacity, the assumption of guarantees, the provision of loans and risk capital, or the activation of public sector sourcing. Phase 2 funding guidelines already include investment subsidies/purchase incentives and funding for investment into production capacity. The range of instruments used to promote battery electric vehicles in Germany and abroad can provide additional examples of approaches.
7. Policymakers can also take actions beyond the NIP to improve **regulatory conditions** affecting the technology’s adoption. Options could include incentives for public sector sourcing, tax reductions, nonfinancial benefits for users of hydrogen technologies, and stronger consideration of hydrogen in regulations to ensure hydrogen is treated equally and considered as a path for a low-carbon energy system of the future. Such efforts should also be coordinated with the NIP to ensure maximum efficiency.

Implementation of Phase 2

8. The program and its funds should be more **actively managed**. This starts with the definition of **clear program targets** substantiated with **measurable** indicators wherever possible. These targets and indicators should be defined by application areas and technologies. Projects should systematically and consistently define their own targets along these indicators, be assessed and prioritized on this basis, and base their reporting on these indicators as well. Project progress should then be tracked against the resulting milestones soon after the work is completed and taken into account in decisions on future funding allocation.
9. **Approval, reporting, and evaluation processes** should be accelerated. The new electronic application process is already a good first step in this direction. Templates, based on existing reporting

⁶ European Commission, 2017

requirements from funding guidelines, could help funding recipients to provide more structured, quantified, and concise documentation of project goals and progress. Using consistent indicators for project goals in sketches, applications, and interim or final reports will make it clear for funding recipient what information is actually needed and easier for program management to track targets and speed up funding and reporting processes. To eliminate the need for duplicate inquiries, templates should contain all information required by both PtJ and the NOW for BMVI-funded projects. An overview of these indicators could also support feedback to program management and regular evaluation.

10. Greater attention should be paid to **crosscutting and overarching functions** in Phase 2. More proactive communication of program success stories, especially to the general public, would further increase acceptance of the technology. Greater knowledge sharing could take place among projects, sectors, and ministries, e.g., status seminars could take place more often and include both BMWi and BMVI projects. Coordination among stakeholders could be similarly strengthened.

Phase 1 of the NIP has given the development of hydrogen and fuel cell technology tangible momentum. If the experiences of the last ten years are put to use, Phase 2 can help this innovative technology to achieve a market breakthrough.

