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Deliverable 5.8 Financial Scheme proposal for market entry of commercial SOFC-based CHP systems

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Introduction

Introduction

European SOFC manufacturers are developing competitive SOFC CHP technologies for a global market. Within the COMSOS project they are establishing a profound basis for their products delivering adequate technical performance and insights into cost-effective manufacturing.

As the products that are being developed within the COMSOS projects are the first commercial demonstrations it is foreseen that the products will experience a fast cost-down curve. For a detailed analysis on the cost down potential please see D5.3.

To realize the foreseen cost down potential the manufacturers must go through a growth phase where both the manufacturing base and the retail network has to established. This is a phase with great financial risk, due to the combination of technical, manufacturing and commercial risks at each level of production. Earlier studies have indicated a great potential for SOFC CHP technology at the foreseen mass market prices. The question remains how the financial risk of upscaling can be dealt with. This report investigates on such opportunities.

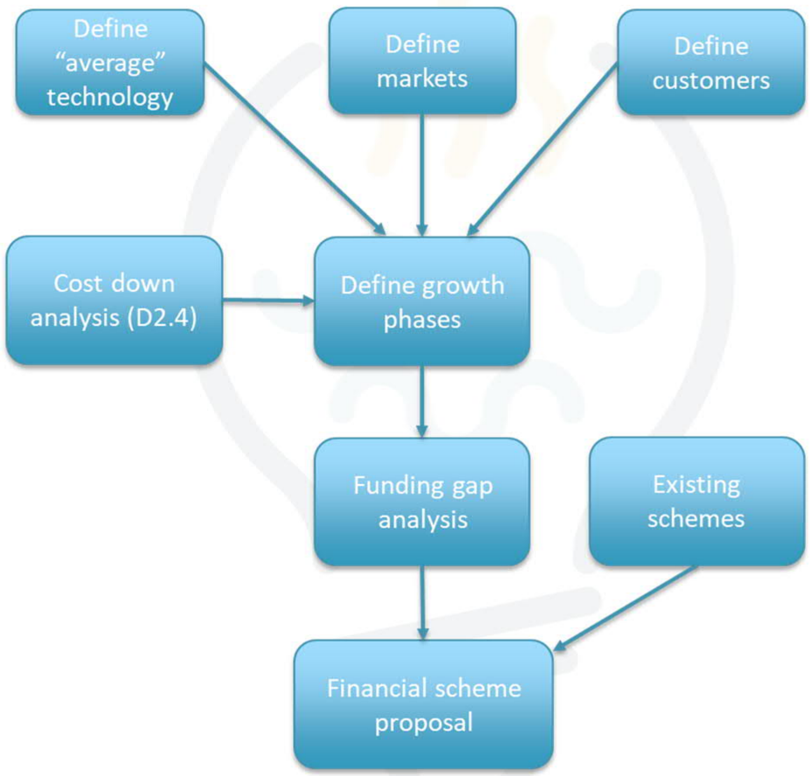
The goal of this analysis is to determine to which extent external funding (capital subsidies or public loans) can help to support the growth phase of SOFC CHP manufacturers in Europe.

Approach

In order to identify the need for a financial support scheme we will make a simplified analysis that will show a robust mechanism to help the SOFC industry to mature.

We will shortly summarize the choices made in defining an average module, interesting markets and potential customers. Based on this and the outcome of the cost analysis from D2.4 growth phases of the industry are established.

These growth phases, the underlying cost curve and acceptable retail price are used to analyse the funding gap. Based on this analysis and an evaluation of the existing schemes, the need and possibilities for a financial scheme will be discussed.



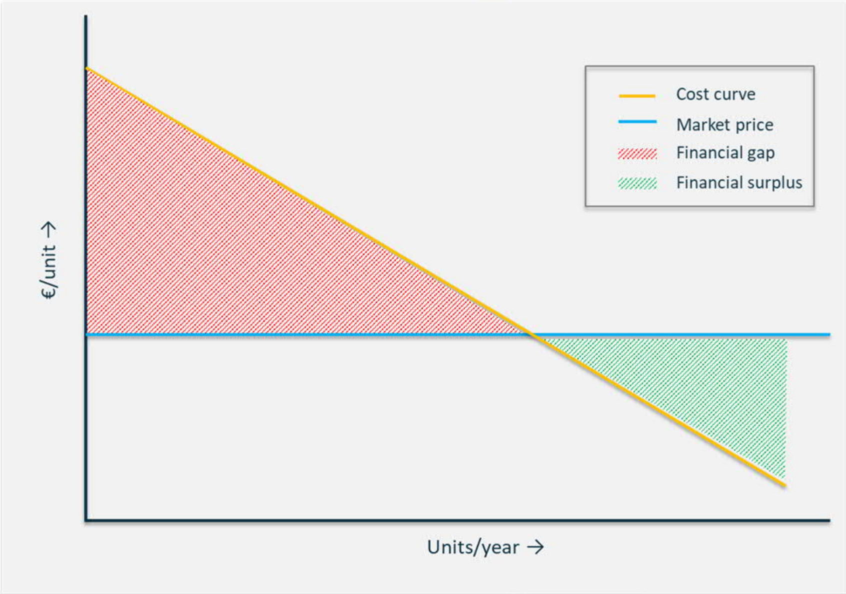
Analysis of Market potential

Need for support scheme

Financial situation

In this first period of market implementation of a new technology an industry often has to deal with a funding/financial gap after which in a later stage a financial surplus could occur if cost prices have dropped. This mechanism is shown in the figure on the right. The general goal of a support scheme is to help a technology through this first period in which production capacity is low and the cost price per unit high. Public support schemes are often in place if a technology offers societal benefits such as, in the case of SOFC, CO_2 emission reduction and the potential of carbon free electricity production. To understand in which way the SOFC industry could benefit from a support scheme, it needs to be clear to what extent they deal with a financial gap and if/when a financial surplus can be reached. Therefore 3 aspects are crucial:

- Cost price development of the technology
- Acceptable market price
- Market size potential



These three aspects have been analysed in previous reports on SOFC technology by ComSos and other stakeholders. A short summary and explanation of the assumptions will now be provided.

Cost curve

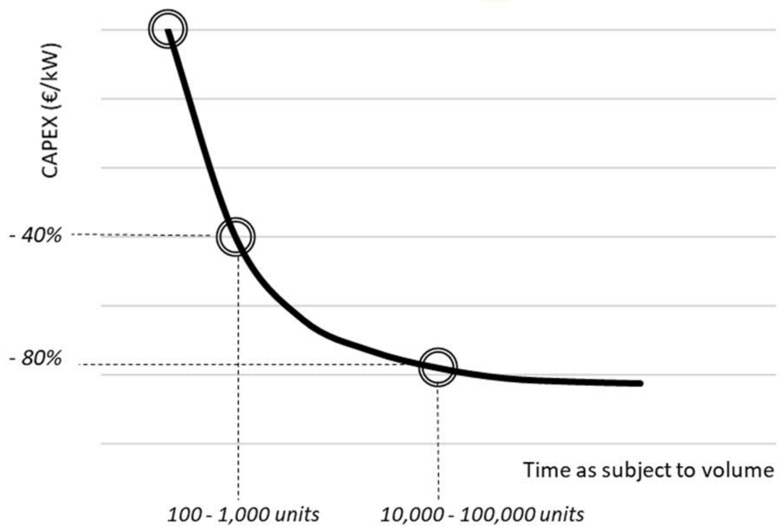
Cost down potential

The cost price of SOFC technology is likely to go down if production increases due to factors as economy of scale and learning-by-doing. The potential for cost reduction can be expressed by the learning rate*. The ComSos target assumes a learning rate of around 15%.

The learning rate is underpinned and compared with learning rates from other technologies and other theoretical and empirical analysis of the costs of SOFC technology. This report is confidential.

Conclusion of this report is that a learning rate of 15% seems to be very realistic. Solar PV and Ion-lithium batteries, for example, appear to have even better learning rates with 21% and 18%, respectively. In the analysis a learning rate of 15% is assumed.

Total cost down potential SOFC technology

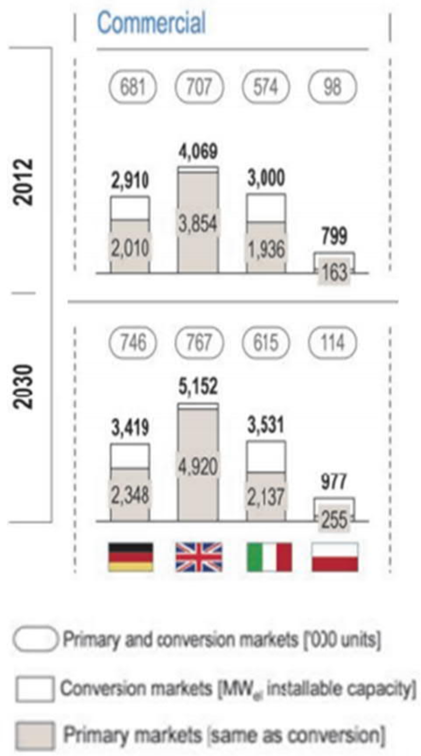


* The learning rate is defined as the % of cost reduction by each doubling of the production capacity

Market size

To be able to utilize the cost down potential of SOFC the potential market needs to be large enough. The scope of the COMSOS project is bound to the commercial sector. The EU commercial sector is large, both in primary and conversion (already CHP customers) markets. The Figure on the right shows the size of the European focus markets.

The number of potential customers for SOFC technology is likely to be lower. Especially in the early phase, in which SOFC technology should focus on premium customers that have a non-financial benefit such as lower carbon footprint or limited NOx emissions. Such a customer will allow for NPV of zero at a given WACC level, for example in a long term power purchase agreement. We expect that these type of customers represent at least 10% of the market. This still corresponds to a multiple of 100.000 potential customers in those four focus market alone. Therefore, we believe that the market is large enough to get to mass production if an interesting business case can be offered.



Roland Berger Strategy consultants, „Advancing Europe's energy systems: Stationary fuel cells in distributed generation," 2015.

Market price

Defining average Comsos technology

The business case of commercial SOFC has been analyzed in deliverable 5.4. However, the three systems that are part of ComSos differ in terms of capacity and other technical characteristics (see figure on the right.

To show an overall view on the chances of SOFC technology, a reference system of 30 kW with average efficiency and degradation has been taken into account. The business case further includes the latest fuel and electricity price developments, national energy taxation schemes and real energy demand profiles per sector.

More information on the assumptions with regard to the business cases can be found in deliverable 5.4.

All key performance data are to be validated within the Comsos project

Market price

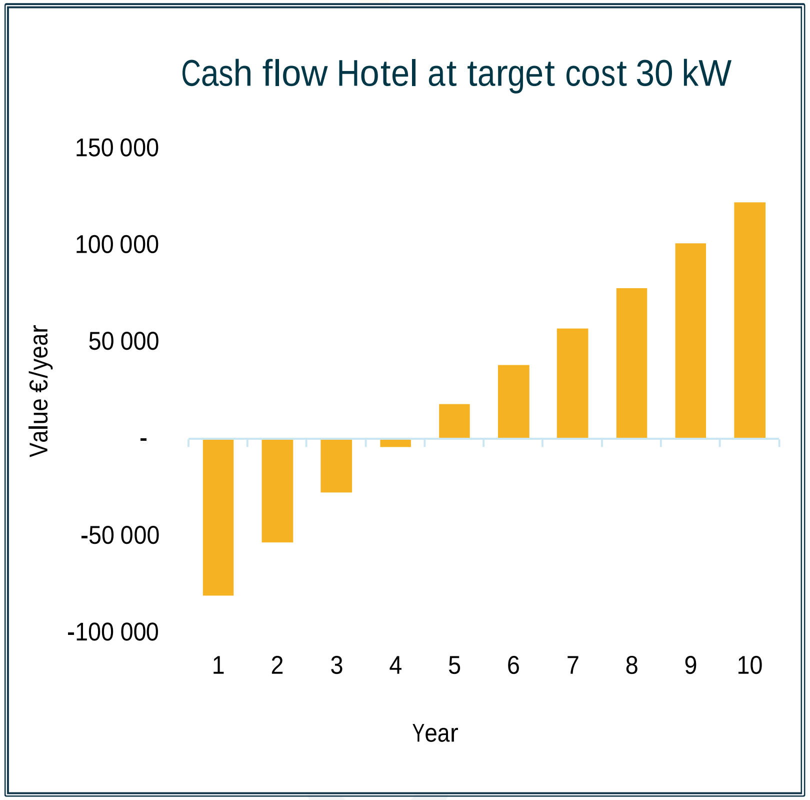
Reference market

The business case of several sectors have been analysed and a hotel is considered to be an interesting sector due to:

- Mostly internationally driven companies with green profile or need for full compliancy with energy regulation
- Scale of the SOFC is sufficient
- Baseload use of electricity
- High heat demand (resulting in high fuel demand and therefore low prices)
- Use for back-up power
- Many existing engine-based CHP

In the figure on the right a cash flow of a hotel under target costs is shown. Also other sectors such as supermarkets, hospitals and SMEs can have similar business cases, dependent on the circumstances. The characteristics of a hotel are considered in the analysis in this research.

We see that data centers might also provide good opportunities but this niche markets should still be attested within field trials to see if commercial size SOFC systems are an optimal fit.



Market price

Optimal and average customer

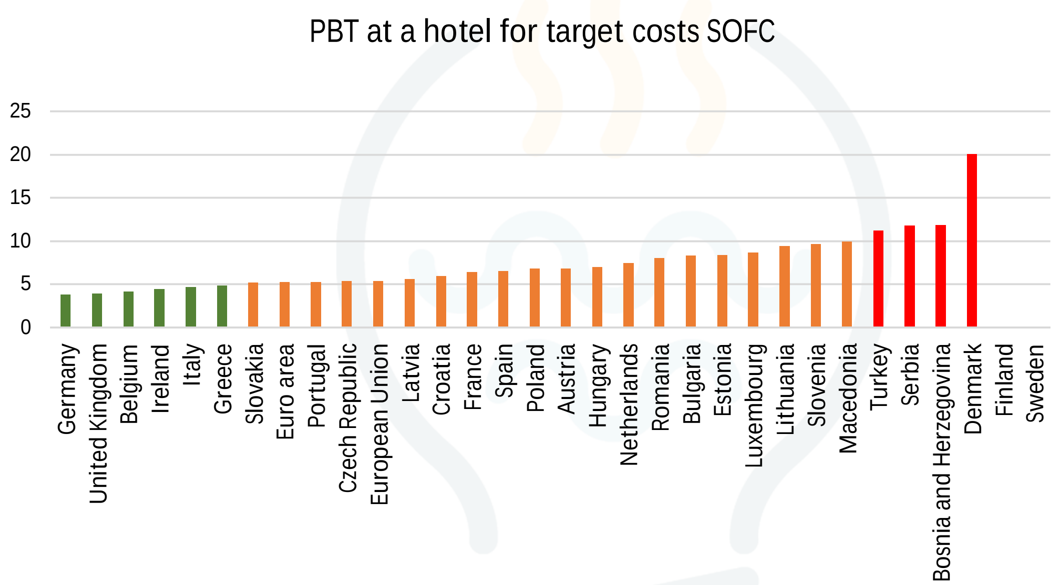
The business case and therefore the acceptable retail price depends heavily on the energy prices. These energy prices are an uncertain factor in the calculations. To integrate this in the calculations regarding the funding gap, two energy price scenarios are used to create a bandwidth:

Upper line bandwidth

Takes into account German energy prices as an optimal case.

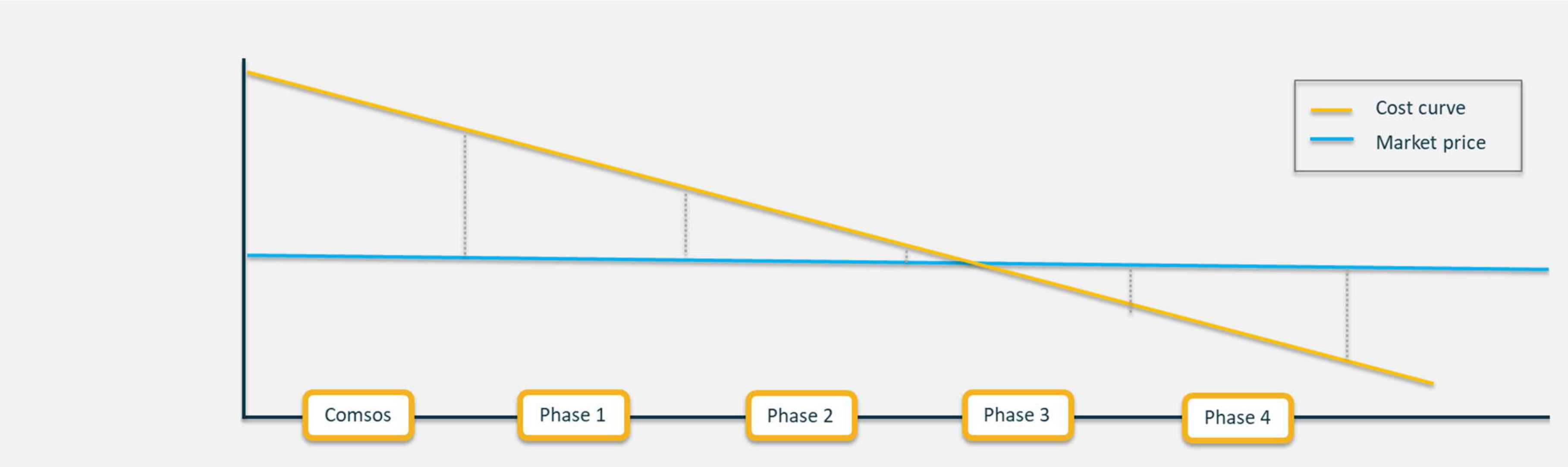
Lower line bandwidth

Takes into account the EU average energy price as a reference.



Graph funding gap

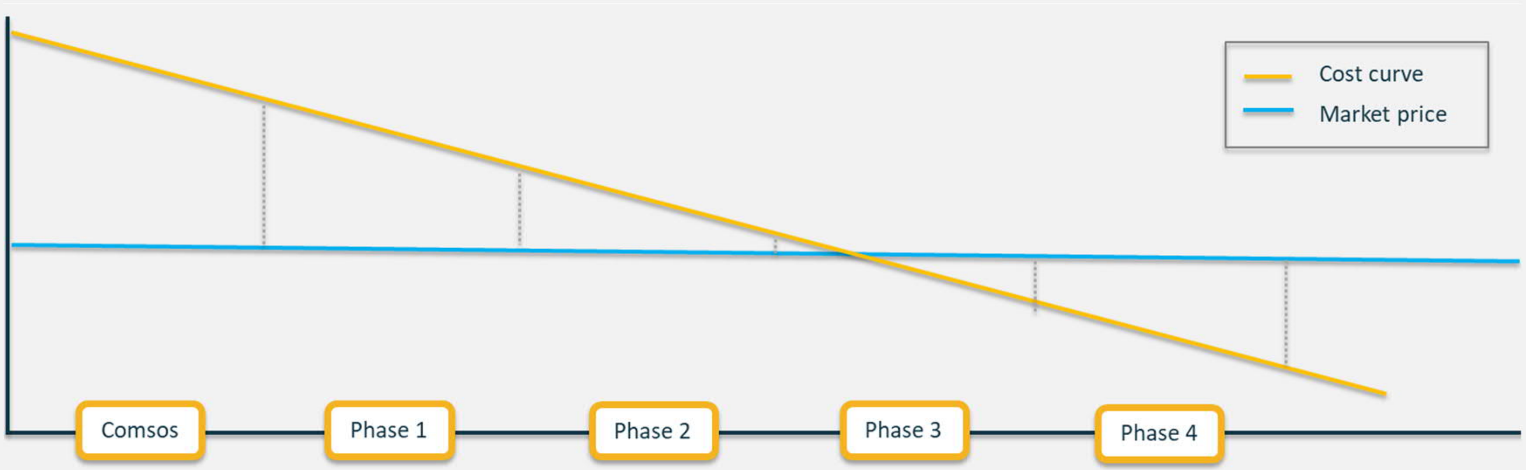
Explanation



The cost curve and the average acceptable market price for the commercial size SOFC industry are illustrated above. We divided the path towards a mature industry into four different phases after the Comsos project. These phases will be the basis for analyzing the funding gap of the industry. In the next page the characteristics of each phase are presented.

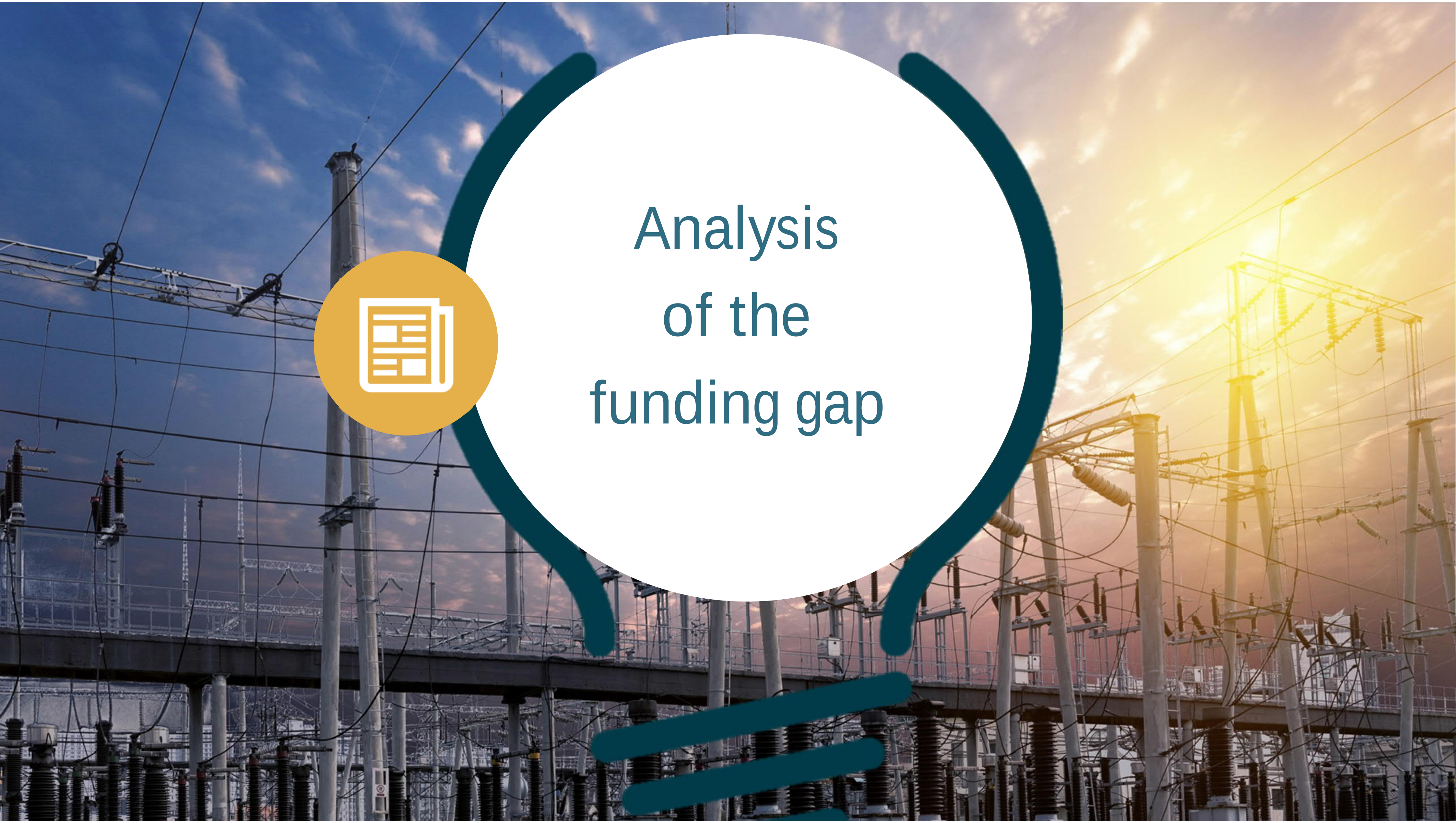
Graph funding gap

Characteristics per phase



Capacity/year	>1 MW	3 MW	10 MW	30 MW	100 MW
Units/year	>30 u	100 u	300 u	1000 u	3.000 u
Length	>2 years	2 years	2 years	2 years	>2 years

Analysis of the funding gap



Explanation of results

The main outcome is represented as the funding gap or the funding surplus. This is the result of the following calculation:

Funding gap = (ACP-CCP) x A x B

ACP = Acceptable cost price (€/kW) when NPV = 0 at given weighted average cost of capital (WACC)

CCP = current cost price per phase
A = number of installations per phase
B = number of manufacturers

Example:

A hotel customer with 5% WACC can allow for investment level of 5600 euro. At cost level of 6000 €/kW this gives a financial deficit per installation of 400 €/kW. This number is than multiplied by the total number of installations.

The analysis is shown for three different WACC levels:

- 2%
- 5%
- 10%

The bandwidth per phase and per WACC is shown as below:

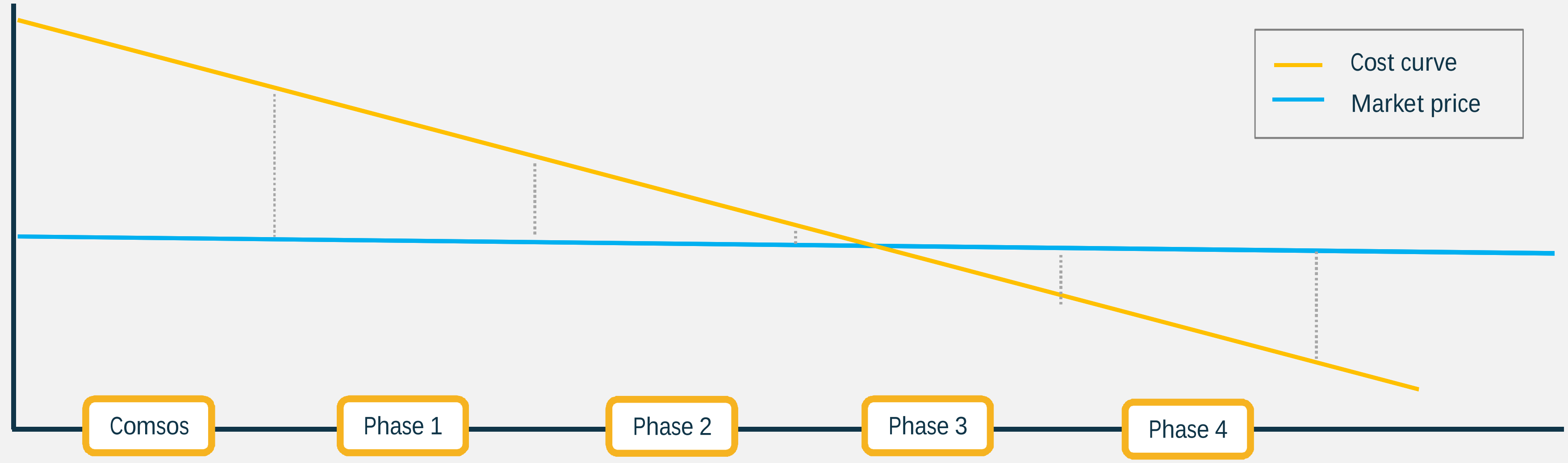
-5M€* ----- 5M€**

*Lower limit
Takes into account the EU average energy price as a reference.
**Upper limit
Takes into account country with relative high spark spread.

Red: Funding gap
Green: Funding surplus

Financial position of the sector

Funding gap over time



2% WACC	-8M€ ----- -3 M€	-22M€ ----- - M€	-9M€ ----- +54 M€	+54M€ ----- +300M€
5% WACC	-9M€ ----- -5 M€	-27M€ ----- -10 M€	-23M€ ----- +27 M€	0 M€ ----- +200 M€
10% WACC	-10M€ ----- -7 M€	-32M€ ----- -16 M€	-36M€ ----- 0 M€	-54 M€ ----- +125 M€

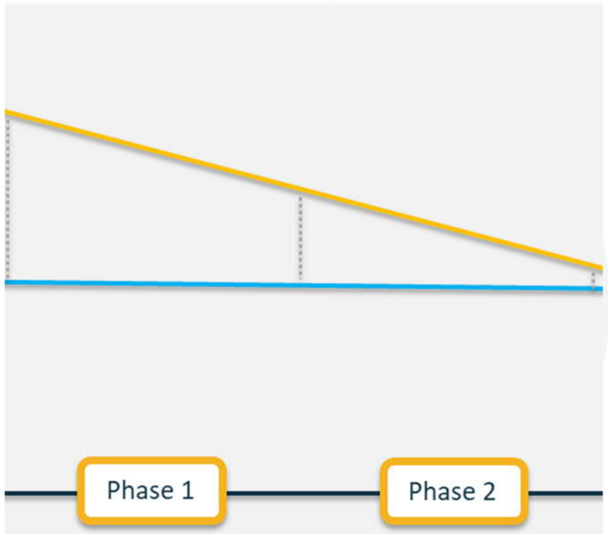
Phase 1 & 2

Funding gap

The analysis shows that in the first phase the cost price is still too high to meet the acceptable retail price. All the complete bandwidths for all WACC are negative. The expected funding gap for the industry related to commercial scale SOFC is 5 to 10 M€ in this phase.

The funding gap is likely to grow in the second phase although the cost price is getting closer to the acceptable retail price. Due to the larger number of sold units the funding gap of the industry can grow up to 30M€. In the most positive scenario the gap is already closed in this phase.

Up to the end of phase 2 a funding gap can be expected for the industry if no support is provided. It shows the need for a significant incentive scheme or a public loan.



-8M€ ----- -3 M€	-22M€ ----- - M€
-9M€ ----- -5 M€	-27M€ ----- -10 M€
-10M€ ----- -7 M€	-32M€ ----- -16 M€

Phase 3 & 4

Funding surplus

Phase 3 shows a turning point. In this phase the cost price is predicted to come below the acceptable retail price in a significant number of cases. Good profits can be made in this phase, which may be used to finance phase 1 and 2. On the lower end of the bandwidth (the average case) a funding gap is still present.

The financial situation of the industry in phase 4 is rapidly improving in phase 4. For optimal cases the funding surplus could be as high as 300 M€. Also, if WACC levels are 5% or less the lower end of the bandwidth provides positive revenues. This means that there is a large potential market for commercial SOFC systems.

Analysis of existing schemes

Existing incentive schemes

There is already a broad range of incentives schemes active for fuel cell CHP. The form as well as the support level can differ significantly. The following support mechanisms have been seen:

- Feed-in tariffs
- Feed-in premiums
- Quota obligations with tradable green certificates
- Loan guarantees
- Soft loans
- Investment grants
- Tax incentives
- Tendering schemes

The support level for fuel cell CHP in certain regions has a huge influence on the regional market and industry developments. On the next few pages an overview is provided of the support schemes that are in place or have been in place and the associated market conditions for fuel cells in the US, South Korea, Japan and the EU.

USA

Characteristic market & support schemes

- Fuel cell industry has received significant support for research and development from the federal government with a total of 2.1 billion in the period of 2005-2015. Moreover, venture capital has had a major role in the uptake of the industry.

- The investment tax credit has been an important support mechanism. Besides that, financial support for deployment mainly via public funding at state level (see textbox). Large variation between states.

- Support schemes aim to support local manufacturers. Foreign or out-of-state entities receive less or are excluded form the support.

- Deployment rates have been significant in certain states, mainly in the commercial scale (100s kW). Has led to significant cost reduction for main manufacturer Bloom Energy with a learning rate of 25%.

Support schemes

Federal level

A main driver of fuel cell deployment in the USA has been the investment tax credit of 30% of the investment cost of the fuel cell. However, the amount of tax credit is currently been reduced to 22% in 2022 and then expires. An alternative scheme has not been presented yet.

State level

On individual state level significant funding levels have also stimulated fuel cell deployment. In California the SGIP program has supported natural gas powered fuel cells with $2.450, while it is now reduced to $600/kW. The quota on renewable sources active in New York and Connecticut have also had a significant impact on the installed capacity in those states.

A complete overview of all subsidy schemes relevant for SOFC can be found on:

https://www.dsireusa.org/

South Korea

Characteristic market & support schemes

- Ambitious plans for renewables due to high GHG emissions and poor air quality have been the trigger for policy support for fuel cell technology.

- The fuel cell market in South Korea is dominated by energy utility, with systems in the order of MWs. This is due to a quota obligation (see textbox).

- Deployment is high in terms of capacity but numbers of installed units and cost figures are not known. It is unclear if significant cost reduction has been reached.

- Support schemes do not favor national/local companies and R&D support has been rather limited. The fuel cell power plants installed in South Korea are all based on foreign technology.

Support schemes

Renewable Portfolio Standard
Fuel Cells are designated as part of the "New and Renewable Energy" program regardless of fuel source and hence qualify for the Renewable Portfolio Standard. Electric utilities and independent power producers have an obligation to have a percentage of their power from new or renewable sources. For large scale power generators fuel cells are an interesting source under the current legislations and market conditions. Moreover, the South Korean Government provides capital subsidies for large-scale fuel cells, which can be as high as 80% for demonstration projects. However, the exact conditions for support are not clearly defined. The fact that there is no specific fuel cell support scheme makes the industry vulnerable. In that matter it is interesting to note that the mandatory share of renewables for public buildings has not lead to much activity around fuel cells.

EU Members

Characteristic market & support schemes

- Feed-in-Tariffs and feed-in premiums have been the most popular method to stimulate CO_2 reduction. It differs per country if fuel cells are included in those support schemes.
- Consistency in support for fuel cells is often lacking with significant changes in schemes over time. An example is the end of the FiTs for fuel cell co-generation in the UK last year.
- Very few support schemes that specifically focus on fuel cells and often lack the right level of support for fuel cells in this phase.
- Focus of support schemes has mostly been on residential application (e.g. Germany; see textbox) and most activity have been seen in that area as well.

Support schemes

In Germany has a capital grant available for stationary fuel cell µCHP with a capacity of 0,25 kW to 5 kW_{el}. Up to 40% of eligible costs will be covered with a maximum of €28k. Germany considers small-scale CHP fuel cell as an exportable technology and hence offer stronger support to build up the industry. Support for larger scale fuel cell CHPs is lacking.

There are no comparable support schemes in other countries. Some countries include CHP in the FiT scheme or have tax incentives in place such as Italy and France but those are not substantial and the impact is low.

A latest review of the available support schemes can be found here:

Review of Renewable Support Schemes in Europe

Japan

Characteristic market & support schemes

- Japan has set ambitious targets regarding carbon reductions in both the commercial sector and the residential sector. Fuel cells, eventually driven by hydrogen, play an important role in plans to reach these targets

- Support has been focused has been on residential systems and activities in the 5 kW capacity range are limited. But the focus will be expanded. The goal is to reach 1 GW of commercial and industrial systems in 2030.

- Both PEMFC and SOFC have experienced large cost reductions (over 50%). The cost of PEMFC has even reached the target price and it no longer qualifies for incentives.

- Deployment rates have been increasing rapidly since 2009. More than 300.000 micro CHP units have been installed, of which more than 75.000 SOFC systems. The goal for 2030 is the installation of 5.2 million systems.

- The industry is led by large conglomerates for which the investments in fuel cell development are not affecting their financial position significantly.

Support schemes

EneFarm

Enefarm is a government funded initiative to develop and install fuel cell micro CHP systems. It included an investment subsidy that gradually reduced as the industry matured and the cost came down. It started with a subsidy for PEMFC more than €10k while currently systems have been sold without subsidy. SOFC systems still receive subsidy of 700€ per system. The EneFarm budget is re-allocated to support larger scale commercial applications as well. This will be done according the same mechanism as for the micro-CHP.

For more information see:

Hydrogen and Fuel Cells in Japan

Learnings

Characteristic market & support schemes

- Feed-in-Tariffs have not been a very successful method to stimulate fuel cell technology. It appears to be difficult to provide enough incentive via such a support scheme.
- Grants or investment subsidies have been the major driver behind the number of installations in most regions.
- Quota obligations also have had their impact on the installed capacity in several regions. This lead to the uptake of fuel cells by large scale firms or utilities.
- Stability appears to be key for the stimulation of the fuel cell industry. Consistent policy in mainly Japan but also in the US have helped to mature the fuel cell industry.
- The access to sufficient financial resources appears to be an important condition for the growth of a FC industry. In Japan investment are done by the large conglomerates while in the US venture capital plays an important role in the development of the industry.

Recommendations and Considerations

Support schemes

Requirements and opportunities

The results of the analysis show the potential of the industry in phase 3 & 4 but also a financial deficit in the first two growth phases. The industry could expand their business in markets with incentive schemes already in place or target specific niches to reduce the funding gap.

However, in order to get through the first difficult phases the manufacturers would be helped out with clear financial incentives for commercial SOFC as well as access to sufficient financial resources.

Stimulating commercial size SOFC technology results in direct CO_2 emission reduction and supports a transition towards hydrogen in the long run. Therefore, it fits perfectly into the EU vision on mitigating CO_2 reduction and moving towards a sustainable building environment.

Therefore support of the commercial size SOFC technology could be offered via already existing support mechanisms such as Horizon Europe, LIFE and InvestEU.

Guarantees and soft loans

InvestEU/EIB instruments

The analysis of the funding gap shows that there is a need for financial support in phase 1 & 2. Financial schemes that offer access to low interest loans and guarantees are therefore required.

Recently, the EU focuses on providing this type of financial support. Soft loans, for example, are an increasingly popular instrument for the EU to (co)finance energy investments. These loans are mostly directly or indirectly provided by a public bank (e.g. EIB) or an intermediary, offering favourable terms and accepting higher risk than commercial financers.

All financial instruments are bundled in the InvestEU program. The program will consist of the InvestEU Fund, in which public and private investments are mobilized through guarantees from EU budget.

The upscaling of the SOFC industry fits into the objectives of the InvestEU programme:

- address market failures or investment gaps and be economically-viable
- need EU backing in order to get off the ground
- achieve a multiplier effect and where possible crowd-in private investment
- help meet EU policy objectives

The InvestEU Fund will be implemented through financial partners who will invest in projects using the EU guarantee. The main partner will be the EIB Group which offers a wide range of initiatives to support clean energy activities. We recommend the manufacturers to discuss the specific opportunities for financial support with the EIB.

Grants

LIFE/Horizon Europe

Soft loans and guarantees will help to overcome the funding gap in the first two phases and build up the industry for commercial SOFC. However, to reduce the funding gap and trigger the market a capital subsidy could provide the industry a boost in the first phase, in which for most cases the acceptable retail price is still a lot lower than the cost price.

The successful roll-out of fuel cells in Japan and US have been supported by a clear and consistent investment subsidy. In Europe the KfW 433 programm and the Horizon 2020 project PACE also illustrates the possibilities of such an approach.

A successor of the ComSos project could be designed as PACE project which is a capital incentive for µCHP to trigger the expansion of industry.

Horizon 2020 is replaced with Horizon Europe in the period after 2020. However, it is more likely that a potential call for upscaling of the commercial SOFC industry will be under the LIFE program.

The support for capacity building for the clean energy transition contributing to climate change mitigation, currently funded under Horizon 2020 for the period 2014-2020, is likely to be moved into LIFE. LIFE will get a Clean Energy Transition sub-programme to support replication and upscaling of clean energy technologies.

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