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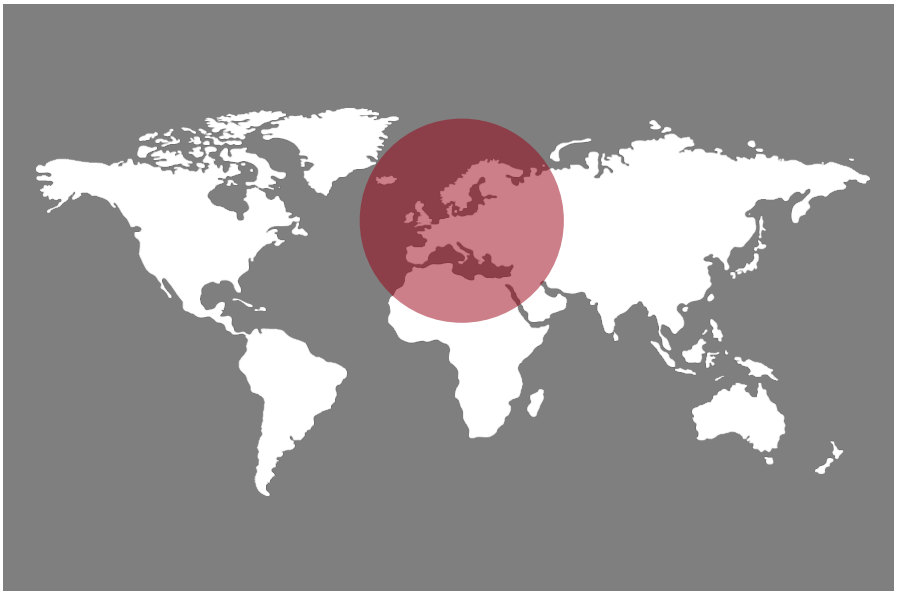

Project volumes and co-financing rates for the industrial sector in the Innovation Fund

Raffaele Piria

POLICY BRIEF

Citation

Piria, Raffaele 2016: Project volumes and co-financing rates for the industrial sector in the Innovation Fund. Berlin: adelphi

Imprint

Publisher: adelphi consult GmbH

Author: Raffaele Piria

Design: adelphi

Information current as at: November 2015

Disclaimer

This report has been produced in the frame of a research project funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety. Only the author is responsible for the contents of this publication.

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Raffaele Piria

Senior Project Manager

piria@adelphi.de
T +49 (30) 8900068-879

www.adelphi.de

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Executive Summary

The Innovation Fund (IF) is intended to support the demonstration of innovative technologies for CCS, industrial processes and renewables. These categories have very different requirements in terms of investment grants and co-financing levels. In the industrial sector, a large number of potential non-CSS based projects are relatively small and low risk, whilst CCS projects are more capital intensive and risky. Thus, it makes sense to define the three categories in a slightly more detailed way: CCS *for industrial processes and power generation*, *all other* industrial sector projects, and renewables.

A competitive environment for the selection of the projects to be supported by the IF is desirable. Competition based on objective criteria is possible among comparable projects of the same category, but hardly conceivable among the different categories. Therefore, a budget quota for the different categories will at least be set implicitly as a result of the implementation rules in the Delegated Act that will be written by the Commission after adoption of the directive.

Most non-CCS industrial sector and renewable projects can be effectively supported with IF grants up to maximum €300 million, and in many cases clearly lower, at co-financing rates of maximum 50%, often clearly lower.

CCS projects, both for industrial processes and for power generation, require larger investment volumes. Due to the lack of a business case at foreseeable CO_2 prices, they also require larger investment grants and higher co-financing rates. However, opening the door to individual grants of up to more than €1.5 billion does not seem justified. Interesting projects can probably be triggered with grants up to circa €600 million.

Introduction

This policy brief intends to support the formation of opinion concerning aspects of the design of the Innovation Fund, part of the revised EU ETS Directive. It was written within few weeks in autumn 2015 by an energy policy expert with no background in industrial processes, based exclusively on a quickly-executed research on the available literature. Interviews with industry experts to verify the findings had been excluded at the request of the client. Such verification is recommended.

The predecessor program, NER300, made investment grants available for technologically innovative CCS and renewables demonstration projects. An important novelty compared to NER 300 is that the Innovation Fund (NER450/IF) will also "support innovation in low-carbon technologies and processes in industrial sectors"[1]. This brief has been written under the assumption that the structure of three activity fields (industry, CCS and renewable energies) cannot be changed, regardless of the views some Member States may have on the role of CCS.

The Commission proposed to make available altogether 450 million allowances for NER450/IF, an increase of 50% compared to NER300. Depending on the average revenues from these allowances, DG CLIMA expects that the total budget available for IF/NER450 will be in the range of €4.5 to €11.25 billion[2], i.e. more than two times and up to five times larger than the NER300 budget.

This paper explores questions related to the appropriate co-financing rates and the meaningful size of projects in the industrial sector. Co-financing rates are relevant only in so far as the future NER450/IF will continue offering investment grants. Although the Impact Assessment by DG CLIMA considered the option that NER450/IF should offer (also) privileged access to capital, it seems likely that at least a part of the NER450/IF budget will be used to provide investment grants.

The first chapter analyses the requirements for the steel sector, as a proxy for a capital intensive and heavily emitting sector. The second chapter analyses comparable publicly funded programs, described in more detail in the annex. The conclusions recapitulate the main findings and give recommendations for next research steps. The recommendations are oriented to provide support while drafting amendments to the directive proposal tabled by the Commission in July 2015.

[1] Quotation according to the Commission's ETS Directive revision proposal of 15 July. This enlargement of scope and the triad of target sectors are taken for granted here, since it had been explicitly requested by the Council in its October 2014 conclusions and it finds broad support in the European Parliament.

[2] Impact Assessment ETS revision [SWD(2015) 135 final], Annex 14, page 224.

1 Investment volumes for decarbonisation measures in the steel sector

Steel mills are among the most capital intensive industrial facilities, and steel making is the industrial sector emitting the greatest amount of CO_2. Thus, a brief look at the steel sector can help in assessing the order of magnitude of the largest industrial sector projects investments that the Innovation Fund (IF) should be able to support.

The main conclusion is that an IF grant of up to €300 million would (in most cases by far) be sufficient to:

- Co-finance substantial technological innovation in most of the new steel mills planned at a global level.
- Co-finance all non-CCS based individual decarbonisation measures listed in the UK's steel sector decarbonisation roadmap.

However, investments for CCS demonstration projects in the steel sector might require significantly more extensive support. Nevertheless, even the largest CCS investments in the steel sector can be supported with significantly lower IF grants than allowed for by the current directive proposal.

A validation of these preliminary conclusions could best be pursued by a consultation with steel industry experts. Whilst such a consultation was excluded by the specifications for the present policy brief, it could be carried out as a next step.

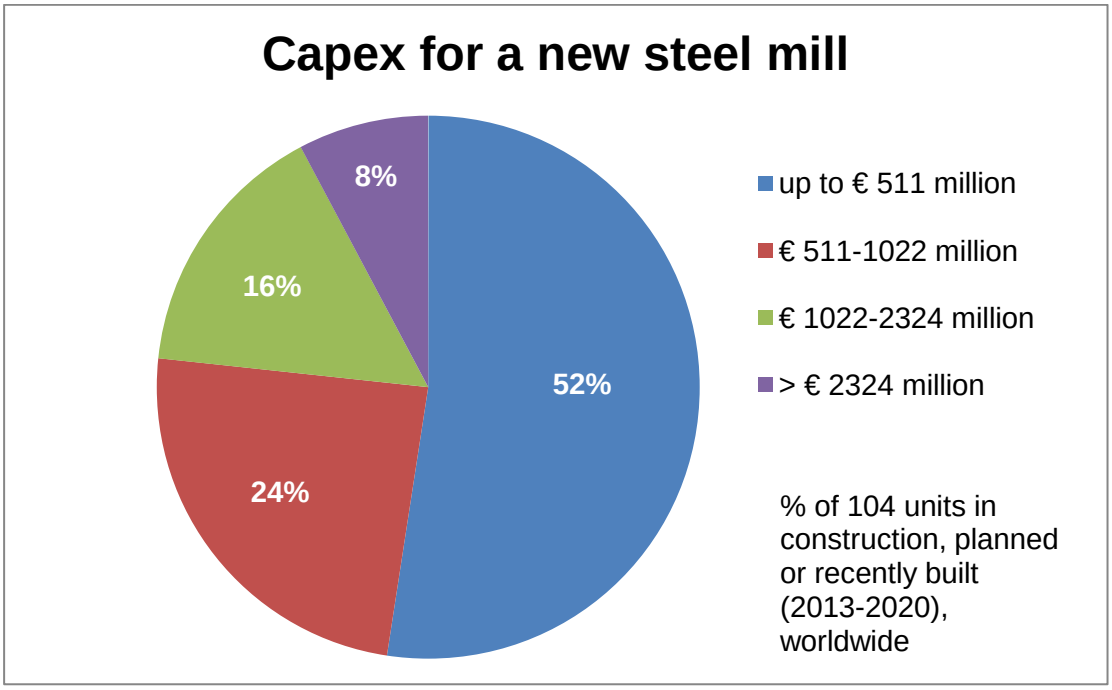
Investment volumes for new steel mills at global level

OECD (2015)[3] is the best publicly available overview of ongoing investment in steel mills at a global level. It provides a probably quite exhaustive list of 342 steel mills that are planned, in construction or have been recently built at a global level, including non-OECD countries. The list includes capital expenditure (capex) data for 104 units, which are the basis for this analysis.[4]

[3] OECD: Excess Capacity in the Global Steel Industry and the Implications of New Investment Projects, OECD Science, Technology and Industry Policy Papers, No. 18. http://www.oecd-ilibrary.org/science-and-technology/excess-capacity-in-the-global-steel-industry-and-the-implications-of-new-investment-projects_5js65x46nxhj-en;jsessionid=qk7jhm63x3d8.x-oecd-live-03 . The sources of this OECD publication are in most cases specialised press reports or company communications.

[4] The average capacity of the 104 units with a capex value indication is 2.9 mtpy (million metric tons of steel per year), whilst the average capacity of the projects without capex values is 1.7 mtpy. Therefore, the projects considered in our analysis are considerably larger than those not considered. This observation strengthens our conclusions, since it can be assumed that the IF-grants required for the projects without a capex data in the OECD data would be in the average considerably smaller than for the projects considered here.

Illustration 1: CAPEX for a new steel mill



Source: OECD (2015) own elaboration. 1USD = 0.93 EUR.

More than half of the new steel mill units require a capex up to maximum €511 million ($550 million). More than 75% require up to maximum circa €1 billion capex. More than 90% require less than circa €2.35 billion. Most of the few ones featuring an even larger capex are very vaguely described investment plans, without even a specification of the technology to be used, or the number of units. It is likely that some of these giant investment plans consist of several units. They might well be downsized or cancelled once detailed technological analysis and profitability calculations have been carried out.

Knowing the order of magnitude of capital expenditure for new steel mills, only two assumptions are needed in order to calculate the IF-grants that would be required to support them.

1) Like for NER300 and other comparable programs, the co-financing provided by the public fund is not calculated on the overall investment for the entire facility, but only on the *additional costs linked to the technologically innovative elements*. Here it is assumed that the ratio between eligible costs and total investment costs is 30%. This is an arbitrary assumption. The verification of its plausibility would require interviews with steel sector experts, which were not planned as part of the research design for this policy brief.
2) Co-financing rates provided by the IF are assumed to be 50%. This can be supplemented by national funding. This is more than the average of comparable programs in the manufacturing sector (see the dedicated section below).

Based on these assumptions and on the OECD data, one can draw conclusions about the volumes of IF investment grants:

IF support	up to €75 million	is sufficient for	> 50% of new steel mill units	
“	up to €150 million	“	> 75%	“
“	up to €350 million	“	> 90%	“

First of a kind demonstrations of innovative technologies are usually not carried out at the largest conceivable scale. Therefore, the largest steel mills are very unlikely to be a relevant benchmark to calculate the size of the future IF grants.

Based on these observations and assumptions, a €300 million cap to the IF support for individual projects would not hinder any non-CCS project in the steel sector.

Investment volumes for decarbonisation measures in existing steel mills

The conclusion of the previous section is confirmed by an assessment of potential investment volumes in existing steel mills, based on WSP-DNV-PB (2015),[5] the steel sector decarbonisation roadmap published in 2015 on behalf of the UK's government. It is based on broad analysis of the available literature and on a wide consultation with experts from the UK's steel sector.

Besides extensive qualitative analysis, this roadmap mentions a list of 30 conceivable technology measures to decarbonise steel production, including a rough assessment of their cost.

4 of the 30 measures are CCS-based and require very large investments, ranging from circa €140 million to circa €1,900 million[6] for a rebuild with advanced technologies and full CCS integration. Supporting the demonstration of such CCS-based measures require particularly high investment grants and should therefore be treated in the same Innovation Fund category as CCS projects for power generation.

However, the non-CCS based measures require substantially less capital expenditure. 16 out of the 26 non-CCS based potential measures require less than €7 million capex. 24 out of 26 require less than €70 million. One measure requires circa € 210 million. Even adding up all these 25 non CCS-based measured, one obtains circa €620 million. At a 50% co-financing rate, this would require an IF grant of €310 million. This is very likely to be an exaggerated approximation, because some of these 25 measures appear to be mutually exclusive.

As for the last remaining non-CCS measure, its high-end cost estimate is circa €560 million. This "improved site or sector integration" seems to entail a complete redesign of a site, and therefore it is likely to exclude many of the other 25 measures. Under this assumption, also this measure could be supported with an IF grant up to €300 million.

[5] Industrial Decarbonisation & Energy Efficiency Roadmaps to 2050: Iron and Steel, a report prepared for the Department of Energy and Climate Change and the Department for Business, Innovation and Skills Report of the UK's government.

[6] Assumed exchange rate: 1 GBP = 1.4 EUR.

2 Insights from comparable public funded programs

In-house research including interviews with several experts[7] and has been carried out to identify public funded programs that provide investment grants specifically aimed at promoting demonstration projects (not only R&D) for innovative technologies to reduce energy consumption, greenhouse gas emissions and other environmental emissions in the industrial sector (including all kinds of manufacturing processes, heavy industry, refineries, etc.) Purely or predominantly R&D oriented programs have not been considered here, as they would be in the EU context more a benchmark for Horizon 2020 than for NER450/IF.

The scope was deliberately broader than NER450/IF, as we expected that few programmes would meet all criteria. This list of programmes can neither be considered exhaustive, nor necessarily representative for all comparable programmes. It simply includes those programmes that could be identified in the available time.[8]

Overview

Table 1 in the following page provides an overview of the main findings. According to this paper's priorities, the focus is on the co-financing rates and on the size of the grants for individual projects in the industrial sector.

Co-financing rates are meant here as the share of the relevant/eligible costs covered by the investment grant provided by the program. In some cases, additional public funding from other sources is allowed, like national funds supplementing NER300 grants. Whilst the exact definition of relevant/eligible costs varies in the different programs, the basic principle is generally similar: relevant/eligible is the fraction of the investment costs that is due to the application of innovative technologies and/or of additional environmental/climate protection measures.

[7] Among others, I am thankful for the support and precious information obtained from Julia Reinaud (Industrial Innovation for Competitiveness Initiative and European Climate Foundation, Paris/Brussels), Christine Wörlen (Arepo Consult, Berlin), Luca Bergamaschi (E3G, London), Riccardo Battisti (Ambiente Italia, Rome), Kacper Szulecki (University of Oslo), Ken Guthrie (Sustainable Energy Transformation, Melbourne), Jos Notemboom (Netherlands Environmental Assessment Agency), Li Shuo (International Carbon Action Partnership), Nigel Cotton (European Copper Institute), as well as the colleagues Katarzyna Goebel and Kristian Wilkening at adelphi. All errors and omissions are only my responsibility.

[8] Having said this, there are a limited number of countries or supranational organisations which have the climate policy drive, the industrial basis and the financial means to implement programs that can function as a benchmark for NER450/IF. The most interesting countries for a further deepening of this research might be China, Japan, South Korea and Brazil. An attempt to analyse comparable programs in China within this research has been abandoned due to the difficulty of obtaining reliable information on the financial parameters.

Table 1: Overview on grant amounts and co-financing rates of selected public funded programs

			Grant amounts (€ million)		Co-financing	
Country	**Program**	**Focus/Coverage**	**Typical/avrg.**	**Largest**	**Typical/avrg.**	**Highest**
EU	NER300	Renewables	47.5	203	39%	50%
EU	NER300	CCS	300	300	34%	50%
EU	EEPR	Rapid deployment, here only CCS projects considered	167	180	n.a.	n.a.
Global	GEF	Many sectors, deployment	2-10	57	15-20%	>60%
USA	ARPA-E	Energy, R&D and demonstration	3	10	40%-60%	80%
USA	Advanced Manufacturing	Energy in manufacturing, demonstration	1-11	n.a.	40%-50%	50%
USA	Biorefineries	Demonstration	25-125	125	30%-45%	n.a.
USA	CCS	Demonstration	123-392	392	15%-60%	68%
EU	LIFE Program	Many sectors, deployment / innovation	1.7	4.9	34%	50%
Germany	Climate-friendly manufacturing	Deployment/innovation	n.a.	1.5	n.a.	30%
Germany	UIP	Environmental innovation, demonstration, partly in industry	1	n.a.	n.a.	30%
Australia	Advancing Renewables Programme	Renewables (only partly in industry), Demonstration	1	111	44%	50%
Poland	Gekon	R&D and demo (energy & environment)	n.a.	circa 5	n.a.	80%

Source: see descriptions of individual projects in the Annex. Exchange rates: 1 EUR = 0.87 USD; 1.5 AUSD; 4.25 PLN

The figures on the grant amounts refer exclusively to investment grants provided by that programme. In some cases, the same or other public programmes also provide privileged financing, which is not taken into consideration here.

The "typical/average" co-financing rates and grant amounts are in some cases precisely derivable from available sources, in other cases approximations.[9]

Key findings on the amounts of the grants

The international praxis confirms the findings of the previous section: it is **necessary to distinguish between CCS and all other innovative low carbon technologies for the industrial sector** based for instance on energy efficiency, material savings, less GHG-intensive processes and renewable energies, including biorefineries.

As for the innovative non-CCS based technologies, there is a very broad range of typical project sizes. Several public programs have funded hundreds of small projects, with grants in the range of €1-10 million, while the larger projects usually receive grants in the range of €10-50 million. Biorefineries are outliers that require particularly large investment, with two NER300 projects receiving a grant around €200 million, and the US federal government providing grants up to the equivalent of circa €125 million.

NER300 proves to have been an ambitious program, with high average grants both for the biorefineries and for the other renewable energy projects.

Although some of the analysed programs do support also projects outside the manufacturing sector, most of the projects covered by this analysis are in the industrial sector. It can be concluded with certainty that **a large number of innovative projects for low carbon technologies in the industrial sector has been successfully supported with public funded grants up to** (and in most cases much less) than **circa €200 million, at co-financing rates below 50%.** Within this research, no examples have been found of *demonstration* projects for (non-CCS based) low carbon technologies in the industrial sector receiving grants larger than € 200 million, the largest ones having been granted to biorefineries.

At co-financing rates of up to 50% of the relevant costs, a €300 million funding cap implies an investment of €600 million in the *technologically innovative, low carbon elements of a factory or refinery*. On the basis of this research, it cannot be excluded that such projects might be conceivable, but no such examples are known.

Both in the EU and in the USA, **CCS projects** have been awarded much higher grants than energy efficiency or renewable projects in the industrial sector. The EU programs (NER 300 and EEPR) and the CCS demonstration programs in the USA provided on average grants in the same order of magnitude (€180 – 300 million). However, most EU funded CCS projects have been cancelled, partly due to acceptance or other problems, but mainly for economic reasons. Two large scale US CCS projects funded by the identified programmes are in operation (Air Products and Chemicals, which received a DOE grant equivalent to circa €247 million at a 66% co-financing rate), or very close to starting operation: (Archers Daniel Mid-

[9] The approximations focus on the parts of the considered programmes that are most comparable to the intended scope of NER450/IF, for instance focusing on demonstration projects for innovative technologies, as opposed to R&D or further deployment of already demonstrated technologies. More details can be found in the descriptions of the individual programs in the annex

land, which received a DOE grant equivalent to circa €126 million at a 68% co-financing rate).

It appears evident that large scale CCS demonstration projects require larger investment sums. However, often below €250 million, with the largest individual CSS project having received circa €391 million ($450 million, for the Summit TX Clean Energy supported by the US DOE). This is just a rather small fraction of the absolute value of the funding cap proposed by the European Commission for NER450/IF, which the Commission estimates to be in the range of €675 million to €1,688 million[10] depending on the ETS prices.

The **proposed increase of the absolute value of the funding cap** from €300 million as in NER300 to up to €1,668 million **would make NER450/IF an extreme outlier** if compared with any of the programs considered in this policy brief.

Key findings on co-financing

In most cases, the co-financing awarded to the projects is in the range of 35% to 50%. In a few cases, lower or higher co-financing rates are offered. If considering only projects with comparable innovation levels, the lowest co-financing rates are often linked to lower technology risks, site-specific business opportunities (e.g. enhanced oil recovery for CCS) or to the existence of additional public financial incentives, while co-financing rates higher than 50% are seldom and often linked to strong R&D elements.

The **proposed increase** of the maximum co-financing rate from 50% to 60% **would make NER450/IF a generous program, but not an outlier** if compared with most of the programs considered in this policy brief.

From this analysis, it is **not possible to draw strong conclusions** concerning the appropriate maximum co-financing rates **for NER450/IF**. Low public co-financing rates have the advantage of higher leverage factors and higher private sector commitment to the following stages of the technology introduction cycle. However, low co-financing rates may not be sufficiently conducive to more innovative or risky endeavours, and thus are less suited for supporting the introduction of breakthrough technologies. On the other hand, high co-financing rates risk creating windfall profits and penalising other projects or technologies that cannot be supported due to lack of funds.

Moreover **other factors can play an analogous and possibly more important role than the co-financing rate**. These include the detailed definition of relevant/eligible costs, the possibility of combing NER450/IF funding with other EU or national funding, the applicability of state aid rules for such national funding and the terms under which the public funds are payable: by making (as proposed by the Commission) parts of the grant payable after reaching certain construction milestones, and thus independently from the entry in operation of the project and from its effective technical performance, NER450/IF is reducing the technical risk borne by the beneficiaries. This has a similar effect as an increase of the co-financing rate.

[10] The European Commission has proposed to leave unchanged the cap of 15% of the overall NER450/IF budget that can be allocated to an individual project. The absolute value of this 15% depends on the ETS price. The Commission estimations can be found in Annex 14 of the See Impact Assessment of the ETS Directive revision [SWD(2015) 135 final], of 15 July 2015.

3 Conclusions

The three fields of action of the Innovation Fund (industrial processes, CCS and renewable energies) present very different features and, accordingly, their requirements in terms of project and investment grant volumes and of co-financing are different.

In the industrial sector, there is a clear distinction between the requirements of CCS-based projects and of all other projects based on innovative processes or technologies, material savings, energy savings, alternative products, etc. Therefore, it makes sense to consider all CCS projects (for power production and industrial processes) in one category, and all other industrial projects in a separate category.

Effective competition between project proposals is possible within the same category, but hardly conceivable among very heterogeneous project types such as CCS for power production vs. industrial process vs. a renewable plant. In absence of explicit and transparent rules, the budget allocation among the three categories will be explicitly or implicitly determined in the detailed program implementation rules to be established by the Commission in a delegated act.

However, the budget allocation between the three categories has a qualitative and political dimension. It seems desirable that it is established explicitly and transparently at apolitical level, as part of the co-decision procedure for the directive text, rather than implicitly by the Commission in the delegated act.

The requirements of the three categories can be summarized as following:

- Most industrial (non-CCS) projects can be effectively supported with investment grants up to €75 million; in some cases grants up to €300 million can be necessary. A co-financing rate of 50% should be sufficient.
- For renewables, the same values apply as for industrial (non-CCS) projects.
- CCS projects, both for power generation and in the industrial sector, require larger investment volumes and higher co-financing rates. However, at a global level no precedents of grants above €400 million could be identified. A cap to the investment grant of up to €1.7 billion, as proposed by the Commission, does not seem justified if a significant participation of the private project developers is to be maintained. A maximum funding rate around €600-700 million would be almost a doubling as compared to the largest precedents, and is probably sufficient to support several projects. The increase of the co-financing rate up to 60%, proposed by the Commission appears reasonable, provided that there will be effective competition among CCS project developers.

Annex A: Interviewing industry experts to verify the findings of this brief

In case a future research design would contemplate interviews with representatives of the relative industrial sectors, it would be recommendable to take into consideration the following possible sources of distortion:

- Confusion between the necessary total investment costs for a project (e.g. new steel mill) and the additional/relevant costs that are relevant for a demonstration project (i.e. the fraction of the total investment cost related to the implementation of innovative low carbon technologies in that steel mill). It could be useful to explain this distinction clearly.
- Negotiation mode: industry representatives might be asking the government for more in order to obtain less. It could be useful to question their estimates, asking for substantiation and confronting the interviewees with the evidence provided in this policy brief.
- Possible lack of consideration of the benefits of a cap: high individual grants necessarily reduce the chances a company has to succeed in becoming a beneficiary. For instance, a funding cap of 15% of the total available funds implies that just six projects might claim 90% of the total available funds at an EU level. Therefore, it could be useful to discuss the caps with experts from the relative sectors, after having established the principle that there will be budget quotas for each category. This procedure is likely to produce more realistic estimations of the actual requirements, as it will make clear that a higher cap implies a smaller number of fundable projects in that category.
- Risk of bias in the selection of the interviewees in favour of the largest companies that are more likely to exert early influence on the positions taken by industrial associations, and have more resources to dialogue with government or researchers sponsored by government. It will be useful to define ways to correct this potential bias by considering also the views of smaller companies, as long as they are likely to submit relevant applications for NER450/IF.

Annex B: Short description of the analysed public programs

World Bank Global Environment Facility

"GEF grants directly support actions to combat major environmental issues such as climate change, loss of biodiversity, polluted international waters, land degradation and desertification, and persistent organic pollutants, as well as stimulate green growth."[11] Since its establishment in 1991, the GEF provided over $14 billion in grants and mobilised more than $70 billion in additional financing for more than 4,000 projects. There are 18 implementing GEF partners,[12] among them ADB, AFDB, EBRD, FAO, UNDP, UNEP and the World Bank Group.

The main limit to the comparability of GEF with NER450/IF is that GEF supports a broad range of projects that provide global environmental benefits, and it does not specifically focus on innovative demonstration projects like NER450/IF is supposed to do. Still, more than a fifth of the GEF-5 period projects in the field of climate change "address the promotion and transfer of innovative low carbon technologies".[13] A principle shared by both NER300 (and presumably NER450/IF) and the GEF is the support of "incremental" or additional costs caused by the pursuit of an additional environmental or climate benefit, as compared to a hypothetical more polluting, technologically standard option. Another element of similarity between the GEF and NER 300 is that both are supranational programs providing co-financing that can or even should be complemented by additional co-financing provided by national governments.

During its history, **the co-financing rates** provided by the GEF for all its "full sized projects" (i.e. projects receiving at least $2 million) have declined from 50% (median project) or 29% (portfolio average, i.e. mean) during the initial GEF-1 phase to 20% (median project) or 13% (portfolio average) during the GEF-4&5 phases up to November 2013.[14] Smaller projects have in recent years higher average co-financing rates, but due to their size are a less relevant benchmark for NER450/IF.

GEF co-financing rates vary significantly depending on the country income groups. As expectable, the GEF co-financing rates are higher in the lower income countries. Most EU Member States belong to the high-income economies. In this country group, the GEF co-financing rates are 8% (portfolio average) or 19% (median project). Bulgaria and Romania belong to the upper-middle-income economies, together with a number of African, Asian, Latin American and West Balkan countries. In this country group, the GEF co-financing rates are 11% (portfolio average) or 20% (median project).

[11] http://www.worldbank.org/en/topic/climatechange/brief/gef , as downloaded on 16 October 2015.

[12] https://www.thegef.org/gef/whatisgef , as downloaded on 16 October 2015.

[13] Chizuru Aoki and Franck Jesus, GEF Long-Term Program on Technology Transfer Advances a Key Tool in Addressing Climate Change, https://www.thegef.org/gef/greenline/july-2012/gef-long-term-program-technology-transfer-advances-key-tool-addressing-climate-c , as downloaded on 16 October 2015.

[14] Co-financing rate is defined here as the ratio between the GEF investment grant and the total incremental costs of the project carried by GEF and all other public and private investors. This and, if not stated otherwise, the following data on GEF, are drawn from "Co-Financing Policy, Recommended Council Decisions for the GEF Council Meeting" of May 2014 in Cancun, GEF/C.46/09, May 6 2014, as downloaded on 16 October 2015 from: https://www.thegef.org/gef/sites/thegef.org/files/documents/GEF.C.46.09_Co-Financing_Policy_May_6_2014.pdf

Among the six GEF focal areas, climate change is by far the one with the highest share of co-financing from the private sector (29% during GEF-4&5, with a 27% average GEF co-financing, and the rest coming mainly from national governments). Presumably, this is linked to the direct economic benefits for companies reducing their energy consumption, their costs for emission allowances or carbon taxes, or obtaining income from renewable energy production.

As **for the project size**: of the 544 GEF Full Sized Projects[15] at national level, only 51 were awarded a GEF grant of over $10 million (average GEF co-financing rate: 10%), and only five above $40 million (all of them in the field of climate change, average GEF co-financing rate: 31%), with the largest GEF grant reaching $49.8 million. However, such large projects are an exception within the GEF portfolio.

USA: Advanced Research Projects Agency-Energy (ARPA-E)

"ARPA-E advances high-potential, high-impact energy technologies that are too early for private-sector investment. (…) We invest in short-term research projects that can have transformational impacts. ARPA-E does not fund basic or incremental research."[16] Whilst ARPA-E does not focus on low carbon technologies as such, most of its programmes cover areas that improve emission rates in the energy sector. ARPA-E covers renewables, CCS and energy efficiency as well as other fields.

The legal basis for ARPA-E defines three main areas of activity:

1) Identifying and promoting revolutionary advances in fundamental and applied sciences;
2) Translating scientific discoveries and cutting-edge inventions into technological innovations; and
3) Accelerating transformational technological advances in areas that industry by itself is not likely to undertake because of technical and financial uncertainty.[17]

Only the third area is a relevant benchmark for NER450/IF, whilst the first two are rather issues covered by R&D programs. The latter usually require higher shares of public co-financing than the technology demonstration projects that are supposed to be promoted by NER450/IF.

In the most recent call for proposals, ARPA-E'S maximum **co-financing rate** is 80%, with higher rates reserved to non-profits or educational institutions under certain conditions. "Large businesses are strongly encouraged to provide more than 20% of the total project cost as cost share. ARPA-E may consider the amount of cost share proposed when selecting applications for award negotiations".[18] Thus, it can be generally assumed that the lower

[15] The GEF Regional and Global Projects are not considered here, because they generally are vehicles for financing a number of smaller individual projects and thus not comparable with NER450/IF.

[16] Unless stated otherwise, all quotes in this section are taken from different parts of the ARPA-E program website: http://arpa-e.energy.gov/

[17] See https://en.wikipedia.org/wiki/ARPA-E quoting Title 42, Chapter 149, Subchapter XVII, § 16538 of the United States Code.

[18] ARPA-E, Financial Assistance.

range of **co-financing rates** offered by ARPA-E is more relevant as a benchmark for NER450/IF. The maximum co-financing rate for ARPA-E Technology Investment Agreements is set at 50%.

Concerning **the project size**: "In the past, most award amounts vary between $500,000 and $10 million in financial assistance. ARPA-E will provide support at the highest funding level only for applications with significant technology risk, aggressive timetables, and careful management and mitigation of associated risks." During the financial year 2014, the selection of 39 new projects was announced, with an average award of $2.3 million each. Since its creation in 2009 and up to February 2015, "ARPA-E has invested over $1.1 billion across more than 400 projects", which corresponds top an average of less than $2.75 million per project [19] The Funding Opportunity Announcement 2015 explicitly defines a range of awards between $1 million and $10 million.

USA: Advanced Manufacturing Office programs

Among the most interesting benchmarks for NER450/IF are a set of the programmes run by the US Department of Energy's Advanced Manufacturing Office, including the New Clean Energy Manufacturing Initiative and the Innovative Process and Materials Technologies. These programs focus on energy efficiency and renewables in the manufacturing sector.

For technology demonstration projects, i.e. those most relevant as a benchmark for NER450/IF, the standard **co-financing rates** offered by AMO are below 50% of the total project costs. For technology development, AMO provides up to 80% co-financing.[20] However, pure R&D is a less relevant benchmark for NER450/IF.

As for the **project sizes**, small early stage concept-type efforts may be in the range of $150,000-$400,000 for each award. The next level of development is typically around $1 million. Larger development projects may involve a pilot-scale test, and could approach or possibly exceed $10 million including non-federal cost share A few larger grants (e.g., $70-100 million over a 5 year period) have been awarded in specific topic areas, but these are for cooperation of various actors, and not for individual demonstration projects. Some specific examples:[21]: the AMO funding requested by the 12 projects selected by AMO in September 2014 ranges between $0.4 million and $4.5 million. Five larger projects announced in March 2013 received an AMO grant between $1.2 million and $7.8 million.

USA: grants for biorefineries

In the USA, several programs have granted funds for the demonstration of innovative biorefinery technologies. An overview on aggregate financial data could not be found in the time available for this research, but some examples of typical project sizes have been included.

[19] US Department of Energy, ARPA-E Annual Report for fiscal year 2014, http://arpa-e.energy.gov/sites/default/files/FY14%20Annual%20Report%207_27_0.pdf

[20] The AMO website does not provide aggregate figures on co-financing rates or sizes of the awards for individual rpojects. Unless stated otherwise, the information of this section originates from conversations and correspondence with Mr Keith Jamison, an expert of the company Energetics, who was indicated as appropriate source by Mr Isaac Chan, Program Manager Research and Development at AMO (August 2015).

[21] Siehe http://energy.gov/eere/amo/innovative-process-and-materials-technologies-0 und http://energy.gov/eere/articles/235-million-investment-innovative-manufacturing-projects-supports-new-clean-energy-0

The only pilot scale mentioned in the integrated biorefinery map of the US DOE Office of Energy Efficiency and Renewable Energy[22] was awarded a grant of $22 million.[23] The three pilot projects mentioned by the same source received grants of respectively:

- $100 million grant (US DOE co-financing rate: less than 34%)[24]
- $55 million grant (US DOE co-financing rate: less than 42%)[25]
- $117 million grant (US DOE co-financing rate: less than 32%)[26]

These grants have been provided over periods of up to 15 years in different parts, covering phases from the first feasibility studies until construction. Additionally to the investment grants, in some cases loan guarantees or other financing support were also provided, which is not mentioned here as this chapter focuses on investment grants.

USA CCS funds

In 2010, Recovery Act funded three large-scale industrial CCS demonstration projects selected by the U.S. Department of Energy (DOE) to continue testing large-scale carbon capture and storage (CCS) from industrial sources.

Table 2: CCS projects funded by the US Recovery Act in 2010

CCS project	DOE grant ($ million)	Other funds ($ million)	DOE co-financing	Status
Air Products and Chemicals	284.0	146.6	66%	Operational
Archers Daniel Midland	141.4	66.5	68%	Advanced construction
Leucadia	261.4	174.2	60%	Cancelled
Summit TX Clean Energy	450	1,250	26%	Uncertain (FID perhaps 2016)
HECA	408	4,000	10%	
NRG	167	775	22%	
Kemper County IGCC	270	4,120	7%	Very uncertain (FID delayed)

[22] http://energy.gov/eere/bioenergy/integrated-biorefineries

[23] http://energy.gov/eere/bioenergy/alpena-biorefinery

[24] http://energy.gov/eere/bioenergy/poet-dsm-project-liberty

[25] http://energy.gov/eere/bioenergy/ineos-new-planet-indian-river-bioenergy-center

[26] http://energy.gov/eere/bioenergy/abengoa

Source: US NETL[27], IEA GHG R&D Program[28], Climate Unplugged[29].

The public co-financing rates range from 7% to 68%. For the Leucadia project, even a high co-financing rate was not enough to ensure realisation of the project.

The absolute amounts of DOE funding range for these 7 CCs from $167 million to $284 million.

EU LIFE-Programm

The EU LIFE Programme has a broader scope than NER450/IF. It funds projects "with European added value" that contribute to the implementation of the EU environmental and climate policy and legislation by co-financing. It has supported a number of innovative and pilot projects, but not only them. Despite of its broader scope, LIFE can provide some interesting indications for this analysis. The LIFE projects database includes more than 750 projects in the manufacturing sector. The following figures refer to the 35 most relevant projects from the point of view of the comparison with NER450/IF have been selected.[30]

- The average co-financing rate of this project is 34%, ranging between 8% and 50%.
- The average grant from the LIFE-Programme is €1.7 million, ranging between €0.4 and €4.9 million.

In course of the last revision of the LIFE Programme for the period 2014-2020, the maximum co-financing rates have been increased to 60% for the period 2014-2017 and to 55% for the period 2018-2020. An increase of the co-financing rate might be a general trend of EU programs, and not limited to NER405/IF.

Germany: Energy Efficient and Climate-friendly Manufacturing

This program started in 2014 and is funded by the German Federal Government and run by the Federal Ministry for Economic Affairs and Energy. It supports measures to increase the energy efficiency and optimise energy usage in industrial processes. The maximum grant amount is €1.5 million, with a maximum co-financing rate of the relevant costs.

[27] http://www.netl.doe.gov/research/coal/major-demonstrations/industrial-carbon-capture-and-storage

[28] John Gale (General Manager IEA Greenhouse Gas R&D Program, "Leading the Way to a Low-Carbon Future", presentation at the International Forum on Recent International Forum on Recent Developments of CCS Implementation, March 2015: http://www.ieaghg.org/docs/General_Docs/IEAGHG_Presentations/IEAGHG_Slide_Deck__Athens_2015SECURED.pdf

[29] Leucadia was not the only cancelled CCS project in the US. All together, DOE returned to the US Treasury $1.27 billion of unspent out of $2 billion unspent CCS funds, as the remaining potential recipients, did not meet he required milestones, see: D. Bailey and D. Bookbinder, "Bad News: Carbon Capture and Storage Money is Going Back to the Treasury" https://climateunplugged.com/blogpost/?postid=1848

[30] Filtering them according to following criteria: a) Only projects funded after 1999, b) the beneficiaries were large companies (i.e. not associations, public agencies, research institutes, NGOs, SME etc.), c) technically relevant for climate action.

Germany: Environmental Innovation Program (UIP)

UIP supports demonstration projects focusing on material efficiency in industrial manufacturing, energy efficient sewage plants, energy and material efficiency in ITC technology and efficient public lighting. Since its inception over 15 years ago, this program has invested more than €750 million. In average, the grants amounted to circa €1 million per project. Circa 50% of the funds went to SMEs, 35% to large companies, and 15% to public institutions.

Poland: Gekon

Generator Koncepcji Ekologicznych (Generator of Ecologic Concepts) is a program funded by the Polish government.[31]

It supports R&D as well as demonstration and implantation of innovative technologies that protect the environmental in the following fields: unconventional gas, energy efficiency, energy storage, water protection, renewable energy sources, other "unconventional methods" of energy generation, recycling. Beneficiaries can be companies, research institutes and other organisations. The maximum co-financing rate is 80%. The maximum grant is around €5 5 million.

Australia:

The Australian Renewable Energy Agency has been awared by the legislator approximately $2.5 billion (€ 1.67 billion) until 2022 to fund activities to advance renewable energy technologies towards commercial readiness. ARENA runs various programs. The most relevant for a comparison with NER450/IF is the Advancing Renewables Programme that "supports a broad range of development, demonstration and pre-commercial deployment projects that have the potential to lower the cost and increase the use of renewable energy technologies in Australia in the long term", including in the industrial sector.

The maximum co-financing rate is 50%. The average co-financing of the 47 projects concluded so far was 44%, with an average ARENA grant of AUSD 1.5 million (circa €1 million).[32] The largest awarded grant so far provided AUSD166.7 million (circa €111 million) funding for demonstration of innovative large scale PV technology. In the current funding announcement, the largest possible grant is AUSD 30 million (circa €20 million).[33]

[31] http://program-gekon.pl/o-programie/

[32] http://arena.gov.au/projects/completed-projects/

[33] http://arena.gov.au/files/2015/09/LSSPV-Funding-Announcement.pdf