CONCEPTUALISATION OF THE POTENTIAL RENEWABLES PULL EFFECT

A result of topic area 3 "Scenarios and transformation pathways" of the research project SCI4climate.NRW

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SCI4climate.NRW is a research project sponsored by the state of North Rhine-Westphalia aiming to support the transformation towards a climate-neutral and sustainable industry. The project is co-operating with the IN4climate.NRW initiative and explores the technological, economic, institutional and infrastructural challenges for manufacturing companies in North Rhine-Westphalia. As part of a transdisciplinary process and in cooperation with stakeholders from the industry sector the project jointly develops possible pathways towards a climate-neutral industry.

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Summary

This report was prepared by the Wuppertal Institute in cooperation with the German Economic Institute as part of the SCI4climate.NRW project. The report aims to shed light on the possible phenomenon that the availability and costs of "green" energy sources may become a relevant location factor for basic materials produced in a climate-neutral manner in the future.

For this purpose, we introduce the term "Renewables Pull". We define Renewables Pull as the initially hypothetical phenomenon of a shift of industrial production from one region to another as a result of different marginal costs of renewable energies (or of secondary energy sources or feedstocks based on renewable energies).

Shifts in industrial production in the sense of Renewables Pull can in principle be caused by differences in the stringency of climate policies in different countries, as in the case of Carbon Leakage[1]. Unlike Carbon Leakage, however, Renewables Pull can also occur if *similarly* ambitious climate policies are implemented in different countries. This is because Renewables Pull is primarily determined by differences in the costs and availability of renewable energies. In addition, Renewables Pull can also be triggered by cost reductions of renewable energies and by changing preferences on the demand side towards climate-friendly products. Another important difference to Carbon Leakage is that the Renewables Pull effect does not necessarily counteract climate policy.

Similar to Carbon Leakage, it is to be expected that Renewables Pull could become relevant primarily for very energy-intensive products in basic materials industries. In these sectors (e.g. in the steel or chemical industry), there is also the possibility that relocations of specific energy-intensive parts of the production process could trigger domino effects. As a result, large parts of the value chains previously existing in a country or region could also be subjected to an (indirect) Renewables Pull effect.

For the federal state of NRW, in which the basic materials industry plays an important role, the possible emergence of Renewables Pull is associated with significant challenges as climate policy in Germany, the EU and also worldwide is expected to become more ambitious in the future.

This report aims to enable and initiate a deeper analysis of the potential future developments and challenges associated with the Renewables Pull effect. Thus, in the final chapter of the report, several research questions are formulated that can be answered in the further course of the SCI4climate.NRW project as well as in other research projects.

[1] Carbon Leakage refers to a shift of industrial production from a country with relatively strict climate protection policies and associated high CO_2 costs to another country with lower CO_2 costs.

1 Introduction and definition of Renewables Pull

In view of the advancing climate change and the accompanying political pressure to act, more stringent measures for the transformation of energy and industrial systems towards climate neutrality are to be expected in the future. Consequently, it is foreseeable that energy-intensive industrial production worldwide will increasingly switch to energy sources and raw materials ("feedstocks") based on or produced with renewable energies. Since a large part of basic materials production is traded on world markets, it is to be expected that for these materials to be produced in a climate-neutral way in the future, the availability and cost of "green" energy will become a relevant competitive factor and thus also an important location factor.

In this context, we define "Renewables Pull" as the shift of industrial production from one region to another region as a result of different marginal costs of renewable energy sources (or secondary energy sources or feedstocks based on renewable energies). As of now this is a hypothetical phenomenon, but it is possible that it will be empirically verified in the future.

In regard to Renewables Pull, the costs that companies incur for the use of these energy sources are relevant. In addition to the pure generation costs, other components include taxes, levies or grid fees. Some of the factors that determine the costs can be influenced directly by government action (e.g. through tax rates) or indirectly (e.g. by ensuring favourable conditions for the expansion of renewable energy plants). However, other important influencing factors cannot be controlled by governments. These include, in particular, the natural and climatic conditions, for example the availability of locations with high solar radiation, good wind conditions (onshore and offshore) or good growth conditions for biomass[2]. The distance of a country to regions with very good corresponding conditions cannot be changed by government measures either.

A relocation of industrial production can take different forms: On the one hand, production in an existing plant at a location with relatively high costs for renewable energies or energy sources or feedstocks based on renewable energies (generally referred to as "green energy sources" in the following) can be terminated due to too high operational costs. Existing plants at locations with relatively low costs for green energy sources, on the other hand, would continue to operate and possibly be more heavily utilised, or additional capacities are even built there to replace the production discontinued at the other location. On the other hand, in the case of a growing demand for certain basic materials, additional production capacities can only or predominantly be built at locations with relatively low costs of green energy sources. This latter case illustrates that Renewables Pull can be effective even if it does not lead to the termination of existing production capacities at any particular site.

In the case of such relocations, however, we only speak of Renewables Pull if and to the extent that the regional differences in the marginal costs of green energy sources are a major cause of the corresponding business decisions - and not other location factors. In other words, a relocation of industrial production can only be attributed to Renewables Pull if this relocation would not have taken place without an existing difference in the marginal costs of green energy sources.

This report describes how Renewables Pull could work *if the* costs of green energy sources are a decisive location factor for energy-intensive industry or will be in the future. This perspective is chosen here to describe the basic principle of Renewables Pull. However, this is not intended to imply a

[2] A very low availability of renewable energies or a lack of availability of certain forms of renewable energies would correspond to very high or infinitely high marginal costs for their use.

judgement on whether, and if so in which cases, Renewables Pull is or will *actually be* a significant factor in the location decisions of energy-intensive industry. This question should not and cannot be answered by the present report, but requires further studies in the future, including empirical studies.

2 Triggers of Renewables Pull

2.1 Three potential triggers of Renewables Pull

Renewables Pull can in principle be caused by three different triggers:

- A **stricter climate protection policy** and associated instruments (e.g. introduction or increase of a CO_2 price) make fossil-based industrial production more expensive and could thus lead to industrial production based on green energy sources becoming competitive in regions with good conditions for renewables.
- A **reduction in the cost of renewable energies** – for example through technical advances or public funding – could lead to their use becoming more economical than the use of fossil fuels in certain industrial applications, even without (additional) climate policy instruments.
- An **explicit demand for "green" raw materials** can emerge on the market, for example because companies want to offer their customers "green" products with a low carbon footprint as a unique selling point.

It should be kept in mind that due to the typically very long-term plant investments, especially in the basic materials industry, not only the *current* characteristics of climate protection policy, the costs of green energy sources and demand preferences are relevant for possible Renewables Pull effects, but also the *future* changes in these characteristics as expected by companies.

Renewables Pull effects could be intensified by the fact that individual industrial applications of green energy sources may only be feasible in certain regions of the world. This includes, for example, the use of concentrating solar thermal energy to generate very high temperatures, which could be used in the future for cement production, among other things (Ambrose 2019).

The three potential triggers of Renewables Pull are explained in more detail in the following sections of this chapter using a simple two-country model. The following model assumptions are made:

- Industrial production based on fossil energy sources in country A and country B is equally expensive in the initial situation and (without a tightening of climate protection policy) cheaper than industrial production based on green energy sources
- The marginal costs of green energy sources are lower in country B than in country A.
- The transport costs of industrial goods between the two countries are negligible[3], but not the transport costs of green energy sources such as electricity, hydrogen or biomass.
- In the initial situation, there is some exchange of industrial production between the two countries. (Although production costs are assumed to be identical, trade still occurs due to somewhat different product characteristics, i.e. goods are not completely homogeneous.)

[3] This assumption is only made in the model for the sake of simplicity. Renewables Pull can in principle also occur in the presence of relevant transport costs, although in this case typically to a lesser extent or only when there is a higher difference in the costs of renewables between the countries.

2.2 Renewables Pull through tighter climate protection policy

The following Figures 1 to 3 first illustrate how tighter climate protection policies can lead to changes in production costs and why, as a consequence, the relocation of industrial production from country A to country B is possible.

Figure 1 shows the case of an identical or similar tightening of climate policy in countries A and B. Tightening climate policy measures in both countries, e.g. induced by an international climate protection treaty[4], leads – explicitly or implicitly[5] – to an increase in CO_2 costs and thus to an increase in the cost of using fossil energy sources and feedstocks (see shaded areas in Figure 1).

Due to the rise in the price of fossil fuels, the economic viability of green energy sources is increasing in both countries – both renewable energy sources used directly in industrial processes (e.g. biomass and solar thermal energy) and those energy sources or feedstocks that are produced on the basis of renewable energies (e.g. green electricity, green hydrogen or green methanol). As a consequence of the increasing competitiveness of renewables, regional differences in the availability and marginal costs of green energy sources are becoming more important for the location factor "energy costs".[6] These differences can result – in addition to regulatory differences such as differing tax rates – from natural and climatic differences. On the other hand, they can (additionally) be caused by differences in the procurement costs of green energy sources from regions with favourable production costs.

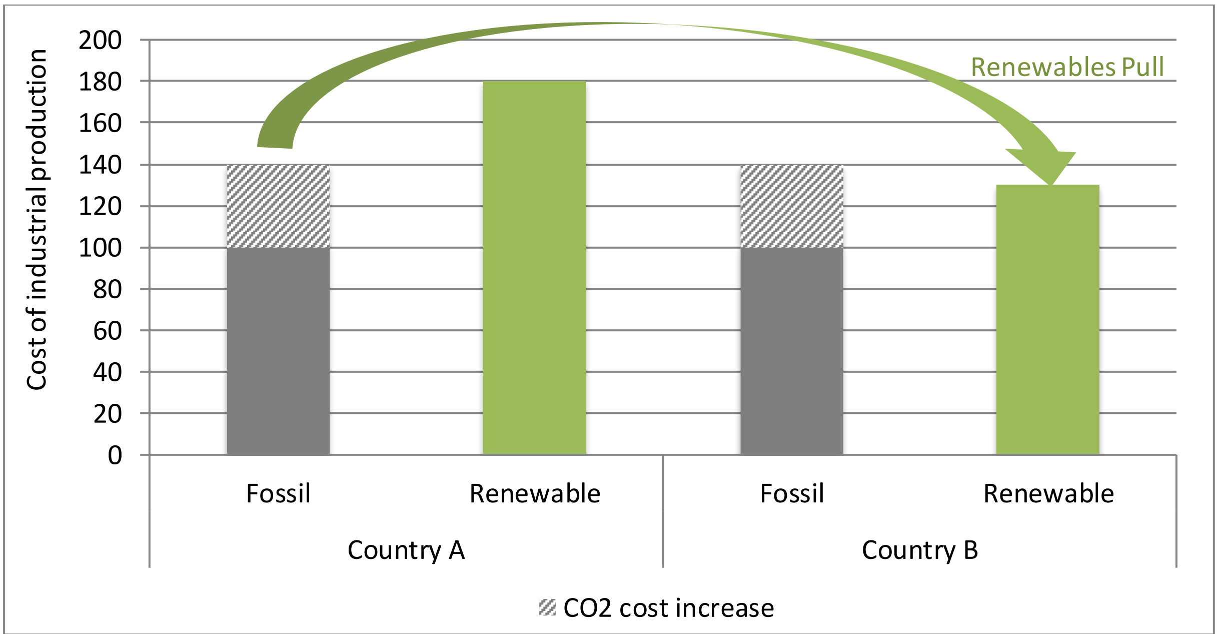

Figure 1: Schematic representation of Renewables Pull due to production cost changes as a result of a uniform tightening of climate protection policy in countries A and B.

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[4] It is not relevant whether it is a treaty with binding measures or "only" climate policy measures introduced voluntarily by both countries – e.g. on the basis of the Paris Agreement.

[5] An explicit increase in the CO_2 price would be brought about by the introduction or increase of a CO_2 tax. Implicitly, the CO_2 price would be increased, among other things, by reducing the quantity of certificates made available in an emissions trading system. Regulatory climate protection measures (e.g. targets for CO_2 emissions from new plants) can also be understood as an implicit increase in the price of CO_2.

[6] These differences existed before, but were not relevant in terms of industrial production as long as fossil fuels were the cheaper option in both countries.

Due to favourable natural and climatic conditions in country B[7], the rising costs of fossil energy sources triggered by more stringent climate protection can be partially compensated by relatively favourable marginal costs of green energy sources. This is not possible in country A, however. Here, production based on green energy sources remains more expensive than production based on fossil energy sources even after the increase of CO_2 costs. The energy costs for production therefore increase more in country A than in country B as a result of the stricter climate protection measures.

The lower increase in energy costs in country B strengthens (ceteris paribus) the competitive position of country B vis-à-vis country A. Consequently, a relocation of industrial production from country A to country B can become attractive in particular for companies in energy-intensive industries – taking other location factors into account – both for meeting demand in country B and for exporting to country A. We refer to a corresponding relocation as a direct consequence of the different marginal costs of green energy sources as Renewables Pull.

The assumed differences between two locations can also arise within individual countries if there are relevant natural or climatic differences between different locations and/or differences in the procurement costs for green energy sources. For example, locations in inland Germany may be disadvantaged in terms of both the marginal costs of harnessing wind energy and access to seaports (with their relatively low procurement costs for imported energy sources) compared to coastal locations in northern Germany.

Even if it was assumed in Figure 1 that climate protection policy is strengthened to a similar extent in both countries, Renewables Pull can in principle also occur if only *one* country pursues a more stringent climate protection policy. If such a tightening is implemented in country A, for example, and at the same time a carbon border adjustment mechanism (CBAM)[8] is set up to avoid or minimise Carbon Leakage, country A could be threatened with a relocation of parts of its industrial production as a result of Renewables Pull (see Figure 2). This would be the case if it became worthwhile for individual companies to set up climate-friendly production based on green energy sources in country B (instead of continuing to produce on the basis of fossil energy sources in country A and bearing rising CO_2 costs) and to export the goods produced there to country A. In this way, companies could benefit from the relatively low marginal costs of climate-friendly production in country B and – due to the low CO_2 footprint of their production – would not be faced with a (significant) border adjustment price when exporting.

[7] In the two-country model chosen here, it is assumed that country B has a clear advantage over country A with regard to its own natural and climatic conditions. This could lead to very low production costs of electricity from solar and/or wind power plants in country B, for example. At the same time, country A cannot compensate for this relative disadvantage through imports, e.g. because it is located far away from regions with favourable generation costs and/or has no coastline and thus no maritime transport connection. Likewise, country B's advantage could also be based on exclusive and low-cost import options.

[8] A CBAM aims to compensate for potential international competitive disadvantages of domestic companies as a result of a stricter climate protection policy. This can be done by making imports from countries or regions in which companies bear no or lower CO_2 costs more expensive according to their CO_2 intensity and by reimbursing the CO_2 costs (or parts thereof) for exports to these countries.

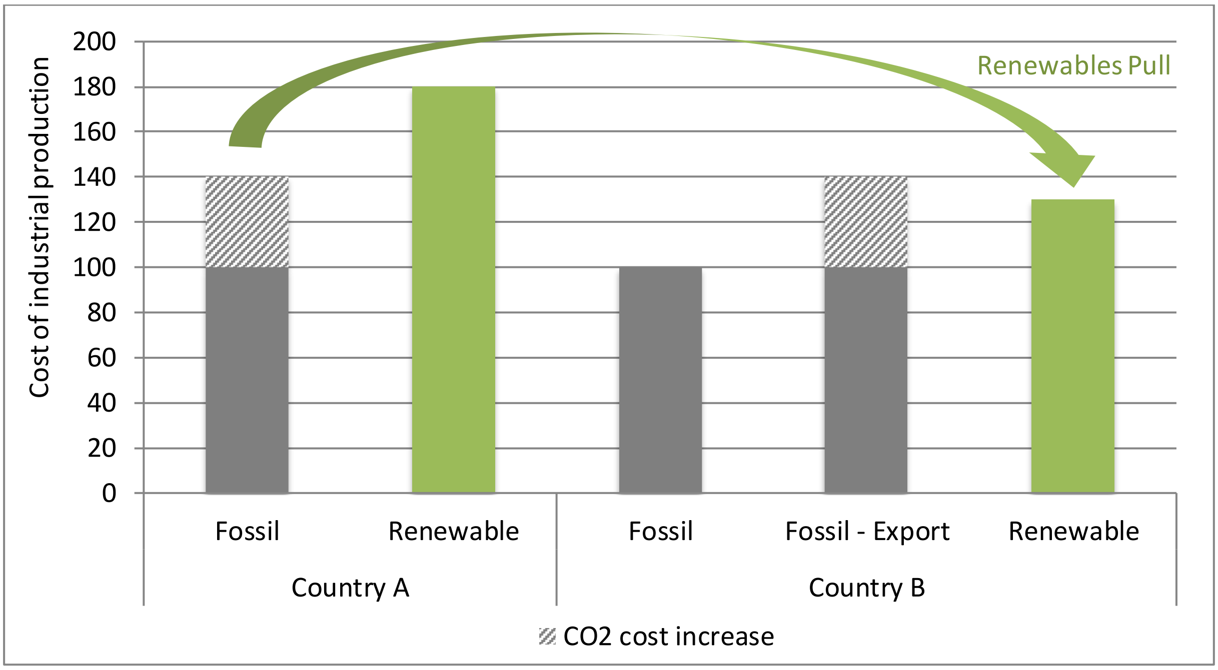

Figure 2: Schematic representation of Renewables Pull due to production cost changes in the case of unilateral tightening of climate protection policy in country A with the introduction of a border adjustment mechanism

A border adjustment mechanism thus contributes to making production based on green energy sources more economical through the desired increase in the price of fossil-based industrial production at home and partly (if intended for export) abroad. This can lead to a situation where the border adjustment mechanism is able to prevent relocations of industrial production through Carbon Leakage, but at the same time induces relocations through Renewables Pull. This relationship should be considered in policy decisions regarding the introduction of border adjustment mechanisms, and further research is needed to assess the actual relevance of this effect for specific regions and time periods.

A unilateral tightening of climate protection policy in country B could also lead to a Renewables Pull shift from country A to country B (see Figure 3), if a border adjustment mechanism is implemented. This could be the case if companies in country A initially exported some of their production to country B. In the new situation, this production may shift to country B as the production based on green energy sources could become the cheaper option as a result of the border adjustment costs that now need to be paid for exports.

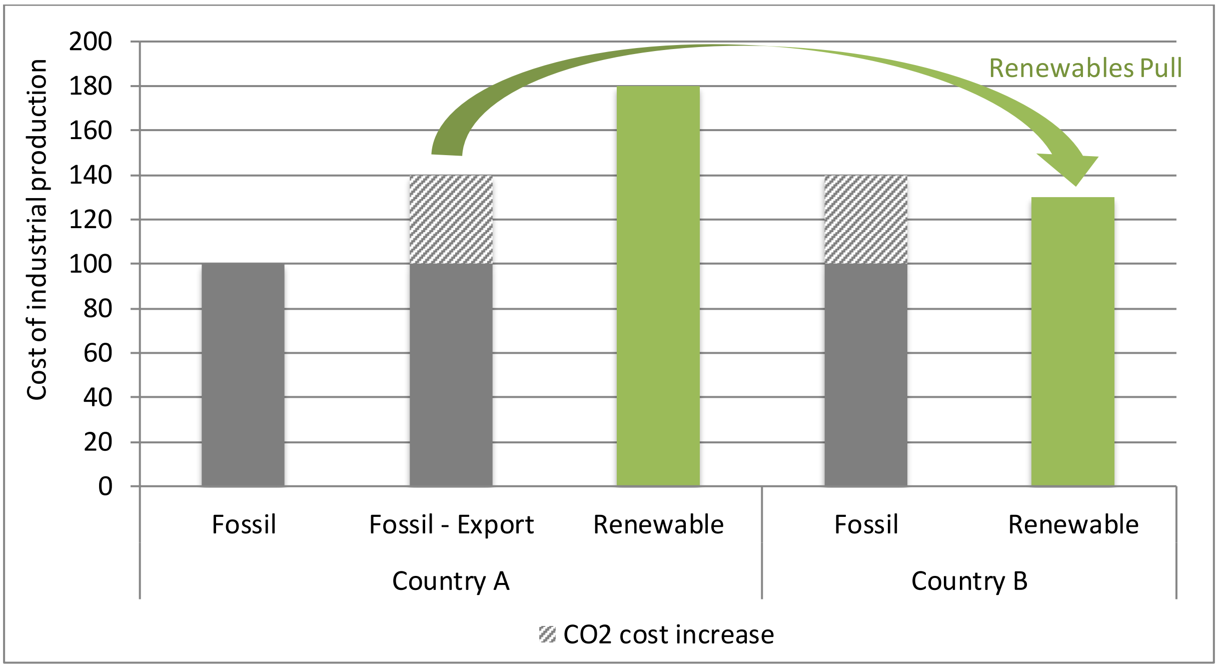

Figure 3: Schematic representation of Renewables Pull due to production cost changes in the case of unilateral tightening of climate protection policy in country B with the introduction of a border adjustment mechanism

The following table summarises the different possibilities of tightening climate protection policies in the two countries and shows in which cases there may be relocation effects as a result of Renewables Pull.

Table 1: Overview of possible relocation effects as a result of Renewables Pull in the case of a tightening of climate protection policy

	Tougher climate protection policy		
	Only in country A	**Only in country B**	**In both countries**
With border adjustment mechanism	Renewables Pull possible (A → B)	Renewables Pull possible (A → B)	Renewables Pull possible (A → B)
Without border adjustment mechanism	No Renewables Pull possible[9]	No Renewables Pull possible	Renewables Pull possible (A → B)

It should be noted that the table only lists the general *possibility of* Renewables Pull. However, whether Renewables Pull *actually* occurs in such cases in reality depends on many factors – not least on the importance of different location factors – and cannot be answered without a thorough empirical investigation.

In principle, however, Renewables Pull can also occur without more stringent climate protection policies, as explained in the following two sections.

[9] In this case, a Renewables Pull effect is not conceivable due to the assumption that in country B in the initial situation, industrial production based on fossil energy sources is cheaper than production based on green energy sources. However, a Carbon Leakage effect is possible in this case (see Chapter 4).

2.3 Renewables Pull through cost reductions in green energy sources

In Figure 4, there is an assumed cost reduction in industrial production based on green energy sources (see dotted areas in Figure 4). This cost reduction may originate, for example, from cost reductions in wind or photovoltaic plants, but can also be triggered or reinforced by cost reductions in the specific processes that are necessary for the use of green energy sources (e.g. in hydrogen-based direct reduction plants for primary steel production). In the case shown, these cost reductions which can result e.g. from learning or economies of scale, mean that industrial production based on green energy sources in country B, which has very good conditions for renewable energies, becomes cheaper than industrial production based on fossil energy sources in countries A and B. As a result, it is conceivable that parts of the industrial production previously located in country A (for the domestic market and/or for export) will move to country B. This would be a Renewables Pull effect.[10]

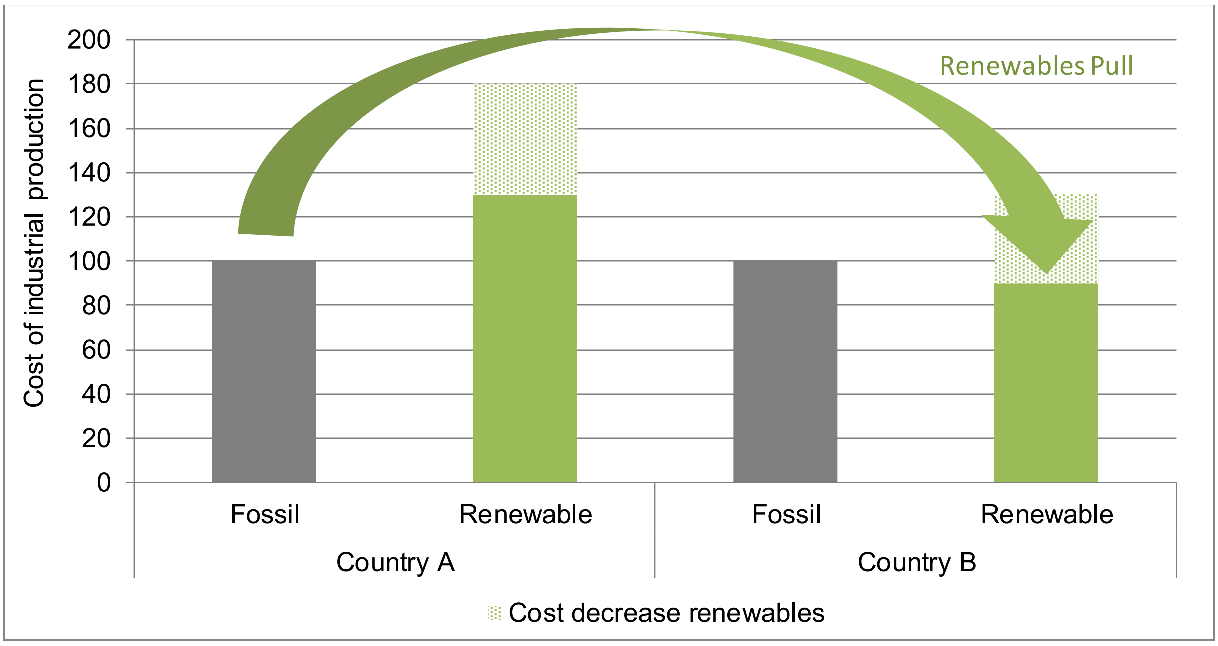

Figure 4: Schematic representation of Renewables Pull due to production changes resulting from cost reductions in renewables-based industrial production

2.4 Renewables Pull through an explicit demand for "green" basic materials

Finally, another trigger of Renewables Pull is conceivable. In this case, it is not a change in production costs that causes a shift in production, but a change in demand preferences towards climate-friendly industrial products (see Figure 5). While in the initial situation the industrial product (e.g. a tonne of crude steel) is seen by consumers as a homogeneous good, regardless of the production process, this may change over time: Some of the consumers could distinguish between the industrial good produced on the basis of fossil fuels on the one hand and the good produced on the basis of green energy sources on the other. Such a distinction can also be induced by the government, e.g. by imposing a quota that obliges certain processing sectors (e.g. the car industry) to purchase a minimum share of "green" raw

[10] It is also conceivable – but not shown in a figure here – that the cost of production based on green energy sources drops in only *one of* the two countries, e.g. due to (stronger) government support for the use of renewable energies in that country. If such a cost decrease in one of the two countries leads to industrial production based on green energy sources becoming cheaper than fossil-based production, a Renewables Pull effect in the form of a shift of industrial production from the other country to this country is possible.

materials[11], but it can also arise as a result of increased environmental or climate protection awareness in parts of society. It is also conceivable that an already existing social awareness only becomes visible on the market as a result of corporate initiatives to heterogenise products.

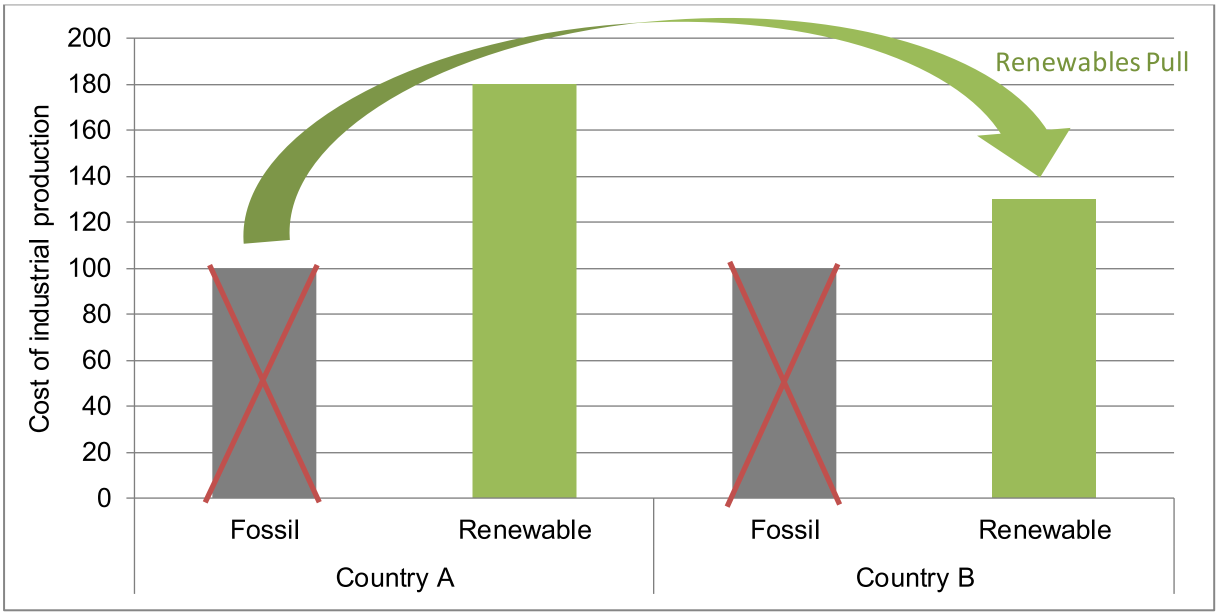

Figure 5: Schematic representation of Renewables Pull through the emergence of a preference for climate-neutral industrial production on the demand side.

If such a distinction is accompanied by a higher willingness to pay for the climate-friendly or climate-neutral industrial good, this can lead to a decrease in demand for fossil-based industrial production in both countries and to an increase in demand for industrial production based on green energy sources. Due to the lower marginal costs of production based on green energy sources in country B, it can be assumed that in this case there will be a certain shift of industrial production from country A to country B – and thus a Renewables Pull effect. The relocated production could then export industrial goods to country A or it could replace former exports from country A to country B by meeting a corresponding "green" demand in country B.

3 Reasons for limited effectiveness of Renewables Pull

It is important to note that Renewables Pull can only be effective if energy costs are a decisive location factor. This is most likely to apply to energy-intensive basic materials industries. However, there are a number of other important location factors in addition to energy costs which are also decisive for location decisions in the basic materials industry. These location factors include the following:

- Political and legal stability
- Spatial proximity to customers
- Spatial proximity to supplying companies or required raw materials
- Deep integration with further processing steps
- Availability of skilled labour
- Existence of sufficiently well-developed industrial and logistical infrastructures

[11] This trigger of Renewables Pull could then be considered a sub-type of the trigger "Renewables Pull through tighter climate protection policy" discussed above.

- Opportunities to cooperate with other companies (e.g. in training or in R&D)
- Wage costs and ancillary wage costs
- (Other) levies and taxes
- (Environmental) requirements
- Stability of energy supply

Many countries that have excellent natural and climatic conditions for the use of renewable energies currently have significant disadvantages compared to industrialised countries in these other location factors. For example, they often lack well-developed industrial structures (and thus companies that could supply preliminary products and purchase final products in close proximity), reliable political and legal framework conditions (which leads, among other things, to higher capital costs and a lack of planning security), a stable energy supply and/or a sufficient quantity of qualified labour. These disadvantages can be decisive in the location decisions of industry and can lead to these countries or world regions being unable to exploit the fundamental advantages in their natural and climatic conditions. Renewables Pull would therefore not become effective in these cases as long as the characteristics of other important location factors cannot be decisively improved in the respective countries.

It should also be noted that Renewables Pull does not have to lead to a relocation of entire industrial sectors, but that relocations of parts of the value chains of individual industrial sectors are also conceivable. In particular, those stages of the value chain that have a high energy demand are likely to be susceptible to relocation as a result of Renewables Pull, while this does not apply to other stages that benefit from proximity to customers. Accordingly, it is possible that downstream stages of value chains in particular will remain in the country of origin. The question of which parts of a value chain are relocated and whether and to what extent other parts of the chain remain in the country of origin or are (successively) moved downstream in the case of relocations depends to a large extent on the integration advantages of different value chain stages. In addition, it also depends on the transport costs for the intermediate and final products of an industry.

There are also various opportunities for industrial policy measures to counteract Renewables Pull in the case of country A or to promote Renewables Pull in the case of country B: With regard to influencing energy costs, for example, energy taxes and levies can be reduced, the energy infrastructure can be expanded or optimised[12] and the most cost-effective electricity system (enabling an optimal use of renewable energy sources) can be aimed for. At the same time, countries can examine whether and how other important location factors beyond energy costs can be improved.

Country A can also aim to maximise the recycling rates of basic materials in order to mitigate the risks of relocations induced by Renewables Pull. After all, secondary production of basic materials is typically much less energy-intensive than primary production. Consequently, the importance of energy costs for location decisions decreases in secondary production, which makes relocations based on Renewables Pull less likely. The lower risk of Renewables Pull in secondary production is supported by the fact that the proximity to secondary materials can be an important cost factor in the production of secondary raw materials. Therefore, relocations to a few (centralised) production sites with very good conditions for renewables are less likely to happen in the recycling routes than in the primary routes.

[12] For example, the government could build or promote infrastructure that enables a relatively inexpensive import of green energy sources from neighbouring countries or regions with better natural and climatic conditions for renewable energies.

4 Similarities and differences to Carbon Leakage

Renewables Pull and Carbon Leakage are different phenomena. Two important similarities, however, are that both can be triggered or intensified by a more stringent climate protection policy and that both lead to the relocation of industrial production. A fundamental difference, however, is that Carbon Leakage is an undesirable phenomenon from a climate policy perspective, as it can counteract effective climate protection efforts by individual countries or regions, while Renewables Pull can be desirable from a climate policy perspective, as it supports the reduction of industrial greenhouse gas emissions in a cost-effective manner.

In contrast to the occurrence of Renewables Pull, a prerequisite for the occurrence of Carbon Leakage is a *difference in the stringency of climate protection policy in* both countries. In Figure 6 below, it is assumed that country A tightens its climate protection policy, but country B does not. Accordingly, CO_2 costs rise (explicitly or implicitly) in country A. Consequently, the industrial production of basic materials based on fossil fuels becomes more expensive in country A, but not in country B. This leads to a lower competitiveness in country A and it could be worthwhile for individual companies (especially those in energy-intensive basic materials industries) to relocate their respective production or parts of it to country B with its lower CO_2 costs. This is at least true if – as is assumed here – no (effective) border adjustment mechanism is or can be put into effect in country A.

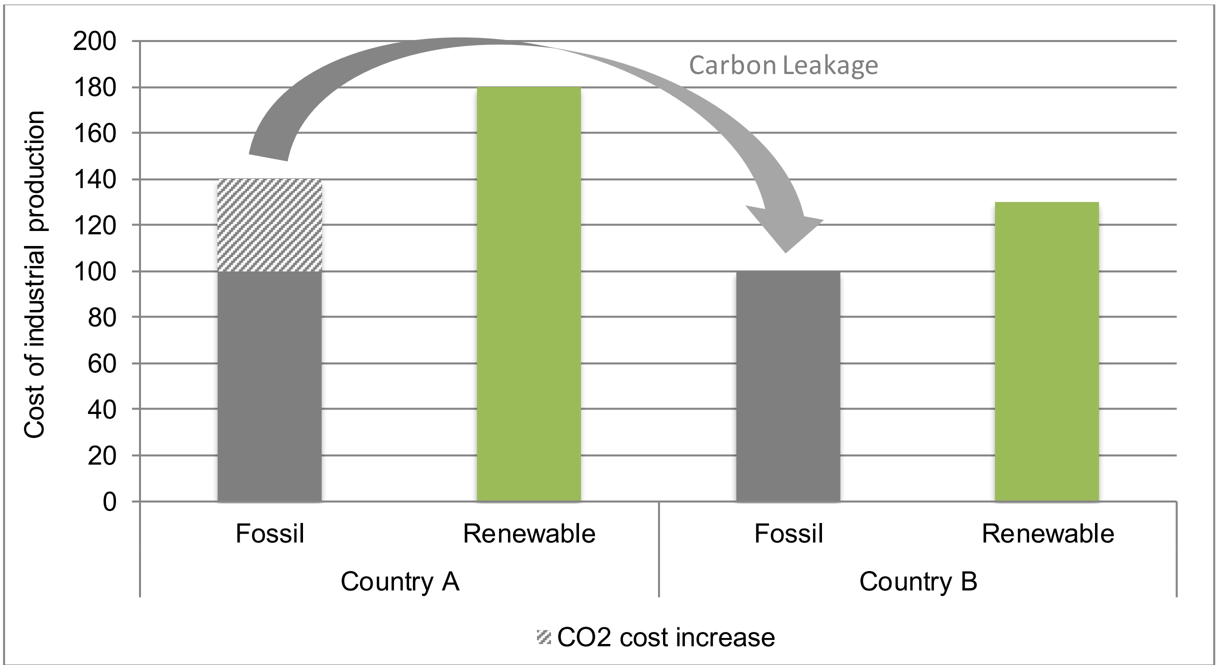

Figure 6: Schematic representation of Carbon Leakage due to changes in production costs as a result of a unilateral tightening of climate protection policy in country A without the introduction of a border adjustment mechanism

Similarly, Carbon Leakage can also occur if only country B implements a stricter climate protection policy. In that case relocations could occur from country B to country A.

As in the case of Renewables Pull, in regard to Carbon Leakage it should also be borne in mind that energy costs are not the only relevant location factor for industry. This may be one of the reasons why the literature has so far not found clear empirical evidence for the occurrence of Carbon Leakage as a result of EU emissions trading (Verde 2020, Boutabba/Lardic 2017). However, CO_2 prices were relatively low during the periods of investigation of the available studies and there were or are various measures to reduce the risk of Carbon Leakage within the framework of EU emissions trading, such as a largely free allocation of allowances to industry.

The following Table 2 shows the potential relocation effects due to Renewables Pull (as already listed in Table 1) as well as due to Carbon Leakage in case of a tightening of climate change policies. The same basic assumptions and notes of Table 1 continue to apply (see above).[13]

Table 2: Overview of possible relocation effects as a result of Renewables Pull or Carbon Leakage in the event of a tightening of climate protection policy

	Tougher climate protection policy		
	Only in country A	**Only in country B**	**In both countries**
With border adjustment mechanism	*No Carbon Leakage* Renewables Pull possible (A → B)	*No Carbon Leakage* Renewables Pull possible (A → B)	*No Carbon Leakage* Renewables Pull possible (A → B)
Without border adjustment mechanism	*Carbon Leakage possible (A → B)* No Renewables Pull	*Carbon Leakage possible (B → A)* No Renewables Pull	*No Carbon Leakage* Renewables Pull possible (A → B)

In principle, the danger of Renewables Pull for industrial locations with suboptimal conditions for the production or import of green energy sources increases the more ambitious climate protection policies become, either in certain parts of the world or globally. It can therefore be assumed that Renewables Pull will become particularly relevant in the medium to long term, when climate protection policies in pioneering countries or regions are gradually tightened further and other countries successively also begin with serious efforts to reduce emissions. As mentioned above, the implementation of ambitious climate protection in other countries is not a prerequisite for the occurrence of Renewables Pull, but the growing demand for climate-neutral or climate-friendly industrial production triggered by increasing climate protection efforts worldwide is likely to strengthen the incentives to produce in those regions where access to green energy sources is particularly favourable.

While Carbon Leakage could become less significant in the longer term, provided that the current global differences in climate protection ambitions are reduced over time, the differences in the framework conditions relevant for the use of renewable energies will remain in place in the long term, e.g. with regard to solar irradiation conditions, wind conditions and the availability of coastal sites.

5 Possible signs of Renewables Pull already in effect

Several reports from companies in the steel and automotive industries in recent months indicate that in some cases current corporate decisions or plans may already be attributable to Renewables Pull.

In June 2020, for example, the companies Salzgitter AG, Rhenus and Uniper, together with the state of Lower Saxony and the city of Wilhelmshaven, agreed to prepare a feasibility study for an iron ore direct

[13] It should be noted that the statement in the table that Carbon Leakage cannot occur with a border adjustment mechanism in place only applies if – as is assumed here – this mechanism is not only implemented for imports (pricing of CO_2-intensive imports), but also for exports (exemption from CO_2 pricing for CO_2-intensive exports).

reduction plant with upstream hydrogen electrolysis at the deep-water port of Wilhelmshaven (Salzgitter AG 2020). The sponge iron extracted from such a plant could be delivered by rail to the smelter in Salzgitter, where it would be melted down and processed into flat steel products. The imported iron ore for German steel production ends up in North Sea ports anyway. In future, large quantities of hydrogen generated electrolytically from offshore wind power or imported by sea transport could also be available at comparatively low cost. In its press release, Salzgitter AG (2020) speaks of "good locational conditions" for the Wilhelmshaven region. If these plans were to be put into practice, it could be a Renewables Pull effect, because part of the value creation of primary steel production would presumably be relocated from the current inland site in Salzgitter to the coastal site in Wilhelmshaven only or mainly because of the cheaper availability of green hydrogen.

The steel producer ArcelorMittal also plans to transport part of the sponge iron produced in its Hamburg plant via direct reduction to its steel plant in Duisburg for further processing (ArcelorMittal 2020). The demonstration plant for hydrogen direct reduction currently under construction in Hamburg will initially be operated with "grey" (natural gas-based) hydrogen, but in the future it will produce "green" steel on the basis of green hydrogen through a 50 MW electrolysis unit that is expected to be built at the Hamburg site in 2025. It stands to reason that ArcelorMittal plans to transport the sponge iron produced there to Duisburg (at least in part) because of the expected lower costs of providing green hydrogen in Hamburg. However, other reasons may have contributed to these plans, e.g. optimal utilisation of existing and planned plants or regional differences in the availability of subsidy schemes.

A possible Renewables Pull effect in the area of aluminium production is indicated by an announcement made by the BMW Group in February 2021 (BMW Group 2021). According to the announcement, the company will start purchasing aluminium produced using solar power. According to the BMW Group, the aluminium is produced in the United Arab Emirates by Emirates Global Aluminium (EGA) on the basis of solar power. On its website, the company states that it “leads the way as the first automobile manufacturer to establish concrete CO_2 targets for its supply chain". This suggests that the BMW Group wants to create a unique selling point by reducing the CO_2 emissions of its supply chain and in this way appeal to environmentally conscious customers. These customers might be willing to pay more for a car with a smaller CO_2 footprint in production. In turn, it could also be worthwhile for the BMW Group to accept a price premium for the low-CO_2 aluminium.

If the decision in favour of the supply contract with the aluminium producer from the United Arab Emirates was made because of lower production costs of "green" aluminium compared to green aluminium from Germany or other countries, a (demand-induced) Renewables Pull effect could be at work. Without the cost difference in the generation of electricity from renewable energies, the quantity of "green" aluminium now ordered from the United Arab Emirates could possibly be provided by a German aluminium producer. However, this hypothesis of a Renewables Pull effect is speculative as long as there is no precise knowledge of the exact motives behind the BMW Group's decision to source the aluminium from the United Arab Emirates. [14]

[14] The BMW Group states that it has been supplied with primary aluminium from the manufacturer in the United Arab Emirates since 2013. The cooperation between the two companies therefore did not start with the supply of aluminium produced on the basis of solar power.

6 Research interest, existing literature and relevant research questions

6.1 Research interest from the perspective of the state of NRW

Energy-intensive industries play a significant role in North Rhine-Westphalia and currently employ around 450,000 people (IN4climate.NRW 2021). An important part of the energy-intensive industries are basic materials industries, which include the steel, chemical and cement industries. These industries' products are the starting point for many other (downstream) industrial value-added stages. The basic materials industry is therefore considered a key industry to which North Rhine-Westphalia owes a large part of its economic prosperity. Consequently, North Rhine-Westphalia's policy-makers have a considerable interest in remaining a key location for basic materials industries in the future.

It cannot be ruled out that, at least in the medium to long term, Renewables Pull could become a threat to NRW as a location. This is due to better natural and climatic conditions for the use of renewables in other regions, both within Germany and in other European and non-European countries. These better conditions may enable a more cost-effective production of industrial goods based on green energy sources.

Consequently, it is of particular interest for the state of North Rhine-Westphalia to gain a better understanding of which sectors or stages of the value chain are likely to experience increased incentives to relocate industrial production in the sense of Renewables Pull, to what extent and in what time frames (or under which framework conditions). Such an understanding may help policy-makers in North Rhine-Westphalian to counteract potentially threatening relocations through appropriate energy and industrial policy measures. In turn, a comprehensive picture of the existing locational advantages and disadvantages of North Rhine-Westphalia's basic materials industries can provide an important basis for the development of appropriate measures.

Possibly unavoidable relocations of industrial production as a result of Renewables Pull could at least be shaped pro-actively through a good understanding of the mechanisms of action and the relevant location factors, for example by concentrating industrial policy efforts on those parts of the value chains of the basic materials industry that are not or hardly likely to be affected by Renewables Pull. Opportunities for a pro-active policy approach also apply to structural policy measures that can help generate alternative value creation in the affected regions and create new jobs. Early cooperation with other regions (e.g. through bilateral energy or resource partnerships) is also conceivable in order to pave the way for cross-regional value chains. This may counter the danger that the loss of particularly energy-intensive value chains will gradually lead to the loss of upstream or downstream value chains.

6.2 Previous research on the topic of Renewables Pull

We are not aware of much literature that systematically addresses the phenomenon of Renewables Pull across sectors.[15] However, IRENA recently addressed the question of how a relocation of parts of iron and steel production could facilitate the transformation towards climate-neutral steel production (Gielen et al. 2020). Furthermore, it has been pointed out briefly in past publications (e.g. Philibert

[15] It should be noted that the term "Renewables Pull" was only recently introduced as part of the work of the SCI4climate.NRW research project and consequently it cannot be assumed that this term has already been used in this sense in existing literature.

2017) that successful global efforts to address climate change could include the relocation of certain industrial activities to regions with very good renewable energy conditions.

As more detailed literature search should examine whether the hypothesis of a limited engagement of the existing literature with the topic of Renewables Pull can be upheld. Should such a detailed search reach the conclusion that in-depth analyses have already been carried out on individual aspects of Renewables Pull, the further research agenda (listed below) may have to be adjusted in order to avoid duplication of work and to build as best as possible on the findings of existing work.

6.3 Relevant further research questions

Due to the apparently low level of research activities on the topic of Renewables Pull so far, there are a number of research questions that need to be answered for a comprehensive understanding of the current and possible future relevance of Renewables Pull as well as the conceivable policy measures to shape this phenomenon. Some of the following research questions will be investigated until the end of the current research project SCI4climate.NRW, while other research questions could be answered in the context of further research projects.

State of research to date on the importance of energy costs and other location factors

- What is the current state of scientific knowledge on the topic of Renewables Pull? How is this knowledge linked to existing knowledge about location factors in the basic materials industry?
- What empirical findings exist on similar issues, especially in regard to potential relocations of industrial production due to Carbon Leakage or environmental protection requirements? What conclusions can be drawn from these findings for the topic of Renewables Pull?

Analysis of individual sectors and their value chains

- What kind of analysis would be needed to provide a more precise understanding of the potential future significance of Renewables Pull for individual basic materials sectors?
- What significance does the topic of Renewables Pull currently have in the strategic considerations of companies in the energy-intensive industry in Germany and NRW?
- To what extent are the stages of the value chain interlinked in important industries and what are the risks of domino effects?
- What are the key interdependencies and the decisive influencing factors that strengthen or dampen Renewables Pull effects in the affected sectors (e.g. transport costs, proximity to customers, high required product standards, energy policy framework conditions)?
- Which of the basic materials sectors represented in NRW and which stages of the value chain within individual sectors are likely to be most affected by Renewables Pull in the future? To what extent could this weaken regional value creation and what are the associated employment effects?

System analysis

- Under which framework conditions could Renewables Pull occur? Could the introduction of a carbon border adjustment mechanism lead to an increased relevance of Renewables Pull?

Analysis of countries potentially benefitting from Renewables Pull

- What are the advantages and disadvantages of specific locations with good renewable conditions? (Detailed analysis of selected locations with regard to various location factors).
- What (additional) requirements do potential target countries with good conditions for the use of renewable energies mainly have to fulfil in order to actually become attractive locations for Renewables Pull relocations?

Analysis of possible measures for avoiding or mitigating Renewables Pull

- What strategies and measures could be taken to avoid or minimise a possible relocation of industrial production from NRW as a result of Renewables Pull or to cushion the associated negative consequences?

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