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Time to phase out support to mature renewables? Approaches and options

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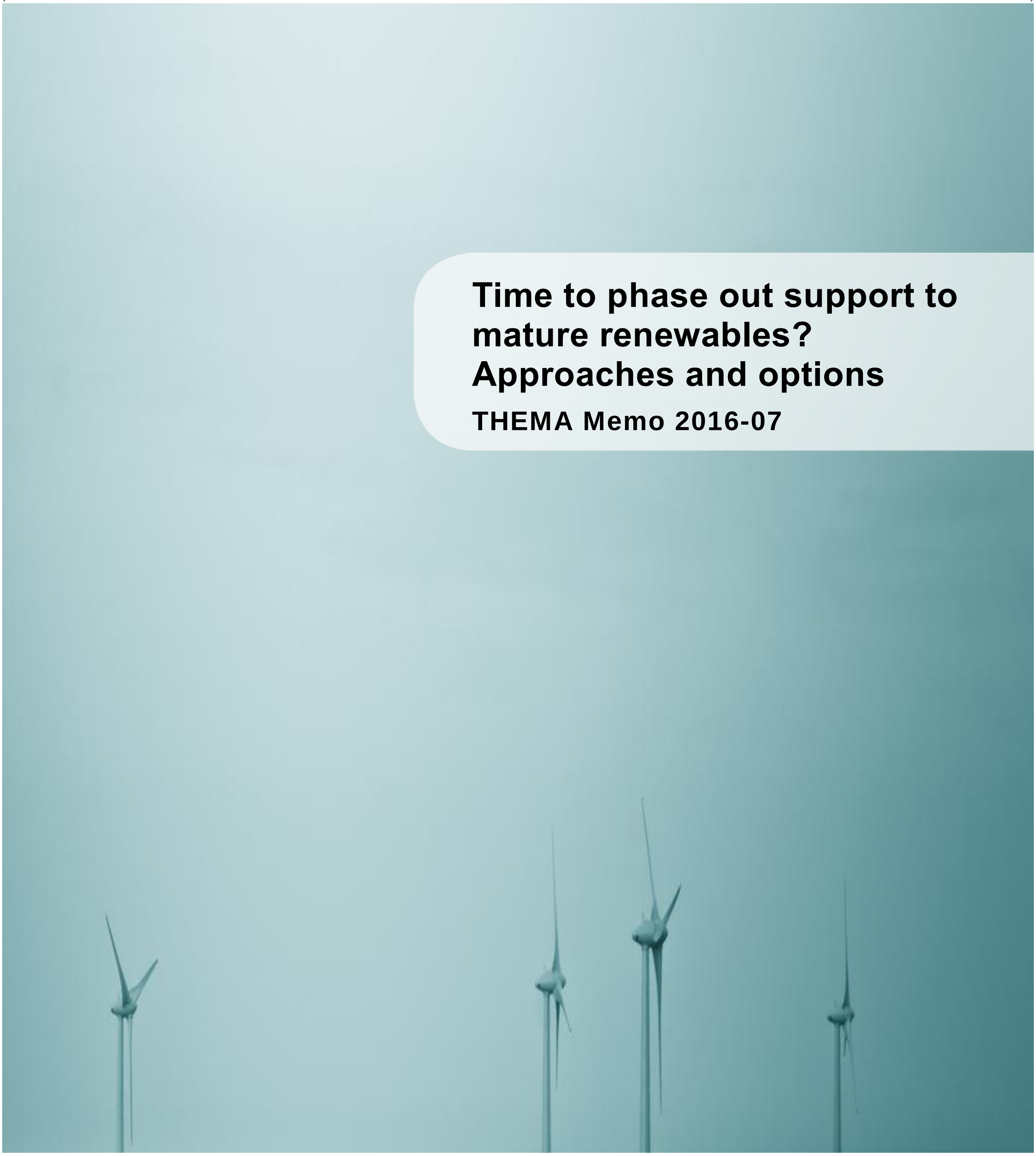

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THEMA Consulting Group is a Norwegian consulting firm focused on Nordic and European energy issues, and specializing in market analysis, market design and business strategy.

As new renewable electricity generation (RES-E) has increasingly penetrated European electricity markets based on support schemes, the costs of such technologies have come significantly down. Now it is argued that wind and solar power, in particular, are mature, and that it is time to phase out renewables support and let the market, including the cap-and-trade scheme for emission allowances and the resulting price of CO_2 emissions, determine the investments in new generation capacity. Others fear that a termination will halt investments in solar and wind, thus jeopardizing the transition to a low-carbon electricity sector, as market prices are too low to render renewables profitable on purely commercial terms. In this memo we discuss when it is time to phase out economic support to mature renewables. We conclude that RES-E subsidies should be phased out when the technologies are mature. Technologies are mature when they earn margins comparable to existing technologies or when only marginal cost savings can be expected from continued support. Low profitability due to excess supply and low market prices is not valid arguments for continued economic support. Continuation of support to mature RES-E is likely to prolong fossil over-capacity in European power markets, depress the CO_2 price, delay investments in flexibility solutions, and increase the need for other interventions, thereby permanently undermining the efficiency of European climate and energy policies.

1. Introduction

While most economists hold that the optimal way of tackling climate change and provide incentives for efficient emissions abatements is to implement a common CO_2 price for all emissions, others argue that it is also necessary to subsidize renewable (emission-free) energy (RES) in order to spur an efficient transition to a low-carbon economy.

CO_2 pricing and RES-E subsidies both incentivize investments in RES-E capacity, but have different implications for power market dynamics. CO_2 pricing increases the marginal cost of coal and gas fired power plants and gives new RES-E capacity a cost advantage compared to thermal capacity. As long as new RES-E generation is needed to balance the carbon market, the CO_2 price and thus the power price would increase until new RES-E capacity is competitive on a full cost basis. The market players are likely to invest in new RES capacity when expected future power prices (including the CO_2 price) make such investments viable, and to choose RES investments since the CO_2 prices make RES capacity competitive.

RES-E subsidies, on the other hand, gives market players incentives to invest in new capacity that does not or to a lesser extent rely on future power prices, depending on how the subsidy is designed. The increase in RES-E capacity would reduce power prices and thus the competitiveness of new and existing conventional capacity. Power prices would be suppressed – at least in the short and medium term – as old capacity is likely to be scrapped at a slower rate than the rate of the RES-E capacity expansion. The demand for emission allowances is likely to be reduced as well, thus yielding lower CO_2 prices. RES-E subsidies directly undermine the effectiveness of CO_2 pricing in the ETS by reducing demand while supply remains the same.

The EU has opted for a mix of policies to mitigate greenhouse gas emissions, with a strong emphasis both on CO_2 pricing and subsidies to renewable electricity generation (RES-E). A main argument for RES-E support is that the technologies are not yet mature. Thus, only relying on CO_2 pricing and the emission cap could have resulted in other mitigation efforts than RES-E and/or very high initial prices for emission allowances, thus challenging the competitiveness of European industry. By combining CO_2 pricing with RES support and RES targets, the emission reductions could be realized without the negative impact high CO_2 and electricity prices could have had on the European economy.

It is widely recognized that the most efficient way to cap emissions and support mature RES-E generation, is to apply a cost on emissions, thereby increasing the cost of the existing fossil-fuel based technology. At the same time, the economic rationale to support technology development and learning effects is also recognized. Hence, until the RES technology is mature, the use of double measures could be justified.

In combination with other market developments, mainly the economic downturn following the 2009 financial crisis and the access to cheap international carbon credits, the result of the mixed policies is that the share of RES-E has increased substantially, while the market for CO_2 emission allowances (EU ETS) has built up a considerable surplus and seen prices plummet. Today, the ETS is largely considered to have had only a limited impact on European emissions.

Now some argue that it is time to phase out support to mature renewables, and let the EU ETS regulate emissions through the CO_2 price, and ultimately the investments in RES-E capacity as well. Sustaining the subsidies to RES-E generation will keep CO_2 and power prices low and subsidy needs high, while not providing efficient climate policies overall. Others argue that with the low electricity prices, such a policy risks halting investments in RES-E capacity, putting the renewables targets and the low-carbon future in jeopardy.

Hence, Europe faces a genuine policy dilemma: Continue RES support and risk the break-down of the ETS, or terminate RES support and let the power and CO_2 markets work, but risk that investments in RES-E capacity comes to a halt. In this memo, we discuss what approach should be applied in order to solve the dilemma, and which market and policy features matter for the solution. The underlying question is:

When should subsidies to mature technologies be terminated?

2. Empirical evidence

Empirical evidence suggests that the increase in renewable energy has decreased CO_2 emissions. However, increased RES-E deployment has also contributed to depress CO_2 prices, and thereby power prices as well. In addition, the increase in RES-E has further depressed wholesale electricity prices due to excess power supply.

|*Figure 1* shows estimates of the contribution to emission reductions from different factors, made by I4CE.[1] According to their analysis, the CO_2 price accounts for less than 10% of emission reductions in the 2005 to 2011 period, while the increase in renewable energy accounts for 4 to 6 times as much. Thus, they hold that the EU ETS, which was supposed to be the cornerstone of the EU energy and climate policy, has become a residual market and has to date played a minor role in achieving significant emission reductions (own translation).

Similarly, ICF[2] conclude that from 2009 to 2012, renewable energy policies have played the most significant role in reducing GHG emissions within the EU ETS. The contribution from CO_2 pricing was only 9%, calculated as a residual. Never-the-less, they hold that the ETS is one of the most cost-effective policies, together with fuel taxes.[3] The cost effectiveness for RES support varies according to the design of the support scheme.[4]

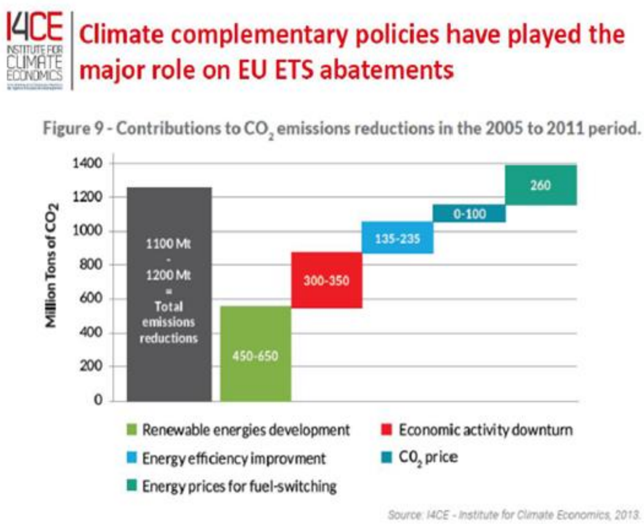
In line with this, several studies conclude that the increase in RES has had a significant depressing effect on the ETS price, although the main culprits for the low ETS price in the 2008-2012 period are the economic downturn and the use of imported credits. One such study is made by GreenStream.[5] Analysing the prospects for the future, they do however find that increased RES deployment and energy efficiency policies are likely to be the most important factors to *sustain* the large surplus of allowances towards 2020 and beyond. A similar study by Blyth and Bunn[6] estimates that without RES subsidies EUA prices would have been 20-40 euros/ton in 2020, instead of 5-30 without them.

Power prices are affected both by the CO_2 price and the increase in generation capacity. A study by Hirth[7] finds that most of the price decline in Swedish electricity prices from 2010 to 2015 is due to high RES-E supply and low demand, while Kallabis et.al.[8] find that 50% of the drop in futures electricity prices in Germany from 2009 to 2013 was explained by lower CO_2 prices, while only 11% is explained by unexpected strong growth in renewables.

3. Economic analysis

The fact remains that a surplus of electricity generation capacity and low electricity prices has resulted from the economic downturn, drop in fuel prices, the low CO_2 price, and the increase in RES-E generation, with its largely inflexible generation and low variable production costs. The low wholesale prices imply that conventional generation struggle to earn sufficient revenues and that renewables are not profitable at market prices.

Figure 1: Contribution to emission reductions 2005-2011 decomposed



[1] Jalard and Alberola (2015): Interactions between the European Union Emissions Trading Scheme (EU ETS) and complementary energy policies by 2030. Institute for Climate Economics. Unfortunately, the report is only available in Spanish.
[2] ICF International (2016: Decomposition analysis of the changes in GHG emissions in the EU and Member States
[3] They do caution that the data underlying the efficiency analysis are weak.
[4] Costs for RES-E support varies significantly across Europe depending on design of support schemes although the targets are set at European level.
[5] GreenStream (2013): Oversupply and structural measures in the EU ETS.
[6] Blyth and Bunn (2011): Coevolution of policy, market and technical price risks in the EU ETS. Energy Policy, August 2011.
[7] Lion Hirth (2016): Reasons for the drop of Swedish electricity prices, Svensk Energi.
[8] Kallabis, Pape and Weber (2015): The Plunge in German Electricity Futures Prices – Analysis Using a Parsimonious Fundamental Model. Energy Policy, August 2016 (Forthcoming).

Meanwhile, the cost of renewable generation, most prominently wind and solar power, has come down considerably. Wind and solar appear to be competitive with conventional capacity, but is not profitable at current market prices alone. A report from Ecofys[9] argues that RES-E support should be continued due to the lack of sufficient market revenues for RES-E capacity. However, their argument seems to disregard the market dynamics and the impact of RES-E generation support on electricity and CO_2 prices.

To assess the preconditions for phasing out economic support for mature RES-E, we recommend to apply a stepwise analysis, with reference to basic economic theory, the purpose of RES-E support, and long-term market dynamics.

In the following we present the recommended reasoning in these three steps:

- First, we discuss the purpose of RES support
- Second, we discuss the implications of the effects of RES-E support on the electricity market
- Third, we discuss the implications of CO_2 regulations

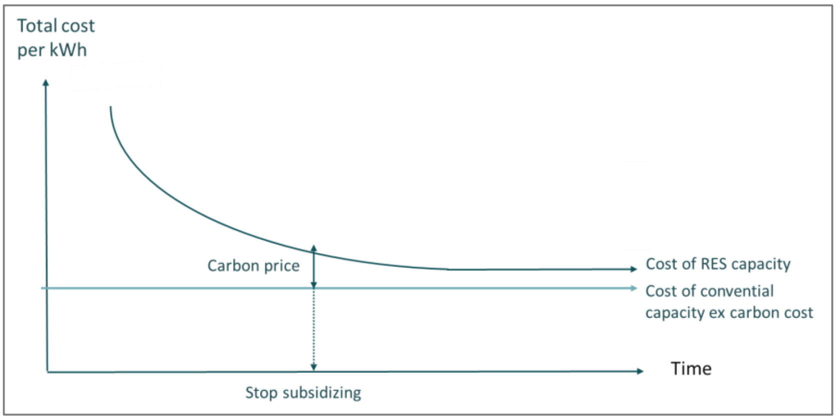
The purpose of RES support

We assume that the regulator wants to stimulate market introduction of a new electricity generation technology that is expected to be more efficient than existing ones, once it is mature. Initially, costs are higher than for existing technologies, but costs are expected to be reduced by increased deployment. In this case the relevant measure is to support RES-E generation. We assume that the regulation is derived from the overall policy objective of reducing CO_2 emissions in the long term. Hence, the immaturity of the technology is the rationale for economic support.

What is the condition for phasing out the subsidy in this situation? The condition should be referred to the objective of the subsidy, namely to make the alternative technology mature. Lynd and Larson (2003) argue that maturity could be measured by the cost margin of the technology, i.e. the technology is mature when the *cost margin* of the production is comparable to the cost margin of existing mature technologies in the same market. The cost margin can be defined as the net value relative to the cost basis per unit of generation, taking both variable and fixed cost into account. The technology is mature when investors are indifferent between investing in RES-E generation and conventional generation, e.g., gas power.

Another definition of maturity is that continued R&D support is likely to bring about only marginal improvements in benefits or costs. If that situation occurs before the alternative technology is competitive, the alternative technology will not continue to penetrate the market once the subsidy is phased out.

Figure 2: Maturity in terms of competitiveness



The case at hand is RES-E technologies that are expected to be competitive with conventional technology when the cost of CO_2 emissions is taken into account. The cost of the alternative technology is higher than that of the existing technology at the outset, but costs are expected to come down due to learning effects associated with deployment levels. Without some sort of regulated incentives, the new technology is unlikely to become competitive because investors would incur a high risk by investing in the immature technology, and because later investors will reap some of the benefits of the learning effects brought about by early investments. By supporting the alternative, immature technology, this barrier for unleashing learning effects can be overcome.

Figure 2 illustrates this case. Time is measured along the x-axis, while the y-axis measures the total cost per kWh of different technologies. The cost of RES capacity falls over time due to learning effects, while the average cost of conventional generation capacity ex carbon costs is assumed to be stable. The regulator should stop subsidizing when the long term marginal cost of RES capacity has fallen down to the same level as the long term marginal cost of conventional capacity including the carbon cost.

Hence, the first conclusion is that *RES subsidies should be phased out when the cost margin on a full cost basis is comparable to the existing technology*.

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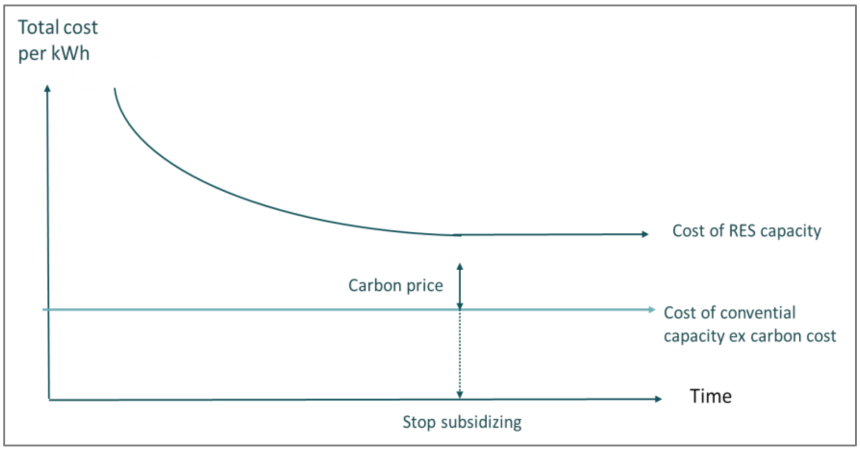
[9] Janeiro, Klessmann, Wigand and Grave (2016): Phasing out economic support to mature renewables? Divers, barriers and policy options.

It should be noted that this conclusion holds even if substantial additional cost savings are expected. If the technology is competitive, these should be realized via market dynamics in this case.

Figure 3: Maturity in terms of marginal learning effects



It could be that the RES technology reaches maturity, in the sense that potential additional cost savings are marginal, before it is competitive with investments in thermal technology <u>at the current carbon price</u>.

Figure 3 illustrates a situation where the regulator stops subsidizing RES investment before the technology is competitive with the existing technology. The carbon price is a crucial element here. If CO_2 regulation is adequate and other alternatives for CO_2 emission reductions are not cheaper, the RES capacity should become competitive as increased demand for allowances presses the carbon prices up.

Hence, the second conclusion is that *RES subsidies should be phased out when the potential for additional cost savings is marginal.*

Impact on the electricity market

Normally, when a technology becomes competitive it should also attract investments. However, the current situation in the power market is that there is significant over-capacity. This implies that investments in existing technologies are not profitable. Instead, coal and, in particular, gas power capacity is phased out or mothballed due to low or negative margins. What the market needs, is a rebalancing of the capacity. By continuing to subsidize mature renewable generation, the over-capacity situation is likely to be sustained longer. If wind and solar power generation is mature, in one or both senses of the definition, continued subsidies are unlikely to bring about substantial additional learning effects. The market will struggle to adjust, and the total subsidy bill will be high. As demand growth is low and power assets are long lived, it can take decades for power systems to rebalance (according to Hirth). The longer off equilibrium the market is thrown, the longer the "natural" rebalancing could be expected to take.

If subsidies are phased out today, it is inevitable that investments in new renewable generation will slow down or be postponed due to the current over-capacity and corresponding low prices. As long as the RES-E technology is mature, however, this does not mean that investments in existing technologies will increase. The competitiveness of different technologies, other framework conditions, and expectations about future prices will still determine investment behavior. Instead, it is likely that investors will postpone (all) investments in new capacity until the market balance gets tighter and higher price expectations make investments in new capacity economically viable.

In the current over-capacity situation, continued support to the alternative technology is likely to prolong the overcapacity situation. In the worst case overcapacity may prevail and become an argument for permanent RES subsidies. It makes better economic sense to phase out the subsidy to mature renewables and wait for investments to become commercially viable as the market returns to equilibrium. If the renewables are mature in the sense of being competitive with existing technologies (comparable cost margins), investors will invest in renewables when the market conditions say so.

So the third conclusion we draw is that *overcapacity and low prices are irrelevant for the question of whether it is optimal to phase out RES subsidies.* Low prices are not an argument neither for continuing nor phasing-out economic incentives to alternative technologies.

This conclusion contrasts the conclusion of Ecofys[10] who base their argument for continued RES-E support on the criterion that economic support for RES-E should only be phased out when market revenues cover generation costs and correspond to investors' risk tolerance. The weakness of the Ecofys study is that it disregards the market implications of continued RES-E support and that new investments in RES-E capacity could be unprofitable due to overcapacity. In principle, continuing RES-E support *could* be the right thing to do in a situation where investing in RES-E is not profitable, but the precondition must be that the technology is still immature.

[10] See footnote 9.

Implications of CO_2 regulation

So far, we have assumed that CO_2 regulation is adequate. Currently, however, CO_2 prices are widely considered too low to incentivize the necessary transition. But that does not necessarily mean that CO_2 regulation is inadequate. CO_2 emissions in the EU ETS are regulated by a cap and trade system. The adequacy of regulations depends on the adequacy of the cap, and not on the CO_2 price.

In line with the EU 2030 targets, the ETS cap for 2020-2030 is currently under revision. The proposed annual reduction factor of 2,2 will bring emissions in the ETS sectors towards 80-95 % reductions in 2050. The establishment of a market stability reserve (MSR) under the ETS will enter into force in 2019 and is expected to balance demand and supply of allowances better. Discussions on a further tightening of the cap based on the targets in the Paris agreement will be discussed in 2018 after global reporting.

Currently, the price of emission allowances in the ETS is still low, lower than the marginal cost of emissions and considered too low to incentivize the needed energy transition. But pricing in the ETS is not independent of RES deployment. Continuing RES-E support while there is a surplus of ETS allowances, will contribute to sustain the surplus situation in the ETS as well. Thus, the same argument holds as for the power surplus situation: The surplus of ETS allowances is not an argument for continued RES-E support, in fact continued support will prolong the low prices of emissions allowances.

Figure 4 sums up the dynamic impacts on the power market and the ETS market of continued vs. phased-out RES report. The impacts are further elaborated in the next section.

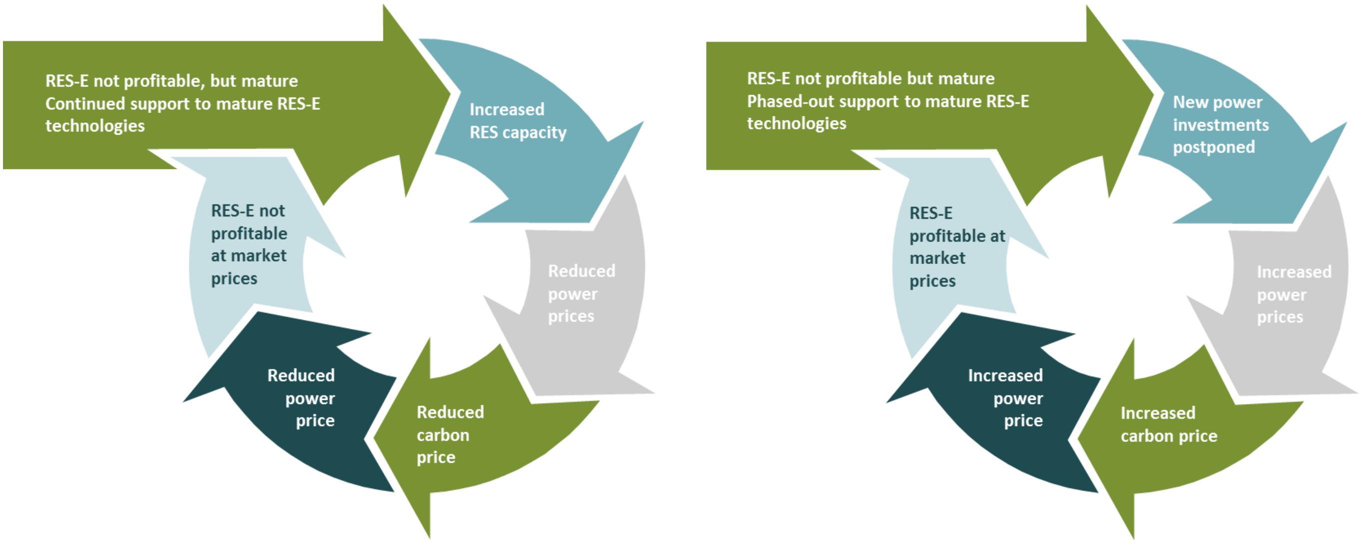
It is important to keep in mind that although the ETS price is low, emissions are lower than the cap. (That is the reason for the surplus.) The gradual tightening of the cap and the implementation of a market stability reserve should cater for an increase in the price of emission allowances. However, if the support to RES-E is sustained, CO_2 prices may continue to be too low. Investors in new generation capacity will be reluctant to invest in new coal power capacity on expectations of strict emission policies in the long run, while investors in gas power capacity will be reluctant to invest due to the bleak long-term expectations about power prices. Moreover, the current low CO_2 price will send a weaker signal to other ETS sectors where emission reductions can be achieved. Thus, continued support to mature RES-E generation is likely to undermine the efficiency of European climate policies, and distort investments in the power market. Instead of letting the cap-and-trade policies work as intended, letting the market balance emission reductions and the capacity mix in the power market, government budgets will be unnecessarily burdened by inefficient climate and energy policies.

In summary, RES-E subsidies should be phased out when the technology is mature, i.e., when it is competitive with existing technologies, or when significant cost savings can no longer be expected. Low market prices due to over-capacity in the power market and over-capacity in the ETS is not a good argument to continue subsidies in this situation.

4. Two alternatives for a sustainable energy transition

When looking at the implications of terminating support to mature RES-E technologies, one has to apply a dynamic perspective. Currently, markets are not in a state of long-term equilibrium, as can be seen by the low (or negative) margins for power generation, and the surplus of CO_2 allowances in the EU ETS. If the market is to take responsibility for investments and the secure supply of electricity even in the future, subsidies to mature RES-E technologies should be phased out. (The alternative is a sustained

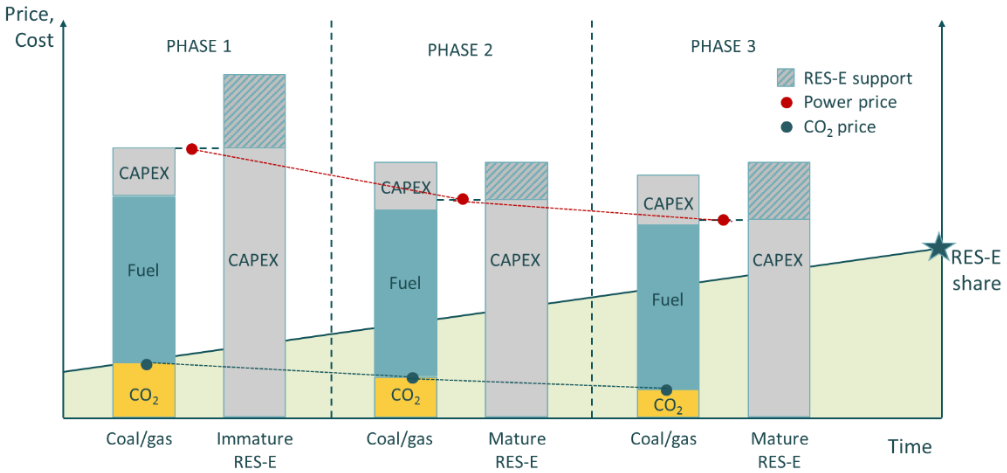
Figure 4: The market dynamics of RES-E support, continued support (left) and phased-out support (right)



reregulation of the industry with politically determined investments.)

We started from a situation where RES-E capacity could not compete with conventional capacity based on coal and gas, including the long-term CO_2 price, i.e. stage 1 in Figure 5. After a long period with support to RES-E, we assume that we are now in stage 2 in the figure, where new RES-E generation is competitive,

Figure 5: Market developments with continued RES-E support

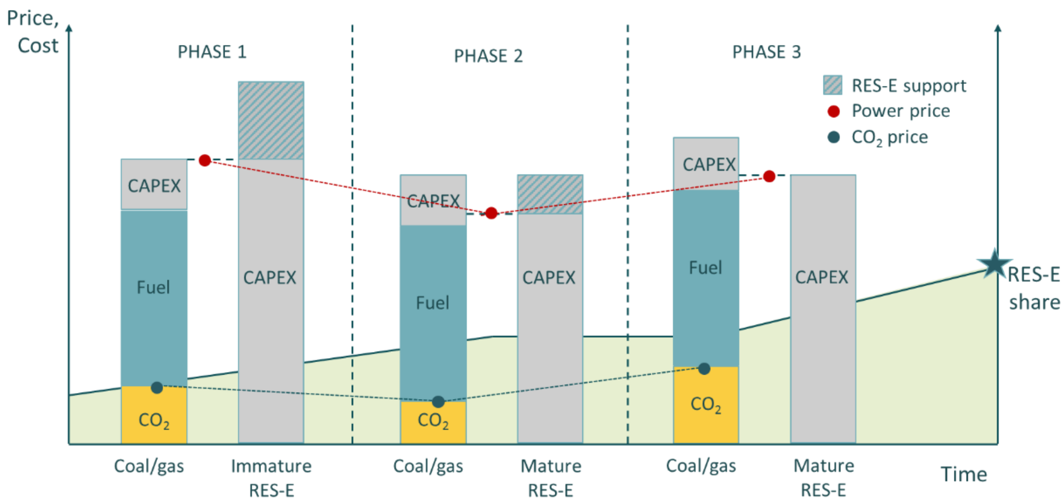


but existing conventional capacity earns margins that are not sufficient to yield normal capital returns. However, as long as the capacity makes a positive margin (above variable costs), the capacity will stay online and produce in hours when the market price covers variable costs, i.e. fuel and CO_2 prices.

Starting from the current stage, with over-supply in the market and mature RES-E technologies (stage 2), there are two viable alternatives to the low-carbon future:

1. Continued (possibly increased) RES-E support, in combination with an adequate, tightened ETS cap
2. Phased-out RES-E support, reliance on the ETS cap and CO_2 price only

Figure 6: Market developments with phased-out RES-E support



We do not consider a third alternative with continued RES support without corresponding ETS measures as viable.

We assume that the emission cap is set at the level necessary to reach long term climate targets (adequate cap), see section 3 above. This implies that CO_2 emissions will be as low or lower as the cap in both alternatives. The discussion is thus not about emission levels, but about the efficiency in fulfilling the cap.

Continued RES-E support: In combination with EU ETS

We assume that the new RES-E technology is mature in the sense that it is profitable on par with the conventional technology (cf. the definition in section 3), and cf. stage 2 in the figure. Market prices are however, too low to merit investments in new generation. The development in the RES-E share is shown by the light green area in Figure 6, increasing over time. The goal is shown by the star in the figure.

If RES-E generation is still subsidized into the market, the surplus situation is likely to be sustained as well. Prices will be depressed and the share of thermal *generation* is likely to be reduced. Existing conventional (typically thermal or hydro) generation *capacity* is likely to be reduced as well, as margins are suppressed even further and old capacity needs to be refurbished. Investments in conventional capacity are not likely to be profitable. Demand for CO_2 allowances will be reduced, and the CO_2 price will stay low.

This market development has several adverse consequences:

- Power prices stay low due to oversupply
- CO_2 prices stay low due to reduced demand for allowances

- Coal power generation gains competitiveness towards gas power generation due to the low CO_2 prices. Investments in gas power generation will be postponed.
- Demand response and storage solutions are less competitive due to low prices and flattened price structures.
- Abatement measures in other industries included in the ETS become less attractive with a lower CO_2 price.

In 2030, CO_2 emissions will still be kept in accordance with the cap and the share of RES-E capacity will be high, but the power system is likely to be less adjusted to the low-carbon society.

On the whole, the consequences are that measures needed in the transition phase are postponed. Such measures include investments in low or zero emission flexibility, such as gas power generation, demand-side response, and different storage solutions (batteries, thermal storage, hydropower reservoirs and pumped storage). Hence, continued RES-E support also increases the chance that other measures, necessary for the energy transition, must be subsidized, e.g. through capacity remuneration mechanisms. Fingrid (2016)[11] warn that such market intervention can come at substantial extra costs and IVA (2016)[12] argues that pushing RES-E generation into the Nordic market comes at a high cost to society. They hold that onshore wind power is a mature technology and that continued subsidies yields an inefficient generation mix, and increases the risk that capacity mechanisms become necessary.

Phased-out RES-E support: EU ETS as the only measure

Now let us assume that RES-E support to mature technologies is instead phased out. The first response from the market will be to reduce or postpone investments in new RES-E capacity. Early on, the share of RES-E generation will definitely be lower than in the first alternative. This may imply that coal power capacity is kept longer, as the (residual) demand for thermal generation is higher. But increased coal power generation also implies that CO_2 emissions from power generation will increase, eventually leading to increased demand in the EU ETS and higher CO_2 prices. Thus, the initial effect may be increased coal power generation, but the subsequent effect will be to improve the competitiveness of gas power generation towards coal power. At the same time, the margins for RES-E generation will also increase when CO_2 prices increase. Moreover, the margins will increase further as surplus capacity is eroded in the power market. The cap contains emissions, and the price of emission allowances will increase if the demand for allowances surpass the cap. Figure 4 and Figure 6 illustrate this benign price dynamic.

Eventually, investments in mature RES-E become profitable on market terms, as the price levels increase and the price structure shows higher peaks. Peakier prices will also provide a stronger incentive for demand-side response and development and use of storage solutions.

Thus, in 2030, the power sector is likely to be better prepared for the low-carbon future in terms of capacity mix and market balance. The result may be more gas power generation and somewhat less RES-E generation than in the alternative with continued RES-E support, but emissions are kept within the same cap.

As the future needs a well-adapted and low-carbon electricity sector, discontinuation of support to mature RES-E stimulates the necessary adaptations and measures, whereas continued RES-E support postpones the transition and is likely to make it costlier.

5. Conclusions and final remarks

In the preceding sections we have argued that RES subsidies should be phased out when the technology is mature in the sense that it is competitive with the existing, conventional technologies. That investments are not profitable is a not a valid economic argument for continued support, since the reason for non-profitability is that the market is oversupplied.

Based on empirical evidence and economic analysis we have concluded that continuation of support for mature RES-E is likely to prolong fossil over-capacity in European power markets, depress the CO_2 price, delay investments in flexibility solutions, and increase the need for other interventions, thereby permanently undermining the efficiency of European climate and energy policies. Moreover, continued support to mature RES-E technologies is likely to increase the risk that other costly measures burdening public budgets or consumers' electricity bills must be taken. Continued RES-E support also risk increasing the cost of abatement both within the ETS and between the ETS and non-ETS sectors as the price of CO_2 allowances is distorted.

If the eventual goal is to make renewable energy competitive on a market basis and to phase out subsidies when RES-E technologies become mature, decisions are more efficient if left to the market provided that regulation of CO_2 emissions is adequate. Hence, it is relevant to ask whether there could be reasons *other* than emission reductions for continue RES-E support, taking into account the multiple targets of the EU Energy Union? The following remarks seek to address this.

What if RES subsidies support other policy goals?

So far, we have assumed that the reason to support RES-E is to reduce CO_2 emissions in the long term. But it could be argued that

[11] Fingrid (2016): Electricity market needs fixing– What can we do?

[12] IVA (2016). Framtidens elmarknad. En delrapport. IVA-projektet Vägval el. (In Swedish.) www.iva.se

increasing the share of renewable energy to a certain level is a goal in itself or desirable for energy security or competitiveness reasons. If so, the targeted RES volume could be fulfilled either before, at or after the time RES capacity becomes mature. What then? If it happens before, the risk is that stopping subsidizing renewables could hinder further learning effects, which subsequently could put the long term goal of making RES technologies competitive in jeopardy. In that case, the subsidy should be continued in order to support the transition to a low-carbon electricity sector. The RES-E target could be seen as too low compared to the volume needed to mature the technology.

If the RES capacity volume is not reached at the time of RES technology maturity, it is less obvious what the right regulatory action would be. That depends primarily on the nature of the additional volume regulation. If the volume is defined independently of the overall policy objective of reducing CO_2 emissions, then the regulator must consider to continue subsidizing RES-capacity in order to realize the RES volume objective in due time. If the RES volume regulation is derived from the overall objective of reducing greenhouse gases, we have the same situation as described above, and the subsidies should be phased out.

What if CO_2 regulations are inadequate?

The situation would be more complex if CO_2 regulations were not adequate, i.e. if the ETS cap were not as tight as it should be. Some argue that current CO_2 regulations are not adequate because the EU has not been able to agree on a sufficiently tight emission reduction target and due to the large accumulated surplus of allowances. In legal terms, however, the agreed annual reduction factor in the ETS does not have an end-date, implying that the cap will continue to be reduced towards 80-95 % reductions in 2050 unless otherwise decided by the legislator. There is an ongoing discussion on whether the proposed factor of 2,2 is sufficient after the Paris agreement or if it should be tightened by increasing the factor to 2,3-2,6. The discussion will continue after 2018. Hence, although CO_2 prices are low, it is not obvious that CO_2 regulations, including the cap, are inadequate.

If the cap is inadequate, the competition between thermal generation and RES-E generation, and between coal and gas generation, would be distorted, favoring thermal over RES-E and coal over gas. Inadequate cap-setting yields too low CO_2 prices, too much thermal generation and too much coal. If it is not possible to attain adequate CO_2 regulations, one has to search for second-best policies: Would continued RES-E support be an adequate policy fix for inadequate CO_2 regulations?

The risk would be that RES-E would not be able to compete in the market, and thus lose out to coal and gas. Some RES-E support would counteract the distortion, but if measures are not carefully designed, e.g. if targets are set too high, one risks that the subsidy acts as an indirect support to coal: Coal becomes more competitive to gas in power generation because RES-E support puts a downward pressure on CO_2 prices. To put it bluntly, it is meaningless to support RES-E in order to reduce emissions beyond the cap in the long term.

However, in this situation, it could also be argued that continued RES-E support would make it easier (less politically costly) to tighten the CO_2 cap.

Other, additional, policy measures than continued support to mature RES-E generation could also be introduced (some have been), for example:

- A ban on investments in coal power generation in order to avoid lock-in effects on emissions.
- A carbon price floor (UK)/corridor for carbon prices (France), in order to reduce uncertainty for investment in low-carbon technologies, including RES-E.
- Adapt RES-E support to market conditions, e.g. via auctions, in order to mitigate the adverse effects of distortive RES-E support schemes and to make the support system more flexible.
- Combine policies with cancellation of allowances (Sweden), in order to make countries that continue to support mature renewables contribute to a corresponding tightening of the cap, thereby reducing or removing the distortive effect on the CO_2 price.

All these measures have in common that they may improve the situation, i.e. mitigate distorted CO_2 regulations (too lenient or short-term cap setting) in the short term, but at the same time, they may create other distortions. It is an empirical as well as an analytical question which solution – or combination of solutions – is the less distortive one. However, even in a situation with inadequate CO_2 regulation, further support to mature RES-E without additional measures is likely to distort market prices and investments, just as in the situation with an adequate cap.

What about capacity adequacy and security of supply?

Some countries are prone to support new RES-E in order to reduce import dependency, especially if generation based on indigenous resources are phased out and replaced with generation based on imported fuels. New RES-E generation based on solar and wind, do however have other technical features than conventional capacity. If all countries strive for a high degree of self-sufficiency based on intermittent resources, there will be a huge over-capacity in the market, and many countries may still depend on imports in the most critical hours (peak load with low wind/low solar generation).

A large influx of RES-E generation, especially if based on poorly designed subsidy schemes, risk deteriorating capacity adequacy (in critical hours). As mentioned, reports from Fingrid and IVA (see footnote 11 and 12) argue that continued RES-E support increases the likelihood that measures to support all capacity become more likely. The more distorted the market price signals, the more likely it is that other costly measures must be implemented, and that the total system costs accelerates.

Appendix: Price formation in the electricity market explained

Market prices determine the value of RES-E generation, and RES-E generation affects market prices.

Electricity generation is valued according to market prices in different time frames. The main revenues do, however, accrue from the day-ahead market, sometimes referred to as the spot or wholesale market for electricity, where prices are set hourly for the day. In the spot market, prices are set according to the marginal bid, i.e. the variable cost of the most expensive generation which is necessary in order to meet demand. As electricity is generally costly to store and consumption varies from hour to hour, the short-term marginal cost of generation also varies from hour to hour.

Prices also vary between market areas according to the composition of generation capacity and interconnector capacity with other markets. Prices differ between markets when the transmission capacity is fully utilized. If not, prices are equalized. Market coupling ensures that electricity flows from low price to high price areas.

In hours with positive prices, the price level is normally determined by variable costs of flexible generation that can adapt to market prices, usually coal and gas generation. The variable cost of coal and gas generation consists mainly of fuel and CO_2 costs. If fuel and CO_2 costs are low, the competitiveness of RES-E generation is weak, whereas it is strong if fuel and CO_2 costs are high.

RES-E generation generally does not adapt generation to short-term market prices:[13] Wind and solar generation have low variable costs and will produce when the wind is blowing and the sun is shining, even if prices are low. If RES-E generation from wind and sun surpasses demand, prices will be zero or negative.

With increasing shares of RES-E generation, there will be more hours with low and even negative prices as RES-E generation is sufficient to cover demand.

For RES-E generation this creates the so-called cannibal effect, or negative correlation between RES-E generation and prices: When RES-E generation is high, prices tend to be low. Thus, RES-E generation is prone to make lower prices on average than flexible generation. This challenge is exacerbated as the share of RES-E generation increases since generation from different facilities are highly correlated (wind and solar generation across large areas).

In the hours when coal and gas power are marginal, the price level is also affected by the CO_2 price. The CO_2 price is set by supply and demand in the EU ETS market. While the cap determines the supply of CO_2 allowances, coal and gas power generation constitutes a large part of the demand for CO_2 allowances. As generation from of RES-E increases, less generation from coal and gas power is needed to cover demand, and the demand for CO_2 allowances declines as well.

If RES-E generation receives production subsidies, they will even earn money if they produce when prices are negative (down to the value of the subsidy). Negative prices imply that the generators are willing to pay to produce, even when market demand is saturated. If demand cannot increase, then some other form of generation must be paid to reduce generation. This usually means that start/stop costs accrue, and is more expensive than simply curtailing renewable generation when prices are negative.

[13] Hydropower without storage (run-of-river) has the same characteristics, while hydropower with reservoirs can store water until prices are higher.