

Competitive tendering for renewables and industrial decarbonisation¹

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Abstract:

Competitive tendering of state aid is a tool for governments to ensure that aid is awarded efficiently and at the least cost for public finances. In the context of aid for investment in renewables and industrial decarbonisation, competitive bidding offers important advantages over administratively set support schemes: it improves cost-effectiveness by keeping support close to each project's funding gap; it enhances efficiency by selecting the projects with the highest social value; and it supports transparency, limiting the scope for regulatory capture. This note discusses auction and contract design principles, with an emphasis on how to ensure effective competition and on recent developments in addressing bidder and project heterogeneity, risk, and multi-source funding.

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1. Introduction

Competitive tendering has become the default instrument for allocating state aid under EU climate, energy, and decarbonisation policy. The case for using competitive mechanisms rests on the general strengths of competition as a price formation and allocation mechanism — particularly in contexts where competitive prices are absent, and there are strong information asymmetries between the tendering authority and bidders. Under administratively set support schemes, the government typically determines the remuneration level based on cost estimates, often without a pre-announced cap on total support. Any eligible operator is then entitled to the same level of subsidy, provided it meets the specified requirements. This approach has proven costly: governments have consistently overestimated the funding gap, locking in high payments well above actual costs.

Auctions, by contrast, let bidders reveal their own costs through competition. Competition among bidders encourages them to disclose information about their current and expected costs, thereby fostering the selection of those projects with the highest social value (efficiency) and reducing payments (cost-effectiveness). The available empirical literature broadly confirms that auctions have significantly reduced support costs compared to administratively set schemes (e.g., Del Río and Linares, 2014; Gephart et al., 2017; Winkler et al., 2018; Anatolitis et al., 2022).

For auctions to deliver on their promise, however, competition must be genuine. A robust insight from auction research is that the degree of competition matters more than the fine details of auction design. When auctions are not truly competitive — because the number of participants is insufficient, or because supply exceeds demand (undersubscription) — bidders can safely inflate bids, informational rents persist, and payments will reflect strategic considerations rather than costs. Some RES auctions in Europe have experienced undersubscription due to factors such as permitting delays, grid-connection bottlenecks, high bidding costs, low ceiling prices, and regulatory uncertainty. The design of the auction must therefore actively foster participation and competition, and tendering authorities must be alert to the risk that undersubscription becomes systematic.

Three concepts are central to evaluating competitive tendering procedures and will be used throughout this note. Effectiveness refers to the ability of a scheme to achieve its deployment or completion targets, i.e., the quantity of renewable capacity, green electricity generation, or emission reductions delivered within a certain time horizon. Cost-effectiveness refers to minimizing the level of public support required to achieve a given target. Efficiency refers to ensuring that support is awarded to the project developers that maximise social value — in many contexts, this will mean the developers with the lowest costs, but not always, since projects may differ in their social benefits (for example, due to externalities, learning-by-doing, or grid impacts).

Cost-effectiveness and efficiency are closely related but not identical: auction design often involves trade-offs between the two. When information about costs is privately held by bidders, those with lower costs are tempted to exploit their cost advantage to extract larger payments — particularly when the number of bidders is low. An extensive body of literature in auction theory has examined ways to keep costs down under these circumstances, and has established that doing so can sometimes come at the expense of efficiency. A first illustration is Myerson (1981)'s optimal auction, which generically includes a reserve price. The presence of a reserve price implies the contract may not be awarded even when that would be efficient from a social standpoint, but it limits bidders' informational rents and reduces expected costs. Similarly, when

some bidders are expected to have lower costs than others, penalising them or equivalently favouring weak bidders through bidding credits can increase competitive pressure and reduce tendering costs (Myerson, 1981; Ayres and Cramton, 1995).

The tension between efficiency and cost-effectiveness is further exacerbated when projects confer different benefits to the tendering authority (project heterogeneity) or when they generate externalities. In these cases, the lowest-cost option may not always be the most efficient. Addressing these issues requires appropriate auction design, including scoring auctions and hybrid auction formats, as discussed in Section 5.

The note addresses two other areas of recent developments in auctions for renewables. The first area is contract design. Auctions for support are indeed not one-shot processes. They are auctions for projects — the construction and operation of a wind farm, the installation and operation of solar panels, an industrial retrofit, and so on. Auctions for projects introduce a time dimension to contracting and, therefore, uncertainty and risk. Bidders may be concerned about the timing of cash flows, given high upfront investment costs and the development and operational risks inherent in such projects. Tendering authorities may worry that winning bidders default or that projects do not perform as promised. This requires careful thought not only about auction design but also about the contracts put out for tender and has been an area of rapid development in legislation and practice, as illustrated by the recent issuance by the European Commission of guidance on two-way contracts for difference.² Contract design trades off risk-sharing and moral hazard: investors should bear risk to the extent they can control outcomes, but not beyond. An important message that emerges from the analysis is that auction and contract design are fundamentally interlinked: contract choices affect bidder heterogeneity and, therefore, the auction's competitiveness.

The second area of policy developments concerns multi-source project funding — notably EU funds and national funds from Member States — a situation that is increasingly common as EU-level instruments such as the Innovation Fund or the European Hydrogen Bank interact with national support schemes. Decentralised, uncoordinated auctions of these different funds create inefficiencies linked to sequentality and competitive fragmentation. We discuss these challenges and alternative institutional arrangements, including the “Auction-as-a-Service” model adopted by the European Hydrogen Bank, as innovative approaches to multi-source coordination in auction design.

This note is structured as follows. To set the stage, section 2 discusses what is special about investment in renewables and industrial decarbonisation. Section 3 reviews the advantages of competitive bidding over administrative support. Section 4 discusses the importance of competition and how to address undersubscription. Section 5 examines auction design in the presence of bidder and project heterogeneity. Section 6 turns to contract design in the presence of risk and moral hazard. Section 7 addresses multi-source funding. Section 8 concludes.

Klemperer (2002, 2004) and Milgrom (2004) provide early surveys of lessons from large-scale auction design applications. Cantillon (2014) provides an early review of auction design considerations for supporting renewables. Dimitri et al. (2006a) present the main principles of strategic procurement design in an accessible way. European Commission (2022a) and Anatolitis et al. (2025) review lessons from competitive tendering for renewables over the past decade.

² Regulation (EU) 2019/943 and Commission guidance on the design of two-way contracts for difference (C/2025/6701).

2. What's special about investment in renewables and industrial decarbonisation?

Investments in renewable energy and industrial decarbonisation share common features that help justify the need for state aid (necessity criterion) and shape the form this aid takes. First, investments in renewable energy and industrial decarbonization contribute to the EU's climate objectives and roadmap. As such, they squarely fall within the exemption set out in Article 107(3) for state aid that facilitates the development of an economic activity of common European interest. Second, we can make the case for the presence of market failures in the current context, both because these investments generate positive externalities (e.g. sector-level learning-by-doing economies) and because alternative ("brown") technologies still do not fully bear the cost of the negative externalities they generate (for example, because of free allowances in the ETS and other fossil subsidies in the EU). The presence of positive externalities and unpriced negative externalities for alternative investments suggests that state intervention may be required to restore efficiency.³ This will be the case *if* the technology – because of these unpriced externalities – is not profitable, i.e. if there is a funding gap.⁴

Beyond these common factors, differences across technologies and contexts will typically call for a differentiated approach to analysing the case for state aid, in particular regarding the choice of policy instrument (appropriateness criterion), and auction and contract design. Relevant aspects to consider include:

1. **Technological maturity.** While wind and solar power have achieved some level of technological maturity, some RES technologies and many industrial decarbonisation options remain immature. Their evolution is difficult to predict.⁵ For these technologies, the main challenge is to spur innovation. As Acemoglu et al. (2012) have argued, in the presence of externalities in both the innovation and production/consumption markets, production subsidies alone are inefficient. They need to be complemented by R&D subsidies. Green hydrogen, to which most net-zero emissions scenarios assign a critical role, is a case in point. Cammeraat et al. (2022) show that green hydrogen produced by electrolysis is not cost-competitive even after accounting for unpriced carbon externalities. Further innovation is needed, for which support for deployment, such as production subsidies, is less effective.
2. **Potential participants.** Auctions work well to keep state aid to a minimum when there is sufficient competition. Competition depends on what is being auctioned. Simpler, well-defined projects, for which building permits are already secured by the tendering authority, will likely attract more bidders than highly complex projects with less mature

³ One could argue that the presence of uninsured risk is another market failure affecting this market. While it is formally correct to say that the absence of long-term wholesale electricity or carbon prices constitutes a market failure because markets are not "complete", using this argument to justify aid in the current context opens the door for state aid in virtually every capital-intensive investment context.

⁴ Some RES technologies are now competitive even on a non-subsidized basis (Lazard, 2025). Moreover, when investment is bulky, as it is in the context of renewable energy and industrial decarbonization, the presence of unpriced positive externalities or unpriced negative externalities for "brown" alternatives is only a necessary but not a sufficient condition for state intervention. Investment levels may well be efficient despite these market failures if they do not create a funding gap. See Cantillon (2014) for a longer and more detailed discussion of this point.

⁵ Lopez et al. (2025) document systematic underestimation of RES deployment in the International Energy Agency (IEA)'s annual World Economic Outlook.

technologies. Industrial decarbonisation investments target existing incumbents, limiting participation by definition. Tendering authorities should keep these contextual factors in mind when evaluating the pros and cons of different auction formats.

3. **Cost structure.** Investments in renewables and industrial decarbonisation tend to be highly capital-intensive and have long lifetimes. Still, projects differ in their operating expenditures (OPEX). For example, wind and solar power have negligible marginal costs, while electricity generated from biomass has material marginal costs. Cost structure matters because it affects the risk profile of these projects and bidders' preferences over contracts.
4. **Project heterogeneity and system-level value.** Renewable investments and industrial decarbonisation do not only involve costs for the firms that make those investments, but they also typically generate different value for the system. Some of these technologies are subject to learning-by-doing and experience curves that benefit other market participants (positive externality). Others impose a cost to the system (e.g. grid access, congestion). The presence of these external costs and benefits means that having these projects compete solely on price is inefficient. Mechanisms need to be put in place to compare apples with apples and ensure a level playing field.
5. **Downstream competition.** Renewable electricity producers compete in the wholesale electricity market. Industrial producers compete with “brown” producers that have not yet decarbonized and with international competitors. This means that the possible distortive impacts on downstream competition of the awarded aid should be a key concern in the design of the tendering process. This concern is reflected in Art. 4 of the 2018 Directive on the promotion of the use of energy from renewable sources, which calls for support to renewable electricity generation to ensure a “market-responsive” integration into the electricity market, and, more recently, in Art. 19d §2 of the Electricity Regulation. In the case of industrial decarbonisation, the aid recipient will typically be an incumbent. Its incentives to decarbonize will depend on the competitive benefits decarbonization provides in the market where it operates.

3. Advantages and challenges of awarding aid through competitive bidding

In this section, we first discuss the main advantages of using auctions to allocate aid, and then turn to challenges that often emerge in implementation.

3.1. Advantages of successful auctions relative to administrative support

Competitive bidding has important advantages over administratively set support schemes, which build on the general strengths of competition as a price formation and allocation mechanism — particularly in contexts where competitive prices are absent and there are strong information asymmetries between the auctioneer and bidders (Klemperer, 2004; Milgrom, 2004).

Information extraction and cost-effectiveness. Competition in auctions forces bidders to “put their money where their mouths are” (Klemperer, 2004) and reveal their costs through their bids. This information is otherwise difficult to extract or estimate, and is especially important for novel or non-existing markets, such as those for decarbonisation technologies (Richstein et al., 2024). This information is then automatically used to set subsidies at the minimum necessary level, i.e., as close as possible to each supplier's funding gap. The funding gap — the amount missing for a

project to be privately profitable on a standalone basis — typically differs across suppliers, projects, and technologies, and is the suppliers' private information.

Efficiency. Auctions more effectively allocate limited financial resources among heterogeneous potential suppliers. Competitive bidding identifies and selects the projects with the highest social value as recipients of subsidies. It may also help determine the most cost-effective technologies to support when these are sufficiently close substitutes to compete in the same auction (Cantillon, 2014; Fabra and Montero, 2023; see Section 5 below).

Effectiveness. By minimising the cost of subsidising each project, successful auctions free resources that can be used to subsidise additional projects within a constant budget, potentially increasing the volume of investment supported. The empirical evidence here is more mixed than for cost-effectiveness: several countries that achieved low support levels through auctions have experienced relatively low deployment and completion rates (Del Río and Linares, 2014; Winkler et al., 2018), underlining the importance of auction design for ensuring delivery (see Section 3.2 below).

Transparency and reduced distortions. Administratively set subsidies are typically the result of explicit or implicit negotiations behind closed doors, leaving room for regulatory capture, lobbying, or undue influence. Auctions, while not immune to these pressures, limit administrative discretion through their public competitive process. The competitive allocation of subsidies also minimises distortions that state aid may create on competition in the European common market, which is one of the main rationales behind the EU's shift towards competitive allocation for all subsidies (Piechucka et al., 2024).

In contrast to auctions, under administratively set support schemes the government determines the remuneration level based on cost estimates, typically without a pre-announced cap on total support. Any eligible operator is entitled to the same level of subsidy as long as they meet specified technical requirements. These features have sometimes made such schemes very expensive for governments. The case of solar PV in Germany, Italy, and Spain in the 2000s is instructive: feed-in tariffs were set based on cost estimates that proved far too high, locking in payments well above actual generation costs as technological learning progressed unexpectedly fast (technological learning might have been helped by the increased deployment linked to generous subsidies). After two decades of experience, the available literature converges on the conclusion that RES auctions significantly reduce support costs compared to administratively set schemes (Del Río and Linares, 2014; Gephart et al., 2017; Winkler et al., 2018; Anatolitis et al., 2025).

That said, when the object of the subsidy is particularly novel and complex, the strict focus on price competition in standard auctions may constrain useful communication between the government and better-informed suppliers. In these cases, administrative processes allow for a more open interaction, at a potential cost in terms of competition and transparency. Hybrid auction formats that combine competition with elements of negotiation — such as the Competitive Procedure with Negotiation and Competitive Dialogue provided under EU procurement directives — offer an option for such complex situations.

3.2. Challenges in the implementation of competitive bidding and how to mitigate them

For an auction to deliver its benefits, it must attract a sufficient number of bidders, induce effective competitive behaviour, elicit the targeted investments, allocate long-term contracts

that are respected by winning bidders, and properly account for dynamic effects. Auction performance can be affected by a number of challenges. We focus here on three that are particularly important in the context of state aid for renewables and decarbonisation. Then we discuss how to mitigate these challenges through auction design.

3.2.1. Unreliable low bids and ensuring delivery

Experience with procurement of construction projects highlights a potential trade-off between cost-effectiveness and effectiveness: when the object of the auction is not sufficiently well defined, price competition may reduce procurement performance (Decarolis, 2014). Competitive bidding of projects to be undertaken in the future can be thought of as an “auction of promises”, where the respect of promises by winning bidders cannot be taken for granted and must be guaranteed by appropriately designed and enforced contractual arrangements.

This post-award governance challenge becomes more important the lower the margins embedded in bids. The more auctions spur price competition, the more they require a complete and enforceable contractual specification of the auctioned project to achieve a successful long-term outcome. For complex, innovative, and high-risk long-term projects, it can be too costly or impossible to design sufficiently complete contracts, leading to unreliable low bids resulting in poor quality, excessive renegotiations, delays, and incomplete or early terminated projects.

Unreliable low bids are typically generated by:

- **Winner’s curse problems:** risk, uncertainty, and limited information among bidders about common cost components (e.g., future input prices, unexpected difficulties at the installation stage, electricity prices, technology success rates) may lead to frequent selection of bids that underestimate realisation costs (Milgrom, 2004; Klemperer, 2004).
- **Adverse selection:** the unreliable technical and financial capacity of the cheapest project developers winning the auction (Manelli and Vincent, 1996; Engel et al., 2006; Del Río and Linares, 2014).
- **Opportunistic behaviour:** excessively low bidding can reflect strategic behaviour by suppliers who anticipate their ability to “hold up” the buyer later, obtaining ex-post price or delivery time upward adjustments once the project is ongoing and the buyer is locked in.

The main tools to address this issue include:

- **Risk allocation and de-risking:** risk-sharing contractual arrangements are crucial in providing right incentives to the contractor while protecting against uncontrollable risk. Buyers should absorb risks that are beyond the control of the supplier (see Section 6).
- **Information disclosure:** winner’s curse problems can be reduced by disclosing all information available to suppliers. Open auction formats also tend to generate information to all bidders and reduce the winner’s curse.
- **Pre-qualification criteria:** restricting entry to bidders that qualify with minimum technical criteria (e.g., grid connection, land rights, construction permits) and financial criteria (e.g., proof of funding, sound financial indicators) ensures capable and reliable participation.
- **Financial guarantees:** bidding bonds and third-party financial guarantees protect against unreliable bids and related bankruptcy risk, whether induced by informational problems or opportunistic behaviour (Engel et al., 2006).

- **Contractual remedies and their consistent enforcement:** well-designed and enforced contractual penalties for delays or other failures to deliver reduce the risk of strategic underbidding.
- **Reputational mechanisms and scoring rules:** monitoring and rewarding supplier past performance at the awarding stage —e.g. incorporating past performance indicators in the qualification or scoring rule — helps reduce unreliable bids by better screening reliable suppliers (Calzolari and Spagnolo, 2009; Andreyanov et al., 2020; Spagnolo, 2012).

3.2.2. Dynamic inefficiency and how to mitigate it

Auctions that focus on current price competition favour mature technologies, which are typically cheaper, over new or innovative ones that have more potential in the long run. Standard subsidy auctions may therefore achieve static cost-effectiveness at the expense of dynamic efficiency: they can lead to technological lock-in and potential windfall profits for the currently least-cost options (Cabral et al., 2006; Fabra and Montero, 2023; Chiappinelli et al., 2025). Moreover, fostering innovation should itself be seen as part of the objective of these auctions. It is often optimal to bundle the innovation and deployment stages within a single competitive bidding procedure, so that part of the informational rent from the deployment phase can be used to reward innovative effort (Che et al., 2021).

This challenge can be mitigated through appropriate auction design, including running technology-specific auctions that allow for endogenous adjustment of the subsidy allocated to each technology, or technology-neutral auctions with constraints and weights — such as scoring rules that account for dynamic efficiency considerations, or technology-specific price ceilings, capacity floors, and caps. The potential costs and benefits of these alternative solutions are discussed in more detail in Section 5. We note that in environments where breakthrough innovations may emerge, scoring rules that qualitatively evaluate innovative content may perform better than capacity floors, because novel technologies might not yet be identifiable when floors are set.

4. The importance of competition and how to deal with undersubscription

The case for using auctions rests on the assumption that competitive bidding will reveal private information about costs, discipline rents, and allocate support efficiently. However, the success of an auction depends critically on the degree of competition. Only when the auction is competitive do suppliers risk losing and therefore submit bids that closely reflect their costs. If the auction is not truly competitive, bidders can safely inflate bids, large informational rents persist, and payments will reflect strategic considerations rather than costs.

A robust insight from auction research and practice is that the degree of competition matters more than the fine details of auction design. The primary determinant of competitive outcomes is the number of independent, active participants (Bulow and Klemperer, 1996; Klemperer, 2004). Careful auction design, however, can foster participation and thereby competition.

A necessary condition for competitive behaviour is the so-called scarcity requirement: the total volume of aid requested by bidders must be larger than the aid offered. When not even this necessary condition is satisfied, the auction is said to be undersubscribed. Common

consequences of undersubscription include all submitted bids being accepted, inflated bids by participants who anticipate undersubscription, lower cost-effectiveness than expected, and failure to meet deployment targets.

Some RES auctions in Europe have experienced undersubscription (Del Río and Kiefer, 2023; Anatolitis et al., 2025). The problem has been ascribed to increased costs (raw materials, logistics, equipment, interest rates), low ceiling prices, risk concerns, high bidding costs, and legal-bureaucratic constraints such as permitting delays and grid-connection bottlenecks. Undersubscription may also reflect suppliers' strategic behaviour at the participation stage, such as rotating cartels.

4.1. Stimulating participation

Attracting more participants is the most direct way to prevent undersubscription. Key design features that can affect participation include:

- **Bidding costs:** Companies face significant costs in participating in auctions. High bidding costs combined with the positive probability of losing make participation risky and deter entry. Bidding costs can be reduced by disclosing information in advance, drafting clear tender documents, and simplifying procedures. When entry is insufficient because bid-preparation costs cannot be reduced further, the buyer should consider reimbursing at least part of these costs to losing bidders.
- **Risk:** Long-term market and regulatory risks, and fear of the winner's curse, are often reported as major factors discouraging participation. These concerns can be mitigated by disclosing available information and by contractual arrangements that protect suppliers from risks beyond their control (see Section 6).
- **Reserve price:** A low reserve price typically deters entry, although it protects against the effects of potential collusive bidding.
- **Pricing rule:** Most subsidy auctions are pay-your-bid (discriminatory) auctions. Uniform price auctions, where all winners receive the same clearing price, may encourage entry by less informed bidders by reducing winner's curse concerns, although they may facilitate collusion or other strategic behaviour (Dimitri et al., 2006b).
- **Auction format:** Dynamic auctions may facilitate entry by reducing winner's curse concerns and allowing learning by bidding. The opposite may occur when potential participants are highly asymmetric, in which case dynamic formats tend to favour stronger bidders and reduce entry by weaker ones (Maskin and Riley, 2000; Athey et al., 2011).
- **Awarding limits:** Specifying a maximum number of contracts or value of subsidy that a company can receive may encourage new entry when incumbents are strong, but awarding limits must be carefully calibrated to avoid ambiguous effects on overall competition (Grimm et al., 2006).
- **Preferential mechanisms and bid discounts:** Setting aside supply for weaker or novel bidders, or giving them preferential treatment in terms of bid discounts, can encourage entry at the cost of some efficiency. As discussed in Section 5, this can also serve to level the playing field across asymmetric bidders (Athey et al., 2013; Chiappinelli and Seres, 2024).

4.2. Preventing collusion

Auction design can also help counter potential collusive behaviour. There's a large literature on this topic to which we refer the reader (e.g., Kovacic et al., 2006). Key tools include:

- **Pricing rule:** Uniform price auctions are typically more subject to strategic manipulation (demand reduction) and collusion than pay-as-bid ones (Wilson, 1979; Klemperer, 2004; Fabra, 2003).
- **Auction format:** Dynamic auctions are more susceptible to collusion. Hybrid formats such as the “Anglo-Dutch” auction, where a dynamic auction is concluded by a final sealed bid round when only two bidders remain, can balance winner’s curse concerns with collusion resistance (Klemperer, 2004).
- **Reserve price:** It limits the damage of possible collusion among bidders.
- **Limiting information circulation:** Restricting information about other bids, both during and after auctions, can reduce the scope for coordinated behaviour.

4.3. Demand-responsive supply

To address undersubscription, awarded volume can be reduced if bid volume is low or submitted bids are too high and increased otherwise, ensuring that the allocation is always competitive (Hansen, 1988; LiCalzi and Pavan, 2005; McAdams, 2007).

Volume adjustments can be done ex-ante, by estimating the number of potential participants from the project pipeline and revising auctioned quantities accordingly; or ex-post, as a pre-announced function of effectively received bids. It is important to avoid ex-post discretion not to increase uncertainty and the scope for abuse: the government may formally commit to the criteria used to adjust quantity and disclose them as part of the auction rules.

The main advantages include:

- No auction is undersubscribed, so that the static cost-effectiveness of the allocation is always ensured.
- Robustness to permitting and pipeline uncertainty: supply adjustment allows procurement to adjust to the actual state of the pipeline.
- Stronger competition: bidding aggressively not only increases the chances of winning but also increases the expected quantity won, as more quantity is awarded when bid volume is larger.
- Intertemporal efficiency: endogenous quantities create an automatic efficiency-enhancing mechanism by which auctioned quantities increase when costs are low and decrease when costs are high.

Potential disadvantages include:

- Designing and managing these adjustment schemes requires significant informational and administrative capacity, pushing the scheme toward administered allocation.
- They may increase uncertainty and bidding complexity, potentially deterring smaller or less informed participants.

Fixed budget auctions are a special case of demand-responsive supply. While the theoretical analysis of budget-constrained procurement is scarce, especially on their comparison with quantity-constrained procurement (Belloni et al., 2018; Rottner, 2025), experimental evidence suggests that the budget format can outperform the quantity target one, in the sense that it provides a greater amount of units for an equivalent budget and has a higher allocative efficiency (Coiffard et al., 2025).

Hybrid auctions that pool projects from different but substitute sectors and adjust supply across technologies as a function of bids are another incarnation of demand-responsive supply. We revisit this question in the next section.

4.4. Undersubscription as a signal of lack of effectiveness

Avoiding undersubscription by endogenously reducing subsidised quantities ensures that the specific auction remains competitive. However, if the risk of undersubscription is systematic and persistent, and is not linked to strategic behaviour, it signals the inability of the current mechanism to generate the desired level of output given market realities or other constraints. Mechanically reducing quantities to ensure competitiveness of each auction solves the static problem but does not address the underlying inability of the mechanism to attract investments, and may further reduce auctions' attractiveness and entry, potentially generating downward spirals in participation and deployed quantities. In these cases, it is advisable to rely instead on instruments that increase participation: reducing or reimbursing bid preparation costs, raising reservation prices, and providing stronger insurance against market and regulatory risks.

4.5. Examples from practice

Renewables auctions. South Africa and Germany represent good practices. In South Africa, simultaneous technology-specific sealed-bid, pay-as-bid auctions were adopted, with capacity limits and undisclosed ceiling prices for each technology; strong compliance measures — including qualification requirements, financial guarantees, and contractual penalties — created strong delivery incentives (Del Río, 2017; Bayer et al., 2018; IRENA, 2013). In Germany, frequent, relatively small staggered technology-specific auctions were implemented, with ex-ante demand adjustment: tender capacity was reduced in case of high risk of undersubscription, indicated by a limited number of newly granted permits and limited past participation.

Energy efficiency auctions. Competitive bidding has been used to grant support for energy efficiency measures in Switzerland, Portugal, and Germany (Radgen et al., 2016; Sousa et al., 2018; Neusel and Hirzel, 2025). These are mostly sealed-bid, pay-as-bid auctions where bids are ranked by cost-effectiveness (e.g., cost per MWh of energy saved). The Swiss ProKilowatt programme implements an ex-post adjustment scheme requiring bid volume to be at least 120% of the available budget. Ex-post evaluation studies concluded that most of these auctions met or exceeded expectations in terms of cost savings and electricity consumption reduction, though some evaluations highlight a persistent weakness in participation and perhaps excessive reliance on downward quantity adjustments relative to targets (SFAO, 2019).

5. Cost heterogeneity vs. project heterogeneity

Participants in auctions are likely to differ in their characteristics and/or in the characteristics of the projects they submit for funding. From an auction design perspective, it is helpful to distinguish situations in which the projects submitted for support are perfect substitutes from the tendering authority's perspective, from situations in which the tendering authority has preferences over different project attributes or cares about the resulting mix of winning projects.

5.1. Projects are perfect substitutes

An example of a situation where projects are perfect substitutes is the auctions for the right to develop an offshore wind farm, where the location and capacity to install have been predefined

as part of the auction design.⁶ Because the project is precisely defined, the main source of bidder heterogeneity in such situations stems from their differences in access to finance or execution costs, i.e., in their funding gap. Likewise, rooftop, agri and utility-scale PV panels are essentially perfect substitutes. The tendering authority does not care which projects receive support; it only cares about the price it pays for them.

Perfect substitutes are the “standard case” in auction theory. The service to be tendered is well-defined and common across bidders, but bidders differ in the cost of providing it. The main challenge in this case is to foster effective competition despite bidder cost heterogeneity. Bidders who see themselves at a disadvantage may not bother to take part. Even if they participate, they may not win due to their cost disadvantage. At the same time, their presence in the auction, especially when tendered quantities are large, may encourage low-cost competitors to submit high support requests, knowing that they will win anyway.

Such concerns likely motivated the caveats regarding the use of competitive tendering in European legislative texts and guidelines. For example, the 2022 Guidelines on State Aid for Climate, Environmental Protection and Energy opens the door, in the context of support for renewables, for “set-asides” auctions whose participation is limited to specific categories of bidders when funding costs are expected to differ significantly across bidders (§104), and allow for exemptions from the use of competitive tendering for small projects, including projects from SMEs and renewable energy communities (§107).

By pooling similar bidders together, set-aside auctions stimulate competition within each auction, reducing bidders’ informational rents and ensuring that the allocated support is as close as possible to their actual funding gap, within that auction. The challenge with set-aside auctions, however, is that tendering authorities need to pre-allocate tendered quantities (MW amount, CO2 savings, etc) to each auction. They typically do so based on their expectations of participation from the different bidder categories. If these do not materialize, this may result in ex-post inefficiencies in support allocation.

Auctions with bidding credits (for bidders with a cost disadvantage) or penalties (for bidders with a cost advantage) are an alternative to set-aside auctions. When the bidding credit or the penalty is set equal to the average cost disadvantage, it reduces asymmetries between bidders, thereby strengthening competition. Quantities allocated to each category of bidders are endogenously determined based on actual bidding, following a pre-determined function. Auctions with bidding credits do not fully restore efficiency – support will continue to be awarded to bidders with a cost (i.e. funding gap) disadvantage to avoid over-paying the low-cost bidder – but they are likely to be more efficient than set-aside auctions especially if the tendering authority has reliable information of cost differences across bidders (Atthey et al., 2013; Kröger et al., 2022; Chiappinelli and Seres, 2024).

5.2. Projects are not perfect substitutes

In practice, many situations arise in which the projects submitted by bidders are not perfect substitutes. Wind farm developments differ in locations and, therefore, in generation profiles and grid impact. Wind, solar, and biomass power have different levels of dispatchability and availability. Decarbonisation technologies have different maturity levels and potential for learning-by-doing and generate different externalities. These situations bring new challenges

⁶ Note that whether projects are substitutes or not depends on the definition of what is being auctioned. The narrower the scope, the closer substitute the submitted projects are likely to be.

above and beyond addressing bidder (cost) heterogeneity: how to compare bids for projects with different attributes and allocate funds ?

These situations are also those for which existing EU legislative texts and guidelines allow for the possibility for tendering authorities to restrict auctions to a single technology because bringing all technologies (and projects) in a single auction may lead to suboptimal results in view of “(a) the long-term potential of a particular technology, (b) the need to achieve diversification, (c) grid integration costs, (d) network constraints and grid stability, (e) for biomass, the need to avoid distortions of raw material markets.”⁷

It is clear that having different technologies compete in the same auction without further correction is not a good idea. Diallo and Kitzing (2024) quantify the technological bias introduced by such often-called “technology-neutral” auctions when different technologies generate different external costs and benefits.⁸

This does not mean we necessarily need to resort to technology-specific auctions. We can address these challenges within a single auction design. The exact form this auction takes depends on whether the tendering authority cares about the resulting mix of awarded projects or whether it is indifferent once bids are converted on a like-for-like basis.

When the tendering authority is indifferent about the mix, it can use a scoring (multi-criteria) auction. Scoring auctions are standard auctions except for the fact that bids and project attributes are first converted into a score (using a pre-announced rule) that represents the tendering authority’s preferences over these attributes. Scoring rules can correct for differences in externalities across competing technologies in the auction, including those arising from learning curves, integration and network costs, and so on. Examples of scoring auctions in the context of support for investment in renewables and decarbonisation include the German multi-technology auctions and 2025 Italian FER X solar PV, where bid prices are adjusted depending on the location of installations (Anatolitis et al., 2025, European Commission, 2025). Scores are then used to select the tender winners.

Scoring auctions have two major advantages over price-only auctions. First, they re-establish a level playing field across technologies and projects, which are now compared on a like-for-like basis, thereby fostering fair competition and, in turn, efficiency. A second major advantage of scoring auctions is that they provide bidders with an incentive to deliver attributes that the tendering authority cares about. As a result, scoring auctions dominate price-only auctions with minimum standards (Asker and Cantillon, 2008).⁹

Tendering authorities can leverage scoring auctions one step further. For exactly the same reason why they may want to give “weak bidders” a bidding credit to foster competition, tendering authorities may wish to tweak the scoring rule to reduce bidder heterogeneity in scoring.

⁷ Directive 2018/2001 on the promotion and use of energy from renewable sources, art. 4.5. The 2022 state aid guidelines are also more explicit than the 2014 version regarding the possibility for Member States to use technology-specific auctions.

⁸ Melliger (2023) provides evidence that many multi-technology auctions held in EU Member States between 2011 and 2020 ended up favouring one technology, but the favoured technology varies across auctions and countries, raising doubt about the presence of a systematic bias.

⁹ This property is especially relevant in the context of the introduction of non-price criteria in auctions as part of the 2024 Net Zero Industry Act. For some attributes, the Act allows the choice to use them as pre-qualification or award criteria. The theory is clear. As soon as suppliers have some agency over these attributes, it is better to include them as award criteria in the scoring rule.

Deviating from a scoring rule that represents their preferences over project attributes hurts efficiency, but can bring costs further down (Che, 1993). The efficiency – cost effectiveness trade-off again.

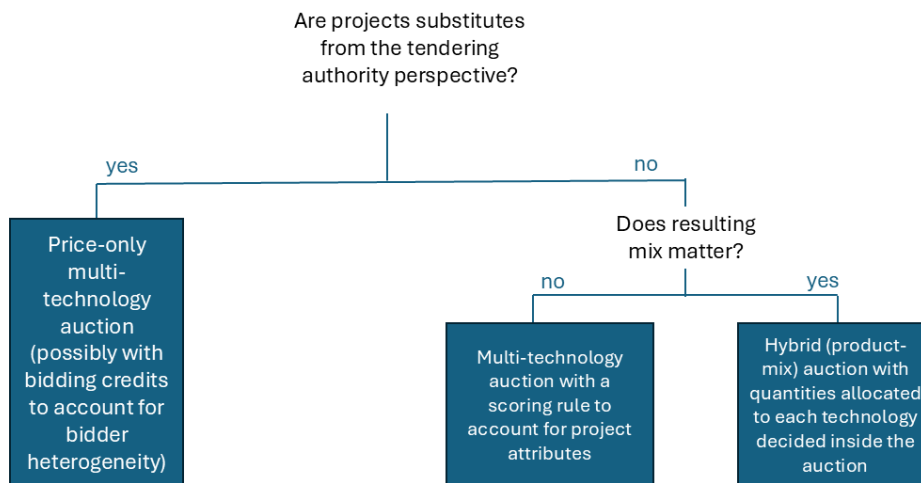
When, instead, the tendering authority cares about the mix of selected projects, scoring auctions do not work, as they do not provide any control over the winning mix of projects. Instead, hybrid auction formats that combine elements of single-technology, multi-technology auctions and scoring auctions offer a solution. In such auctions, the budget or tendered capacity allocated to each technology is set endogenously as a pre-defined function of submitted bids and the tendering authority's preferences over the resulting mix. If bids for one technology are especially competitive, more budget/capacity will be allocated to that technology. The trade-off depends on the resulting mix. If a lot of capacity is already allocated to one technology and the tendering authority has a preference for diversity, then the costs need to fall further to allocate the next unit of capacity to that technology. The exact way in which budget or capacity is allocated across technologies follows a pre-announced rule that captures the tendering authority's trade-off between costs and diversity (see Cantillon, 2014, for a discussion of the EDF virtual power plant auctions and the UK auctions for non-fossil fuel support).

Klemperer (2010) provides a first formal analysis of such hybrid auction formats, which he calls a product-mix auction. Fabra and Montero (2023) show that the product-mix auction is the optimal mechanism in a setting where a tendering authority auctions off support for investment in renewables, potential suppliers offer projects in one of two technologies that are not perfect substitutes. Their analysis also confirms that such hybrid auction format is more efficient and cost-effective than either technology-specific auctions or multi-technology auctions, without a correction for technology in the winner determination criteria.

While the exact product-mix auction format has not been used to auction support for renewables and industrial decarbonisation, the 2021 Spanish multi-technology auction with minimum quotas for each technology comes close: when costs across technologies diverge significantly, minimum quotas ensure that low-cost technology suppliers compete among themselves for the remainder, driving procurement costs down. Quotas also ensure a minimum level of technological diversity. Instead, when costs are similar across technologies, the auction behaves very much as a technology-neutral auction. Quantities allocated to each technology are determined by both prices and the tendering authority's preference for minimum quantities in that technology.

Figure 1 summarizes the discussion so far with an indicative decision tree for tendering authorities interested in exploring alternatives to technology-specific auctions in the presence of bidder and project heterogeneity. In all cases, these alternatives bring the technologies to compete with one another, but with some adjustments to ensure effective competition, accounting for differences in bidder cost heterogeneity, project differences, and the tendering authority's preferences over project attributes. We have argued that these alternatives can promote efficient technology choices and reduce procurement costs.

Figure 1: Multi-technology auctions are flexible



Still, these auction formats are also more complex for tendering authorities to set up and manage. Whether the benefits justify the effort depends on the context. For example, we have argued that multi-technology auctions with bidding credits are superior to holding two separate single-technology auctions because there is uncertainty about the ideal allocation of quantities across technologies. When, instead, the tendering authority has extensive information about the existing pipeline of projects but limited information about cost differences across technologies, separate single-technology auctions may perform very well, and there is no need for more complex formats. Similarly, in the context of industrial decarbonisation, we may expect tendering authorities to be better informed about the likely pipeline of projects (since these will typically come from incumbents) than their costs, making sector or even technology-specific auctions more attractive than multi-sector schemes with corrections for cost and externality differences.

6. Uncertainty and contract design

Investments in renewable electricity generation and industrial decarbonisation are intrinsically risky. Future improvements in battery technology and their timing are uncertain. Future carbon prices are uncertain (see Drupp et al, 2024).

From an investment perspective, it is useful to distinguish between persistent and idiosyncratic risk. Persistent risk refers to situations in which shocks and structural changes are long-lived, and the long-term value of the variables of interest is uncertain. The examples of the battery technology and carbon prices above fit this category. Idiosyncratic risk, instead, refers to situations in which there may be short-term deviations around the mean or trend in the variables of interest, but their long-term value is known with high accuracy. For example, wind production is not perfectly known ex-ante, but we can predict a wind turbine's output based on its location and technology. So wind production is subject to idiosyncratic risk. The value of wind generation, on the other hand, is at least partly subject to persistent risk: future electricity prices depend on the speed of the energy transition and are therefore highly uncertain.

It is persistent risk, not idiosyncratic risk, that increases the investment hurdle. It does so through two channels. First, uncertainty introduces a time dimension to irreversible investment decisions, such as those involving long-lived capital expenditures. It's no longer *how much* to invest or *in what* to invest that matters, but also *when* to invest. The possibility of a bad shock in

the future – a policy reversal, a wrong technological choice, low prices – makes waiting valuable. As a result, uncertainty delays irreversible investment (Dixit and Pindyck, 1994).

The second channel through which uncertainty increases the investment hurdle is through the cost of capital. Equity investors require a risk premium when returns are uncertain. Banks charge higher interest rates on risky loans. High costs of capital are especially problematic for investment in renewables and industrial decarbonisation given their high capital intensity.

Governments can alleviate these problems in two ways. First, by reducing the amount of uncertainty firms face when considering an investment in renewable energy generation or decarbonisation. This includes measures beyond state aid, such as (1) technological phase-ins, phase-outs, and technological standards that reduce technological uncertainty and help coordinate the transformation of sectors and supply chains, and (2) policy stability.¹⁰ Second, by hedging firms from some of the uncertainty and compensating for the excess investment hurdle created by this uncertainty, i.e., by providing state aid. We focus on this second lever in the following but note that reducing uncertainty in the first place can be more effective and efficient.¹¹

6.1. The risk-sharing and moral hazard trade-off in contract design

A central lesson from contract theory is that there is some benefit to the principal (in our current context, the tendering authority) from hedging contractors against risk. Reducing risk decreases investors' cost of capital and thus total levelized project costs. In turn, this reduces the funding gap. Đukan and Kitzing (2023) estimate that project de-risking through longer support periods, revenue stabilization measures, and less stringent penalties and delays can reduce support for renewable electricity generation by 1.9 to 3.3 EUR/MWh (see also Đukan et al., 2025).

Full risk insurance is typically not desirable, however. As soon as investing firms have some influence on the proper execution or performance of the investment, as will typically be the case, it is desirable to ensure they internalize the consequences of their action. A robust insight from contract theory, therefore, is the classic risk-sharing – moral hazard arbitrage: investors should bear risk to the extent they have control over it. In the context of investment in renewable electricity production, this means leaving most of the production risk to investors but protecting them from large movements in electricity prices over which they have little control. It also means making payments contingent on project execution to improve realisation rates and avoid default. These considerations mean that the design of the contract tendered is at least as important as the auction rules in the tendering process.

6.2. Contractual arrangements for different dimensions of risk

Different contractual arrangements address different dimensions of risk. They also involve different trade-offs.

Investment risk (CAPEX overruns, construction delays). Front-loaded instruments, such as investment grants combined with conditional payments and partial coverage of cost overruns, reduce upfront financing stress while mitigating moral hazard.

Input or output market price risk. In principle, derivatives are the standard tool for firms to hedge against price risk. Unfortunately, these markets rarely exist for maturities beyond a few

¹⁰ In a sample of all publicly listed companies in the US between 1990 and 2019, Basaglia et al. (2025) show that climate policy uncertainty reduces capital expenditure, employment, R&D and clean patenting activity in carbon-intensive sectors.

¹¹ This is related to the appropriateness criterion for state aid.

years. They cannot, therefore, provide hedging for investments in renewable electricity generation or industrial decarbonization whose lifetimes are much longer. Instead, governments in Europe have often adopted pay-as-produced instruments, such as feed-in tariffs or contract-for-difference (CfD) schemes, to promote investment in renewable electricity generation.^{12,13} The reason for this choice seems to follow logically from the risk-sharing – moral hazard arbitrage principle discussed above: investors have some control over their production, through careful project design and siting, but little control over prices (absent market power). Pay-as-produced contracts protect investors from price risk while leaving them exposed to production risk.

The problem is that such contracts often introduce another source of moral hazard, namely, distortion in production incentives. Specifically, pay-as-produced support reduces incentives to curtail wind or solar power production even when it is efficient to do so, i.e., when prices are negative.¹⁴ In the case of sliding feed-in-premiums, where the financial settlement uses a reference price that differs from the spot price and is instead an average of the spot price over a given period, Kremer et al. (2025) show that electricity producers can be led to curtail production inefficiently. This can happen during episodes of high prices, as was the case during the 2022 energy crisis. Schlecht et al. (2024) provide a systematic overview of the shortfalls of pay-as-produced schemes and their fixes. They also propose a new solution, financial CfDs, designed to reduce revenue risk while avoiding these market distortions (see also Newbery, 2023 for an alternative, and Kitzing et al., 2024, for an overview of options). The general message when it comes to price risk is to revert to contracts that are more closely aligned with standard fixed-price, fixed-quantity derivative contracts that decouple support from actual generation.¹⁵

Production risk. Wind and solar production is intermittent. Green hydrogen production depends on the availability of renewable electricity generation and is therefore also intermittent. Notably, this production risk is predominantly idiosyncratic, not persistent, so it is small, once production is aggregated over the scale of a year or the investment's lifetime.¹⁶ Production risk may be more material for new, untested technologies. Payments based on expected generation provide insurance for production (and price) risk but remove incentives for firms to optimize design and operation for production. They also raise the question of how expected generation is determined, as firms are likely to be tempted to over-report expected production if they are not held accountable for realized production. McAfee and McMillan (1986) show that such contracts are never optimal.¹⁷ Instead, firms should be rewarded or penalized for ex-post deviations between

¹² The main difference between pay-as-produced instruments and standard derivatives is that derivative contracts specify the volume whose price is protected, independent of actual production.

¹³ Article 19d of the Electricity Market Regulation requires that direct price support for investment in renewables and nuclear power takes the form of two-way CfDs, starting in 2027.

¹⁴ Van Steenberghe and Ovaere (2025) quantify the market impact of these distorted incentives on the UK day-ahead and balancing market.

¹⁵ European Commission (2025) provides guidance for Member States on the design of smart two-way CfDs. On top of the production distortion, the guidance also considers the risk that CfDs reduce beneficiaries' incentives to participate in forward electricity markets, thereby reducing the liquidity and efficiency of these markets. Re-establishing incentives for participation in the forward markets means exposing beneficiaries to some price risk. There is a tension here between two goals: encouraging investment by reducing risk and supporting liquid forward markets.

¹⁶ The increased levels of curtailment of renewables change this assessment somewhat by re-introducing persistent quantity risk (see Egli, 2020).

¹⁷ McAfee and McMillan's original article focuses on the case in which bidders have private information about the expected cost of a project and can reduce it by exerting effort. We have adapted their results to the case where bidders have private information about the expected production of a project.

realized production and announced expected production. Schlecht et al. (2024) argue that, when variable costs are negligible, as in wind and solar power, hedging revenue risk, rather than price or quantity risk, is preferable.

Duration of support. The duration over which aid is paid is another relevant dimension of contracting as far as risk sharing is concerned. In the context of highway franchising, Engel et al. (1997) argue that adjusting the franchise length to realized demand reduces unnecessary risk for investors who have little control over demand and thereby reduces costs. In the context of production support for renewables or other decarbonisation investments with production risk, this is equivalent to adjusting the duration over which aid is granted as a function of realized production.

6.3. Option theory and downside risk

Option theory provides a complementary perspective. A central insight from option theory is that it is the possibility of a negative shock that makes the option to delay investment valuable. Governments can speed up investment by reducing this downside risk.

For investment in renewables, the primary source of downside risk is the possibility that electricity prices are too low to cover the investment costs and provide a reasonable financial return. Mechanisms that protect investors from too low electricity prices therefore reduce this downside risk. Two-sided CfDs obviously do this, but lighter insurance schemes that only protect investors from negative tail risk, such as one-sided CfDs with a very low strike price, could already be effective at removing the option value of delay.

For industrial decarbonisation, the picture is more complex for two reasons. First, decarbonisation technologies mostly differ from the status quo technologies in their inputs (less so in their outputs, since the idea is to produce the same thing with a lower carbon footprint). So, it is price developments in their input markets that is the main source of risk. Second, what drives investment in decarbonisation is not only the profitability of the decarbonisation investment but also how it compares with the status quo technology (opportunity cost) at the end of the current investment cycle. A key driver for this comparison is the carbon price. The higher the carbon price, the less attractive the status quo technology and thus the more attractive (in relative terms) the decarbonisation option. Likewise, the higher fossil fuel prices, the less attractive the status quo technology. Protecting investors against too-low carbon and fossil fuel prices, therefore, reduces downside risk. Several Member States have recently introduced support mechanisms for industrial decarbonisation that do precisely this. In Germany, the Climate Protection Contracts scheme (Klimaschutzverträge), offers 15-year two-way carbon CfDs to support decarbonisation efforts in energy-intensive industries. The carbon CfDs seek to compensate investors for the differential costs between green and brown investments.¹⁸ The SDE++ (Stimulerend Duurzame Energieproductie) scheme in the Netherlands provides one-sided CfDs, which protect investors from downside risk in carbon and energy prices but leave them with the upside in the event of high carbon or energy prices.

The general message is clear: reducing downside risk, accounting for opportunity costs, decreases the option value of waiting and therefore speeds up decarbonisation. Option theory further offers a framework for evaluating alternative measures to support investment. Murto et al. (2025) develop a model in which investors must decide whether to invest in renewable electricity

¹⁸ See <https://www.klimaschutzvertraege.info/en/home> and European Commission (2024).

capacity and compete downstream with thermal producers subject to a carbon price. The only source of uncertainty is the future price of carbon. They show that both carbon price floors and electricity price guarantees (FiT/CfD) speed up investment by reducing downside risk for investors, but that FiTs and CfDs yield lower market prices and higher consumer surplus. Intuitively, FiTs and CfDs do not affect electricity wholesale prices as much as carbon prices, in markets where thermal generation sets the market price. They quantitatively compare investment subsidies, electricity price floors and collars, a carbon tax, and carbon price floors in a model calibrated to the Nordic electricity market. By reducing investment costs, investment subsidies mechanically decrease the hurdle rate for investment but do not protect investors from downside risk. Electricity price floors and collars reduce downside risk for investors and keep prices low for consumers. A fixed carbon tax increases the competitiveness of renewables and removes all uncertainty. Carbon price floors instead only reduce the downside risk from low carbon prices. Both are effective at driving investment but lead to higher electricity prices and lower consumer surplus than other options in their scenarios.

We can speculate about the way these results extend to industrial decarbonisation. The main difference here is that the policy tool may affect the risk profiles of both the decarbonisation investment and the brown (status-quo technology) investment. For example, a fixed carbon price removes carbon risk for *both* brown and decarbonisation investments, whereas a carbon floor reduces downside risk for decarbonisation investments but not brown investments. A carbon floor is therefore likely to be more effective at driving investment in industrial decarbonisation.

6.4. Revisiting bidder heterogeneity in the presence of risk-sharing

The previous section focuses on optimal contract design to balance risk reduction for investors while preserving incentives for delivery and downstream market integration. When these contracts are awarded through competitive tendering, McAfee and McMillan (1986) show that there is an additional reason to reduce the amount of risk borne by bidders when the source of risk is correlated with bidder heterogeneity (in the context of auctions for renewables, one interpretation is that expected generation is negatively correlated with the funding gap): reducing risk exposure reduces bidder heterogeneity in the value for the contract, increasing competition. Fabra and Llobet (2025) report a similar finding: it is valuable for tendering authorities to auction contracts that include a fixed-capacity payment, in addition to a pay-as-produced reward.¹⁹ Adding the fixed-capacity payment reduces the pay-as-produced payment, thereby reducing risk and bidder heterogeneity. Reducing risk reduces the funding gap. The reduction in bidder heterogeneity increases competition, bringing the award amount closer to those funding gaps.

Another consideration when bidders' cost structure differs is that bidders will typically not be indifferent between contracts (Cantillon, 2014; Schlecht et al., 2024). Because high-fixed-cost, low-variable-cost technologies are more sensitive to production risks, bidders with these technologies will typically prefer fixed-capacity payments to pay-as-produced payments. Conversely, pay-as-produced payments are likely to be preferred by high-variable cost technologies. When these technologies compete in the same auction, contract design is therefore no longer technology-neutral. A solution to ensure a level-playing field is to allow bidders to select the type of contracts they prefer as part of the auction mechanism and rank

¹⁹ Their setting does not have negative prices so the kind of distortions generated by pay-as-produced contracts discussed above do not apply.

offers using a scoring rule that accounts for the expected payments that result from these contract choices.

These results show that auction and contract design are interrelated. Contract design can serve to increase the competitiveness of the auction stage by reducing bidder heterogeneity and ensuring a level playing field.

7. Efficient tendering in the presence of multi-source funding

When funding for a set of projects is available from different sources — for example, EU funds and national funds from Member States — funding allocation from one source may affect funding allocation from other sources. This is an increasingly relevant situation as EU-level instruments such as the Innovation Fund and the European Hydrogen Bank interact with national support schemes. The design of a competitive bidding process with multi-source funding touches on complex issues in the literature on competing auctions, multiple-lot auctions, and sequential auctions.

7.1 Potential problems with multi-source funding

When funds available from different sources for a common set of projects are allocated through separate, uncoordinated auctions, these auctions are necessarily sequential and compete for the same pool of bidders. The literature on sequential and competing auctions provides clear takeaways.

Sequential auctions have many drawbacks relative to simultaneous ones. Among other things, they induce bidders to strategically delay bids, generate participation and price declines between early and late auctions, lead to less efficient outcomes, and are more exposed to collusion. When independent auctions compete for the same pool of bidders, competition tends to be fragmented across mechanisms: this fragmentation intensifies when bidding is costly, reduces competitive pressure, and may undermine both price discovery and cost-effectiveness. Order-dependent outcomes, like declining participation and prices in later auctions (the market thinning effect), may generate “races to auction first” among competing auctioneers trying to minimise the chance of undersubscription in their respective auctions. Therefore, apart from special cases, competing auctions are generally dominated by a single integrated mechanism.

7.2. Scenarios

How should auctions for funds from different sources be organised? We consider four scenarios.

7.2.1. Full centralisation

Abstracting from political considerations, the most efficient approach is to pool all funds and run a single auction. Full centralisation, with EU and Member State funds pooled and allocated in a single auction where projects from all EU Member States compete on equal ground, would remove the inefficiencies of sequential and competing auctions and also eliminate any remaining concern that state aid from one or a few Member States might distort competition in the common market.

Unfortunately, political considerations about Member States' willingness to contribute additional subsidies make this ideal solution unlikely to be feasible. EU auctions are open to firms and projects from all Member States, but Member State aid auctions are typically only open to projects on their territory. Pooling EU and Member State funds in a single auction open to all EU

projects would likely undermine the incentives for Member States to tap their own budget. If Member States aid is important, full centralisation remains an ideal benchmark against which alternatives can be assessed.

7.2.2. Full decentralisation

In a fully decentralised scenario, Member States and the EU run separate, independent auctions that will necessarily be sequential. All potential negative effects of sequential competing auctions — including reduced competition from demand fragmentation, strategic bid distortion, declines in participation and prices, and races to auction first — will be relevant. Competition and selection will be further limited by participation restrictions in the Member State auction. The only positive aspect of this scenario is that it preserves Member States' incentives to contribute additional funds.

7.2.3. Decentralisation with coordinated timing and award rules

In this scenario, separate Member State and EU auctions are run simultaneously, removing incentives for strategic bid distortions and order effects linked to sequential auctions. With low auction-specific bidding costs, Member State bidders will participate in both auctions, and market fragmentation effects will be greatly reduced. Since the set of bidders is different in the EU and Member State auctions and bidders are capacity-constrained, a somewhat more complex awarding rule is necessary: projects winning in both auctions should receive the subsidy from the auction where removing their bid generates less inefficiency (i.e., where the best losing bid is closer; Dimitri et al., 2006b). If bidding costs are significant, simultaneity will not solve market fragmentation, and competition and cost-effectiveness will remain lower than in the centralised case.

7.2.4. Hybrid format/partial centralisation

In this scenario, centralisation is partial: there is only one auction simultaneously awarding EU and Member State funds, participants submit only one bid, but Member State funds are only available to bidders from the same Member State. In other words, Member State funds are set aside in a separate “bucket” reserved to projects from that Member State only.

This is the approach adopted by the **Auction-as-a-Service scheme** for the European Hydrogen Bank tenders under the Innovation Fund. These auctions provide funding to cover the cost gap between green and fossil-based hydrogen. On a voluntary basis, Member States may choose to allocate a pre-defined amount of national funding for hydrogen production projects on their territory. The EU runs a single auction: the most competitive projects, independent of Member State, are awarded EU budget until it is exhausted. Projects next in the ranking are then financed by the respective national budget(s), if present, and not financed otherwise (European Commission, 2024a).

This hybrid format is an excellent compromise. Only one bid per project needs to be submitted, so most of the issues discussed above and those linked to auction-specific bidding costs vanish. On the other hand, Member States' incentives to contribute are preserved because their funds will only be awarded to projects from that Member State.

A remaining question is the **priority order** in awarding EU vs. Member State funds. Under the current format, EU funds are awarded first. Stronger Member State bidders may then win EU funds and exit the ranking, leaving weaker Member State projects to win Member State funds with little competition remaining (since projects from other Member States are not eligible). If, instead,

Member State funds were awarded first, they would be allocated to the strongest projects from that Member State, and the weakest Member State projects would only be funded if they win in the EU auction. This alternative sequence could improve the overall selection of projects receiving support and increase Member States' incentives to contribute, since Member State funds would more likely be exhausted.

8. Concluding comments

When it comes to auction design, it has become cliché to write that “no one size fits all”. While this is true, some issues are first-order and others are second-order. At the heart of competitive tendering for renewables and industrial decarbonisation lies a key trade-off between efficiency, cost-effectiveness, and effectiveness. Efficiency seeks to allocate projects to investors that maximise social value. Cost-effectiveness is about ensuring that aid is kept to the minimum necessary to carry out the project. Effectiveness is about actually delivering the quantity of investment targeted. There is a tension among all three because investors' costs are private information, competition is fragile, and the objects auctioned are complex long-term projects.

For competitive tendering to deliver its advantages over administrative schemes, competition must be genuine. This requires actively attracting participants, designing auction rules to prevent strategic behaviour, and managing the risk of undersubscription. Systematic undersubscription is not just a problem for individual auctions; it signals a deeper failure to attract the investments needed and should trigger a reassessment of participation incentives rather than a mechanical reduction in auctioned quantities.

Because investments in renewables and industrial decarbonisation deliver their benefits over a long period of time, what is auctioned is not a one-shot transaction but a contract contingent on output or performance. Contract design plays several roles: it can help reduce risks for investors and therefore reduce their funding gap; it needs to incentivise investors to deliver on their promises; and it must avoid distorting downstream markets through perverse production incentives. While pay-as-produced CfDs have proved effective at reducing investment risk in the context of renewable electricity generation, they have created market distortions. This is a very active area of research, and no single solution has emerged, but contract theory, option theory and auction theory offer a coherent framework for thinking through the options.

As EU-level and national funding increasingly co-exist, designing coordinated mechanisms that avoid the inefficiencies of sequential and competing auctions, while preserving Member States' incentives to contribute additional resources, is an emerging and important challenge. The Auction-as-a-Service model of the European Hydrogen Bank represents a promising approach, though further refinements — including on the priority order for allocating EU vs. Member State funds — are worth exploring.

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