Informing decision makers about innovation policy options and their evolution

The Energy Innovation Policy Explorer allows users to view the energy innovation policies that are featured each year in The State of Energy Innovation in one place, and to filter the information by country and category. It provides an easy-to-navigate means of understanding which governments use different policy types, the ways in which each policy is tailored to the needs of energy innovators, and where to find more information. Each policy included in the Explorer can also be found in the IEA's wider policy database, which is less tailored to energy innovation policy makers' needs.

Nurturing new technologies to maturity can create local economic prosperity, and the technological transformation of energy systems is set to be a major market opportunity for all economies during the 21st century. Countries around the world are striving to become home to the next breakthrough energy technology company or to host world-class energy supply chains, with good reason. Without enhanced energy innovation, several short and long-term policy goals – from energy security to competitiveness and mitigating climate change – will be out of reach.

As governments expand the variety of innovation policy measures and tune their design to the specificities and maturities of the technologies, an up-to-date repository of policy creativity is especially valuable. Energy technology innovation – especially that which is related to hardware rather than software – has characteristics unlike those of other technology areas, including relatively long development timelines, large upfront investments and regulatory barriers to entry. The range of policies in place or in development now includes not just R&D grants, but also tax incentives, inducement prizes, business equity, loans, laboratory vouchers, loan guarantees, equity and incubation services, knowledge networks, regulation of large companies, cross-border co-operation and access to laboratories. A significant number of these tools have been widely applied to energy innovation only in the past decade or two.

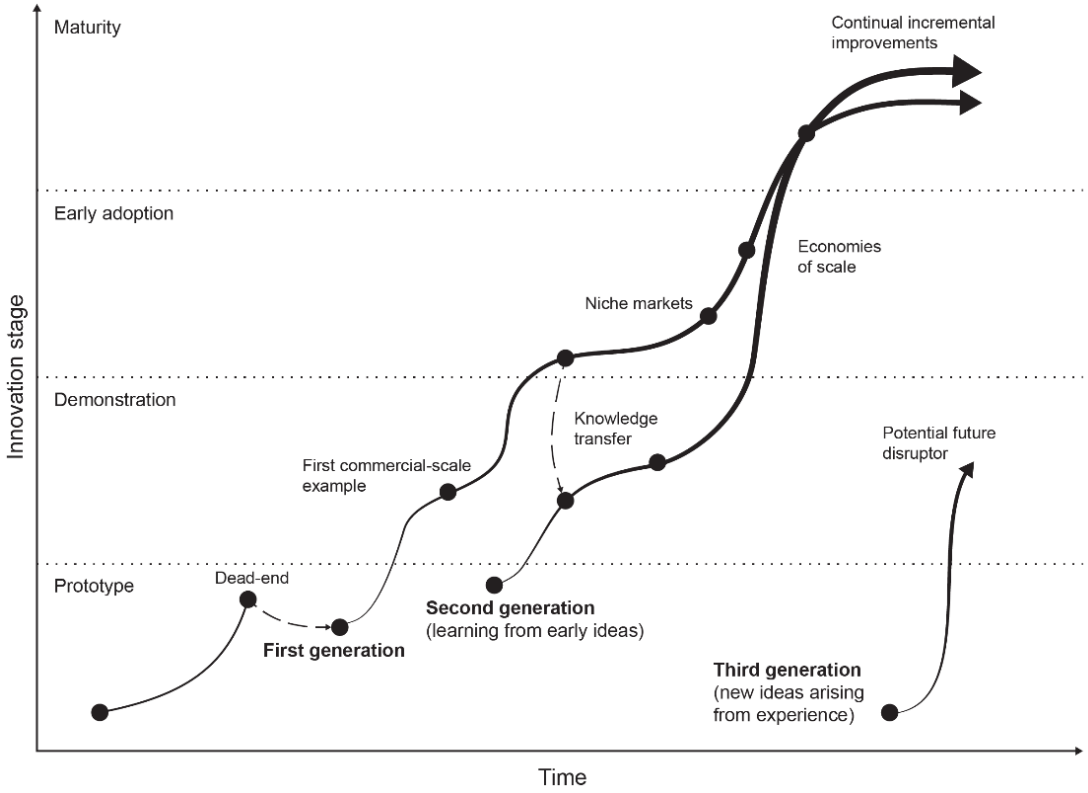
This Policy Explorer helps governments to take inspiration and lessons from their peers around the world, providing a sound basis for trying new approaches and learning more rapidly from experience. In some cases, it is still too early to judge how best to design policy tools or the scale of their impact, which highlights the importance of evaluating impacts and widely sharing the findings.

Energy technology innovation is an evolutionary process involving a range of stakeholders and stages

Innovation policy must embrace the full breadth of innovation activities as ideas progress to higher levels of technology readiness and spark new ideas for improvements or totally

separate products along the way. The innovation journey is characterised by discontinuous learning processes, and no technology passes all the way from idea to market without being modified. The innovation trajectory for each technology – which could be a fully-fledged system, a single component of a larger system or a modification to an existing product – is influenced by feedback loops and spillovers at different stages of maturity and often involves setbacks and redesign.

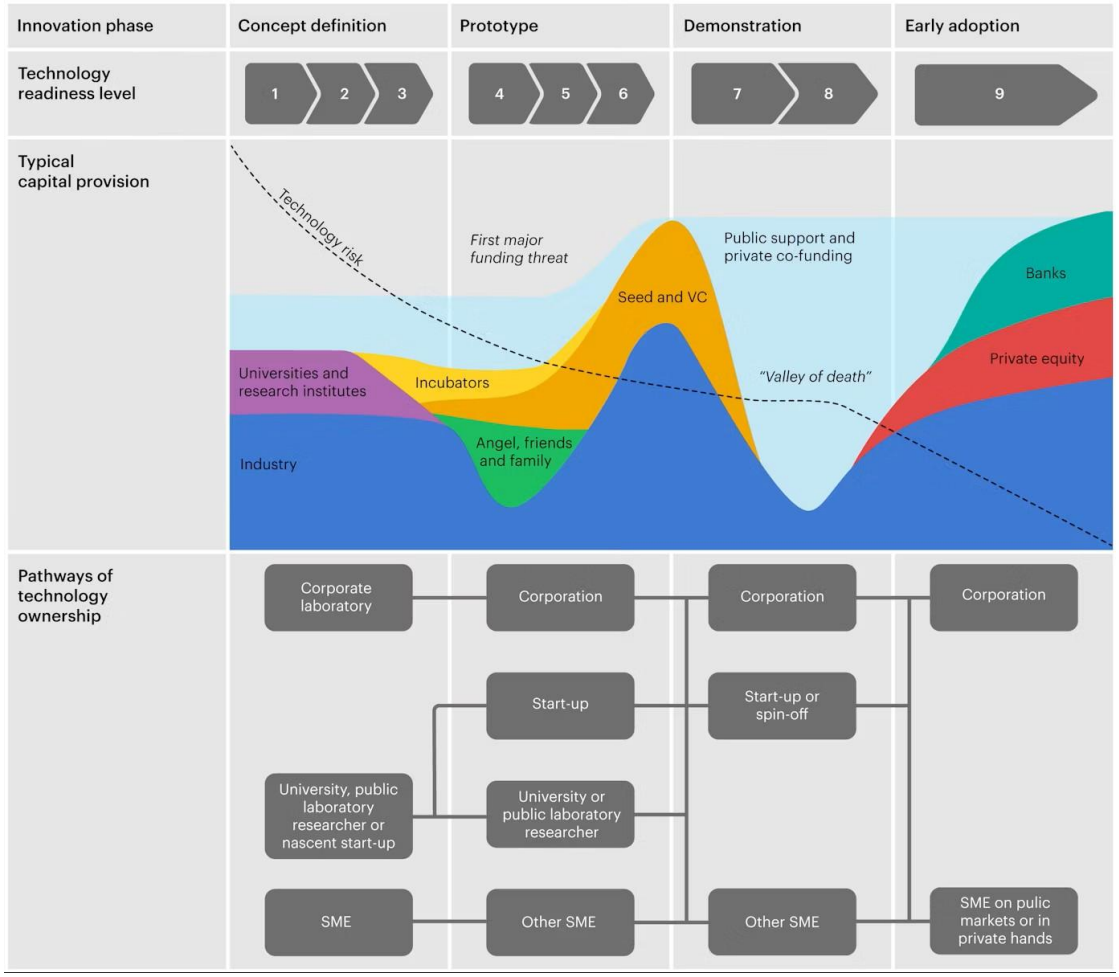
Four stages of technology innovation and the feedbacks and spillovers that improve successive generations of designs



Source: IEA (2020), Clean Energy Innovation.

Technology risk is highest in the earlier stages of a new product or process' development. It is higher for entirely new types of technology, and lowest for incremental modifications to commercial products. This is not the stage at which most capital is required, however. Absolute capital requirements are highest from the demonstration stage onwards, as the sizes of projects approach first-of-a-kind commercial scale. As technology risk is still considerable at the demonstration stage, and market demand is often underdeveloped, these projects involve the highest combination of capital and risk. As a result, failure rates at this stage are high – sometimes for non-technological reasons – earning it the nickname the "valley of death". Governments typically play a critical role in helping innovators to scale up from successful pilot projects to first-of-a-kind commercial projects with the greatest chance of successfully testing and proving their technology.

Representative capital provision, public funding gaps and ownership pathways for new clean energy technologies



Innovation phase	Concept definition	Prototype	Demonstration	Early adoption
Definition	Application of a new scientific advance or a new combination of existing knowledge to tackle an energy challenge.	Concept is developed into a design and then a prototype for a new device, a new configuration of existing devices or a new component to improve a product on the market.	The first examples of the new technology are introduced onto a given market at the size of a single full scale commercial unit. The purpose is to show that the technology is effective and to reduce the perception of risk for financiers.	The technology is bought or used by customers who want to try it out or need it for a particular purpose. In many cases revenue from early niche markets still doesn't cover costs.
Start-up needs	• Capital to survive without income • Capital to pay for experimentation • Access to laboratory facilities • Scientific advice • Business mentoring • Business services (e.g. legal) • Peer to peer networking	• Capital to survive without income • Capital to pay for technology testing and building prototypes and pilots • Capital to grow the team • Access to test rigs • Access to office space • Scientific advice • Business mentoring • Business services (e.g. pro-curement and pitch training) • Networking with potential customers, recruits	• Capital to survive with insufficient income to grow • Capital to grow the team • Capital to pay for building pilots and demonstrations • Access to test rigs • Access to demonstration sites in commercial environments • Business services (e.g. contractual and negotiation) • Networking with potential customers and investors • Exposure to international markets	• Capital to survive with insufficient income to grow • Capital to retain talent in a competitive market • Capital to invest in equipment, marketing and manufacturing • Business services (e.g. contractual and negotiation) • Working with regulators on compliance and barriers • Networking with investors and potential acquirers • Access to international markets

Source: IEA (2022), How Governments Support Clean Energy Start-ups.

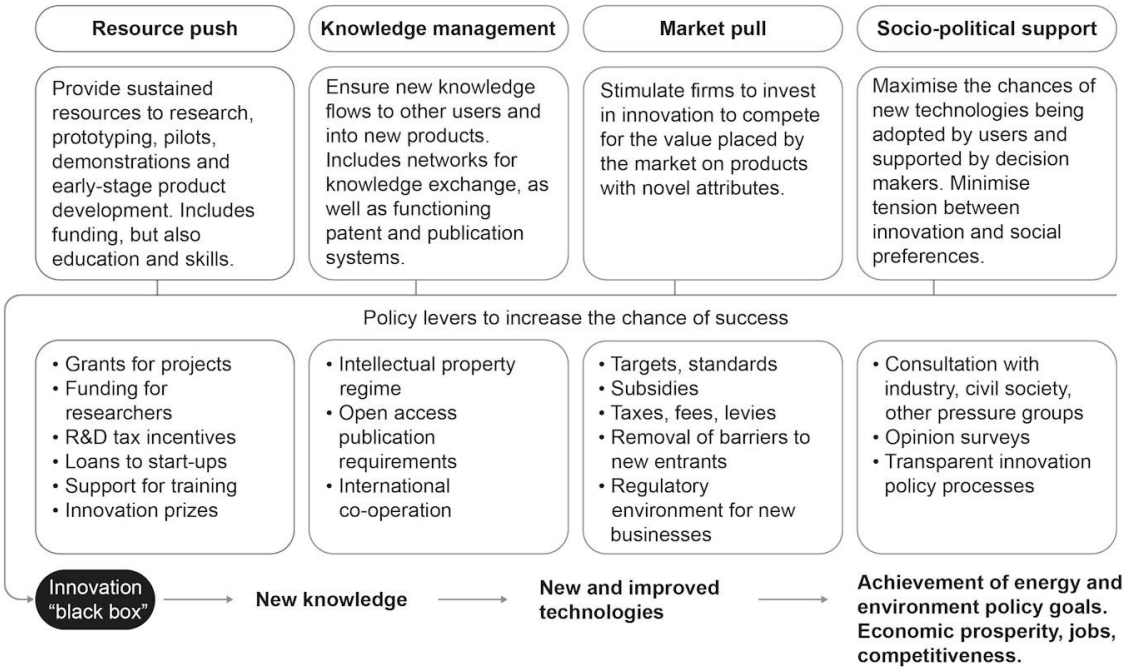
The most successful innovating regions have well-integrated ecosystems of researchers, entrepreneurs, government institutions and potential technology users. Typically, they have targeted government support for each phase of the innovation journey that involves links between stakeholders and phases.

Four overarching innovation policy pillars

Each time a government takes an action in pursuit of a policy objective, it can choose from a wide range of possible instruments. The starting point for selecting a policy instrument is typically consideration of how the overall policy goal can be most efficiently achieved, such as by setting strategies or targets; regulating the behaviour of companies or individuals; transferring government funds to companies, institutions or the public; or providing information and education. These different options each contain policy design choices, such as whether to allocate government funds via grants, tax incentives or debt, and how to select the recipients. Policy packages may combine different measures towards a single objective or multiple objectives.

While most governments rely on public funding to steer innovators towards national technological priorities, international experience suggests that the countries making the largest impacts though energy technology innovation actively cultivate four different interconnected policy dimensions.

Four pillars of effective energy innovation systems



Source: IEA (2020), Clean Energy Innovation.

An innovation system will struggle to translate research into technological change without action under each of these pillars.

Resource push: a sustained flow of R&D funding, capital for innovators, a skilled workforce (e.g. researchers and engineers) and research infrastructure (laboratories, research institutes and universities) is required. These resources can come from the public or private sectors, including philanthropic sources, and can be directed to specific problems or basic research. Resource push measures represent the bulk of the entries in this policy explorer, and there are examples of novel approaches to selecting recipients and ensuring they receive the capital support they need. This includes giving grants as prizes or organising public "requests for information" to explore a technology area before choosing how to structure a call for proposals.

Knowledge management: it must be possible for knowledge to be exchanged easily between researchers, academia, companies, policy makers and international partners.

Market pull: the expected market value of the new product or service must be large enough to make the R&D risks worthwhile, and this is often a function of market rules and incentives established by legislation. If the market incentives are high, then much of the risk of developing a new idea can be borne by the private sector.

Socio-political support: there needs to be broad socio-political support for the new product or service, despite potential opposition from those whose interests might be threatened.

These four pillars are used to structure the Policy Explorer. Some of the policy examples combine multiple policy types to strengthen their impact. For example, the European Innovation Council combines an equity fund for start-ups with grants for new business scale-up and advice on access to resources, depending on the needs of recipients. Canada's Women in Cleantech Challenge combined an award to recognise innovation with a grant to an incubator, grants for R&D and new business scale-up, actions to connect innovators and potential customers, as well as access to public laboratories, facilities and technical expertise. The United States' Advanced Research Projects Agency – Energy (ARPA-E) blends grants for R&D projects with advice on access to resources, expert platforms to inform government, and grants for new business scale-up.

The data includes measures that encourage and reward domestic innovation without requiring deep pockets, which is particularly relevant to governments in emerging and developing economies, as well as smaller advanced economies. Measures include participating in projects co-funded by more than one government, prizes (including inducement prizes), facilitating access to government-led laboratory and testing facilities, establishing networks of researchers and users, knowledge-sharing, patent processing and information campaigns. These examples are intended to help interested governments to find out more about policy design for these tools, and to help bilateral and multilateral funders to identify effective opportunities to provide support.