

Standing Committee on the Law of Patents

**Thirty-Eighth Session
Geneva, November 2 to 6, 2026**

APPENDIX: CASE STUDIES RELATED TO THE STUDY ON BEST PRACTICES AND CHALLENGES IN TECHNOLOGY TRANSFER IN THE HEALTH AND GREEN TECHNOLOGY SECTORS FOCUSING ON INDUSTRY-ACADEMIA COLLABORATION, CONSIDERING NATIONAL AND INTERNATIONAL REGULATORY FRAMEWORKS

Document prepared by the Secretariat

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Appendix

Case Studies

A. Case Studies on industry-academia collaboration in the Health Sector

The following Case Studies illustrate how technology transfer in the Health Sector is shaped by the interaction of regulatory frameworks, intellectual property management, and institutional capacity. Rather than treating technology transfer as a linear process, these examples demonstrate that outcomes depend on the degree of alignment across macro-level governance structures, meso-level institutional systems, and micro-level transactional mechanisms.

Across the Case Studies, several cross-cutting themes emerge. First, **alignment is the primary driver of successful technology transfer**. Where regulatory pathways, intellectual property strategies, funding mechanisms, and institutional capabilities operate in a coordinated manner, innovation can move rapidly from research to real-world application. Conversely, where these elements are fragmented or misaligned, even highly promising technologies may face delays, inefficiencies, or barriers to commercialization.

Second, **regulatory and intellectual property systems are inherently interdependent** in the Health Sector. Patent protection alone is insufficient to ensure successful commercialization if regulatory approval pathways are uncertain or delayed. Similarly, regulatory clarity without a viable intellectual property position may fail to attract private investment. Effective technology transfer therefore requires the integration of these systems from early stages of development.

Third, **institutional capacity** plays a critical role in shaping outcomes. Universities, technology transfer offices, research institutes, and industry partners must possess the expertise and infrastructure necessary to manage intellectual property, structure collaborations, and navigate regulatory requirements. Strong institutional ecosystems are better able to translate scientific discoveries into viable products. The Case Studies also illustrate that successful K/TT may be evaluated using multiple indicators, including licensing activity, startup formation, follow-on investment, development milestones, commercialization outcomes and, where relevant, broader societal impacts.. Relevant indicators include regulatory advancement, manufacturing scale-up, clinical use, patient reach, improved access, workforce or institutional capacity building, and the creation of sustainable pathways for continued innovation.

Finally, flexibility is essential, particularly where public-health emergencies, affordability, access or local implementation needs require collaboration structures to evolve over time. Adaptive regulatory mechanisms, innovative licensing models, and collaborative partnerships can enable more responsive and equitable technology transfer outcomes.

The Case Studies below: mRNA COVID-19 vaccines, CRISPR gene editing technologies, and hand rehabilitation robotics, collectively demonstrate these dynamics and provide insight into best practices and persistent challenges in industry-academia collaboration.

Case Study 1: University–industry transfer and development of mRNA COVID-19 Vaccines (United States of America/Germany)

The rapid development of mRNA COVID-19 vaccines was enabled by a series of interconnected university, public-research and industry relationships rather than by a single technology-transfer transaction. Foundational work on messenger RNA, nucleoside modification, lipid delivery and immune response emerged over many years from universities, public research institutions and biotechnology companies. The resulting knowledge and IP were combined through licensing, sponsored research, co-development arrangements and company formation before and during the pandemic.

One important university-industry pathway involved research by Katalin Karikó and Drew Weissman at the University of Pennsylvania concerning modified nucleosides that reduce undesirable immune responses and improve the therapeutic utility of mRNA. The university protected relevant inventions and licensed rights through commercial intermediaries and biotechnology companies. These rights ultimately contributed to the technology base used by BioNTech and Moderna, although the companies also relied on their own IP, technical know-how, delivery technologies and development capabilities. The Case Study therefore illustrates that a commercially viable platform may depend on multiple complementary IP rights and knowledge contributions rather than on a single university patent.

In the Pfizer–BioNTech collaboration, BioNTech contributed its mRNA platform and vaccine-development work, while Pfizer supplied large-scale clinical-development, regulatory, manufacturing and global-distribution capabilities. The relationship was structured as a co-development and commercialization partnership rather than as a direct university license. The underlying university-originated research entered the collaboration through earlier licensing chains and accumulated know-how. This distinction is important: the university-industry K/TT occurred through the transfer and commercial development of foundational technologies, while the later Pfizer–BioNTech agreement governed the joint development and commercialization of a specific vaccine candidate.

Moderna followed a different pathway. It combined internally developed mRNA and delivery capabilities with research collaboration involving the US National Institutes of Health, including work on antigen design and vaccine development. Public funding supported foundational science, platform development, clinical research and manufacturing readiness. The respective ownership and inventorship positions became the subject of later disagreement, illustrating the importance of clearly documenting background IP, foreground IP, inventorship, data rights and publication arrangements in long-running public-private research collaborations.

Government intervention during the pandemic operated through mechanisms distinct from the underlying K/TT agreements. Operation Warp Speed and related federal actions provided development funding, advance procurement commitments, manufacturing support, supply-chain coordination and regulatory engagement. Advance purchase agreements reduced market and scale-up risk by committing governments to purchase doses if regulatory and contractual conditions were met. They did not themselves transfer university IP or technical know-how and should therefore be distinguished from licenses, research collaborations and co-development agreements.

At the macro level, established IP rules, substantial public research funding, emergency regulatory pathways and government procurement reduced scientific, regulatory and market risk. At the meso level, universities, public research institutions, biotechnology firms and pharmaceutical companies possessed specialized and complementary capabilities in invention management, platform development, clinical research, manufacturing and distribution. At the micro level, licenses, research collaborations, co-development agreements, manufacturing arrangements and procurement contracts allocated different rights and responsibilities across the development chain.

The Case Study produced exceptional development and deployment outcomes, including rapid clinical testing, regulatory authorization and global manufacturing at unprecedented scale. Its societal impact extended beyond the commercial success of individual products. The coordinated research, development, regulatory and manufacturing effort contributed to population-level disease prevention, reduced severe illness and supported the reopening of health systems, economies and public life. It also demonstrated how decades of publicly supported platform research can generate broad societal value when combined with capable industry partners, regulatory flexibility, manufacturing investment and advance procurement. It also exposed continuing challenges. These included disputes concerning inventorship and

ownership, dependence on complementary patent and know-how portfolios, manufacturing-capacity constraints, supply-chain challenges and differing views regarding access and commercialization of technologies developed through combinations of public and private investment.

The principal K/TT lesson is that rapid development resulted from alignment among several forms of collaboration rather than from patent licensing alone. Universities and public institutions supplied foundational research and protected or shared relevant knowledge; biotechnology companies integrated the technology into development platforms; pharmaceutical partners contributed clinical, regulatory, manufacturing and distribution capabilities; and governments reduced development and market risk. Clear treatment of background and foreground IP, continuing know-how transfer, partner capability and coordinated public support were therefore central to the outcome.

The Case Study therefore represents a high degree of alignment across all three levels. Macro-level funding, emergency regulation and procurement reduced development and market risk; meso-level institutions supplied complementary scientific, clinical, manufacturing and distribution capabilities; and micro-level agreements connected the relevant technologies, partners and responsibilities. The speed and scale of deployment provide a concrete illustration of how alignment across the K/TT system can convert foundational research into population-level health impact.

Case Study 2: CRISPR Gene Editing - Fragmentation and Complexity (United States of America)

CRISPR gene-editing technology illustrates how transformative academic research can generate substantial commercial activity even where ownership, freedom to operate and licensing rights remain contested. Foundational work by researchers associated with the University of California, Berkeley, the University of Vienna and the Broad Institute contributed to overlapping patent positions concerning the use of CRISPR-Cas systems. The resulting disputes were not merely questions of academic recognition; they affected how universities structured licenses, how companies assembled freedom-to-operate positions and how investors assessed development risk.

The principal academic institutions pursued different commercialization pathways. The University of California and its partners licensed CRISPR-related rights into companies including Caribou Biosciences, Intellia Therapeutics and CRISPR Therapeutics, while the Broad Institute licensed relevant rights to Editas Medicine and other parties through field-specific arrangements. These structures helped attract specialist investors and development teams, but they also created a landscape in which companies could require rights from more than one institution or portfolio depending on the application, jurisdiction and technical implementation.

The patent disputes affected development in several practical ways. Prospective licensees and investors faced higher legal-diligence costs and uncertainty regarding which rights would ultimately be required. Companies sometimes pursued parallel licensing, cross-licensing, settlement or technical design-around strategies. Field-of-use restrictions and multiple surrogate or intermediary companies added further complexity when technologies had applications across human therapeutics, diagnostics, agriculture and research tools. Litigation and patent-office proceedings also consumed institutional and company resources and complicated valuation and partnership negotiations.

At the same time, the fragmented IP environment did not prevent commercialization. Multiple venture-backed companies were formed, substantial private investment was raised, strategic partnerships were established with pharmaceutical companies, and CRISPR-based therapeutic programs advanced through clinical development. The eventual approval of a CRISPR-based

therapy demonstrated that regulatory development and product commercialization could continue despite unresolved or overlapping platform-level IP questions. In December 2023, the US Food and Drug Administration approved Casgevy for certain patients with sickle cell disease, making it the first FDA-approved therapy to use CRISPR/Cas9 genome editing. The approval converted a platform originating in academic science into a regulated therapeutic product for a serious inherited disease and provides a concrete measure of societal and translational impact. This suggests that strong science, capable development partners, substantial financing and carefully structured field-specific rights may partially mitigate, but not eliminate, the costs of fragmented ownership.

At the macro level, differences among patent systems and regulatory approaches created jurisdiction-specific uncertainty. Patent outcomes and the treatment of gene-edited products varied across markets, affecting filing, licensing and development strategies. At the meso level, universities used different licensing and company-formation models to commercialize their respective portfolios. At the micro level, agreements relied on exclusive field-of-use rights, sublicensing authority, milestone obligations, cross-licensing and portfolio aggregation to manage overlapping rights.

The outcomes were therefore mixed. Fragmentation increased transaction costs, created freedom-to-operate uncertainty and may have contributed to duplicated investment and restricted access to some foundational technologies. Yet competition among institutions and companies also supported multiple development pathways and accelerated investment across therapeutic and non-therapeutic applications. The Case Study should therefore not be understood as evidence that fragmented IP necessarily prevents innovation. Rather, it demonstrates that unclear or overlapping ownership can make commercialization more expensive and difficult, while capable actors may still advance technologies through layered licensing, negotiation, litigation, technical adaptation and strategic partnership.

The Case Study therefore illustrates partial rather than complete alignment. Scientific capability, company formation, private financing and regulatory execution were sufficiently aligned to produce an approved therapy. At the same time, fragmented ownership and freedom-to-operate uncertainty continued to increase transaction costs and complicate licensing and partnership decisions. Its significance lies in showing both what a capable ecosystem can accomplish and the additional cost of doing so where the IP landscape remains contested.

The principal K/TT lesson is that platform technologies with broad applications require early attention to ownership, inventorship, field definition, background rights and interoperability among portfolios. Universities should consider, and licensees should assess not only patent validity but also the complementary rights, know-how and development capabilities needed for a particular product.

Case Study 3: PLUTO Hand-Rehabilitation Robot in India – University-Hospital-Industry Collaboration for Accessible Care (India)

The development and commercialization of the Plug-and-Train Robot for Hand Neurorehabilitation, known as PLUTO, provides a concrete example of health K/TT addressing a locally significant healthcare need. PLUTO was jointly developed by researchers at the Indian Institute of Technology Madras and Christian Medical College, Vellore to improve access to repetitive hand-rehabilitation therapy for people affected by stroke and other neurological or musculoskeletal conditions. The collaboration combined engineering expertise, clinical practice, public and corporate funding, institutional K/TT support and an industry commercialization partner.

The technology was led by engineering and clinical researchers from IIT Madras and CMC Vellore. IIT Madras contributed capabilities in mechanical engineering, robotics, design and rehabilitation-device development, while CMC Vellore contributed bioengineering, clinical rehabilitation expertise, patient access, usability assessment and clinical validation. This combination was important because the value of the technology depended not only on technical performance, but also on whether it could be safely and effectively integrated into rehabilitation practice.

PLUTO was designed as a compact, portable and modular device. It uses interchangeable attachments to support different wrist and hand movements and incorporates therapeutic games and real-time feedback to encourage repetitive training. Its modular design was intended to reduce cost and make the system usable in hospitals, rehabilitation centers, smaller clinics and potentially home settings.

The collaboration progressed beyond prototype development. The technology was patented and licensed by IIT Madras and CMC Vellore to Thryv Rehab Solutions for commercialization. Institutional K/TT functions supported the protection and licensing of the technology, while the commercialization partner assumed responsibility for product development, manufacturing and market introduction.

The Case Study also provides evidence of implementation beyond the execution of a license. Institutional reports indicate that PLUTO has been evaluated or used in multiple clinical settings, has reached more than 1,000 patients and has been used by approximately 100 clinicians. It has also been examined in home-based rehabilitation settings. These outcomes distinguish the Case Study from a technology-transfer effort that ends at patent filing or contract execution.

At the macro level, the project benefited from public translational funding, India's growing emphasis on indigenous medical-device innovation and a healthcare environment in which affordability and access are important design considerations. At the meso level, alignment arose from the complementary capabilities of an engineering institution, a hospital and clinical research partner, institutional K/TT functions and a commercialization company. At the micro level, the collaboration connected technical development, clinical testing, patent protection, licensing, manufacturing and implementation through a sequence of coordinated relationships.

The Case Study illustrates successful alignment, but also shows that licensing is not the final measure of impact. Continued success depends on regulatory compliance, manufacturing quality, affordability, product support, clinician training, procurement and adoption across different healthcare settings. Nevertheless, PLUTO demonstrates how co-development around a clearly defined local health need can move academic research beyond publication and patent filing into clinical use and commercial deployment.

The principal K/TT lesson is that medical-device translation benefits from sustained interaction among engineers, clinicians, users, K/TT professionals, funders and commercial partners. In this Case Study, engineering and clinical capabilities were integrated from the design stage; funding supported technology maturation; institutional K/TT functions enabled protection and licensing; and an industry partner was engaged to support commercialization. The result provides a tangible example of how alignment across macro, meso and micro levels can produce accessible technology with measurable patient and healthcare-system relevance.

B. Case Studies on industry-academia collaboration in the green technology sector

The following Case Studies illustrate structurally distinct models through which green technologies have moved from research environments into industrial application and commercial deployment. Although there is a wide variety of successful examples in the licensing and adoption of green technologies across various territories including Australia, India, China,

and Brazil, the Case Studies presented here have been selected because each represents a notable departure from conventional technology transfer practice, whether in the institutional architecture employed, the IP strategy pursued, or the financing mechanisms mobilized.

Together, they span three geographic regions Latin America, Europe, and the United Kingdom and cover distinct technology domains: renewable energy and sustainable agriculture, next-generation photovoltaics, and bio-based sustainable materials. Each Case Study is examined with attention to the roles played by universities, research institutions, industry partners, and public agencies in enabling the transfer, and to the lessons each model offers for practitioners working in contexts where institutional capacity, funding access, and regulatory maturity vary significantly.

Case Study 4: Public co-financing of scale-up and validation infrastructure for clean technologies (Chile)

To attract large green tech investments, Chile has open calls to subsidize plants and industrial facilities for green hydrogen (H₂V), electromobility, batteries and electrolyzer manufacturing capabilities, hydrogen fuel cell logistics applications, among others. For instance, the first call of the Chilean Economic Development Agency (CORFO) for green hydrogen projects selected six proposals with a combined capacity of 388 MW, targeting production of over 45,000 tons of renewable hydrogen annually and CO₂ reductions exceeding 600,000 tons per year, with USD \$50 million in direct co-financing disbursed. The broader H₂V Chile financing facility stands at approximately USD \$1 billion. Additionally, CORFO also opened a tender to subsidize a new center for scale-up and industrial validation of clean technologies, where a consortium of universities and companies (called ASDIT) was awarded this initiative. The new Institute of Clean Technologies (ITL) focuses on innovation and technological development that promotes sustainable solutions for industry, especially in mining, energy and lithium, and has a USD \$240 million budget for a 10-year horizon.

As shown, Chile has used competitive public calls to co-finance industrial facilities and scale-up infrastructure for green technology, mainly in the energy sector. While infrastructure co-financing is an industrial policy instrument and not – in itself – technology transfer between academia and industry, it is an enabling capability for green technology validation and scale-up; steps that are key for potential adoption by industry. The model has some advantages in its collaborative structure: a competitively awarded consortium in which university research groups and industrial partners are parties to the same instrument, rather than counterparties in a bilateral license. Nevertheless, as a limitation, the model depends on the existence of a development agency with the mandate and the balance sheet to co-finance infrastructure over a ten-year horizon, and on a domestic industrial base capable of absorbing the results. Its replicability to countries without those conditions is not established. Also, the ITL is recent, evidence that technologies have moved from research into industrial use through it is not yet available, thus the Case Study is an institutional design worth observing rather than a demonstrated outcome.

Case Study 5: Competitive public tendering for the licensing of publicly developed agri-environmental technologies (Uruguay)

The National Institute of Agricultural Research of Uruguay (INIA) has focused on offering green and agrifood technologies (usually bio-inputs and plant varieties) via public calls. The institutional vehicle for this transfer is a competitive public tender system through which INIA issues formal calls for interested parties to enter into licensing or sublicensing agreements, enabling private seed producers and local agricultural operators to multiply, market, and commercialize INIA-developed technologies under defined contractual conditions.

During the present year, there was an open call for sublicensing of a variety of ryegrass (*Lolium multiflorum*), and its sublicense agreement template is fully available to the public (INIA, 2026), enabling prospective applicants to conduct prior legal and commercial due diligence on the contractual conditions, royalty structure, authorized use scope, quality control obligations, and territorial limitations before committing to the process.

INIA's approach constitutes a coherent institutional mechanism for the transfer of publicly developed green and agri-technologies, combining open competitive access, publication of contractual documentation in advance, protection through plant variety rights, and a defined scientific value proposition in locally adapted germplasm. Though, the mechanism has to be considered with caution. Its conditions are specific: it requires a technology suitable for standardized terms, a protected IP that supports enforcement, and a body of prospective licensees large enough to make a competitive call meaningful.

Case Study 6: Licensing agreement chain for next-generation photovoltaics - the Oxford PV perovskite case (United Kingdom)

The University of Oxford developed a perovskite photovoltaic technology for optoelectronic devices comprising organometal perovskites with mixed halide anions ($\text{CH}_3\text{NH}_3\text{PbI}_2\text{Cl}$), achieving a power conversion efficiency of 10.9% in a fully solid-state device architecture that eliminates the liquid electrolyte component required by earlier dye-sensitized cell designs. This foundational invention protected through the WO 2013/171517 international patent family, with granted patents in Europe and in the United States of America, established the leading IP framework upon which the entire commercial perovskite sector subsequently developed. A related patent family, WO 2015/092397, further comprises metal halide perovskites chemically bonded to organic passivating agents, addressing interfacial defect density reduction as a critical pathway to commercial-grade device stability.

The commercialization of this technology proceeded through two successive and structurally distinct stages of IP transfer. In the first stage, the University of Oxford, acting through its wholly owned technology transfer subsidiary Oxford University Innovation Ltd, granted an exclusive and worldwide license over its foundational perovskite patent portfolio to Oxford Photovoltaics Ltd (Oxford PV) - a spin-off company co-founded in 2010 by Prof. Henry J. Snaith, specifically to translate laboratory-scale perovskite research into industrial-scale photovoltaic manufacturing. This agreement vested commercial exploitation rights comprehensively in Oxford PV while preserving formal IP ownership at the university, in accordance with established academic technology transfer practice.

In the second stage, Oxford PV executed a series of territorially differentiated sublicensing deals, each governed by distinct exclusivity conditions according to target jurisdictions: an exclusive sublicense granted to Trinasolar (April 2025) for the manufacture, sale, distribution, and sublicensing of perovskite-based photovoltaic products within mainland China, and a non-exclusive license granted to First Solar Inc. — the largest thin-film solar manufacturer in North America — covering the development, manufacture, and distribution of perovskite semiconductor-based solar devices across the United States of America and Canada markets (February 2026). Together, these two sublicensing agreements confer commercial authorization over the three largest solar markets globally — China, North America and the European Union — establishing Oxford PV's portfolio as the reference IP architecture for next-generation tandem photovoltaics across jurisdictions representing the preponderant share of global solar deployment capacity.

Currently, Oxford PV has consolidated its position as a leading IP licensor and now controls a portfolio exceeding 400 patent applications across multiple national and regional jurisdictions — covering materials chemistry, deposition processes, and finished product configurations.

Case Study 7: Industry-led research consortia for bio-based materials - the Continental Taraxagum case (Germany)

A structurally distinct model of green technology transfer is illustrated by the Taraxagum project, developed in Germany through a multi-institutional consortium comprising Continental AG (headquartered in Hanover, Germany), the Fraunhofer Institute for Molecular Biology and Applied Ecology (IME), and the University of Münster. Launched in 2011, the project sought to develop an industrial-scale process for extracting natural rubber from the Russian dandelion as a sustainable alternative to conventional rubber derived from the tropical rubber tree (*Hevea brasiliensis*) a crop cultivated almost exclusively in Southeast Asia and associated with tropical deforestation and high-emission long-distance transport.

The technology transfer architecture in this Case Study differs notably from both the public tender model and the sequential licensing chain examined above. Rather than originating in a formal TTO licensing agreement or a university spin-off, the Taraxagum innovation emerged from a co-financed, multi-party R&D consortium in which Continental as an industrial anchor embedded itself directly in the research process from the outset, thereby securing privileged access to resulting IP while sharing development risk with public research partners. The project received co-financing from the European Union under the European Regional Development Fund (2014–2020), illustrating how macro-level public funding instruments can de-risk and accelerate green technology development at the consortium level.

The IP strategy combined genomic research (including sequencing the dandelion genome to optimize latex rubber yield) with proprietary breeding and cultivation methods, and process patents covering root processing and rubber extraction, constituting a layered portfolio that protects both the biological inputs and the manufacturing process. The Taraxagum Lab Anklam, inaugurated in 2018 in northeastern Germany, functions as a dedicated scale-up and validation facility, enabling the transition from laboratory findings to pilot-scale production. In 2018, the first commercially available tire incorporating dandelion rubber (the Urban Taraxagum bicycle tire) was brought to market, representing the world's first series-produced tire with a tread derived entirely from this alternative bio-based source. The project was further recognized with the German Sustainability Award, evidencing the alignment between IP strategy, environmental objectives, and institutional reputational value.

This Case Study is particularly instructive because it demonstrates that effective industry-academia green technology transfer does not require a formal university TTO as intermediary when an industrial partner with sufficient R&D capacity is integrated into the research consortium from inception. It also illustrates a financing model combining private industrial investment with EU structural funds that is increasingly relevant for green technology practitioners seeking to bridge the capital gap between early-stage bio-based innovation and industrial validation, including in regions such as Latin America where analogous public co-financing mechanisms are emerging.

C. Case Studies on Licensing Models, Contract Structures and Remuneration Schemes in the Health and Green Technology Sector

1. Case Studies in Health Sector

In the Health Sector, governments also play an important role as early-stage investors in pharmaceutical innovation and the licensing of academic biotechnologies to industry as a means for achieving a social return on public sector investments in biomedical science. Choosing an appropriate model for the license agreement is critical for successfully establishing and managing the expansive and complex relationships that are becoming more common between industry and universities.

Case Study 8: Oxford/AstraZeneca vaccine – technological order agreement term (United Kingdom)

This Case Study utilized a Technological Order Agreement Term (TOAT), a unique legal instrument that allowed for the transfer of technology that was still under development. This was crucial for accelerating API production concurrently with batch validation during a global crisis. This Case Study involved two related but legally and operationally distinct arrangements. First, the University of Oxford entered into a licensing agreement with AstraZeneca, granting the company the rights required to continue the vaccine's development and support its global manufacture and distribution. This arrangement connected university-generated research with AstraZeneca's clinical-development, regulatory, manufacturing and distribution capabilities. Its broader significance lies in how the licensing structure supported the rapid scaling and international distribution of a vaccine that was still undergoing clinical development. Second, AstraZeneca entered into a separate manufacturing and technology-transfer arrangement with Bio-Manguinhos, the vaccine-production unit of the Oswaldo Cruz Foundation, Fiocruz, in Brazil. This arrangement covered the staged transfer of manufacturing processes and know-how required for local production of the vaccine's active pharmaceutical ingredient, API, as well as batch validation, regulatory documentation, personnel training, quality-system alignment and supply-chain coordination. A Technological Order Agreement Term, TOAT, was used in connection with the AstraZeneca–Bio-Manguinhos/Fiocruz transaction to facilitate the transfer of a technology that was still under development. This allowed production capabilities to be established while the manufacturing process and validation requirements continued to evolve.

The pandemic required these contractual relationships to operate as adaptive and iterative frameworks rather than as static transfers of patent rights. Clinical trials were still under way, production processes were being optimized, regulatory pathways were evolving and global demand was unprecedented. The arrangements therefore had to accommodate staged process transfer, continuing know-how exchange, manufacturing at risk, regulatory coordination and ongoing technical updates. Taken together, the Oxford–AstraZeneca license and the subsequent AstraZeneca–Bio-Manguinhos/Fiocruz technology transfer illustrate how interconnected licensing, manufacturing and technology-transfer arrangements can support rapid production scale-up and wider geographic distribution. The Case Study also demonstrates that successful Health-Sector technology transfer depends not only on access to patents, but also on the effective transfer of know-how, local manufacturing capacity, regulatory coordination, public-sector support and institutional orchestration (da Fonseca et al., 2023).

Case Study 9: CRISPR Technology and Surrogate Licensing in Precision Medicine-surrogate licensing (United States of America)

The CRISPR ecosystem represents one of the most technically complex examples of university-originated biotechnology licensing (Contreras and Sherkow, 2017). The traditional bilateral licensing models were insufficient for technologies characterized by fragmented patent ownership, platform-level applicability, extremely high commercialization uncertainty, multiple therapeutic indications and large regulatory burdens. Thus, Universities increasingly relied on, surrogate licensing entities, patent aggregation structures, exclusive field-of-use licenses, sublicensing authority and milestone-triggered commercialization rights (Sherkow and Contreras, 2018). The surrogate firms managed intellectual property portfolios, negotiated licenses, and coordinated downstream commercialization strategies. The rationale behind surrogate licensing included; simplifying fragmented patent ownership, facilitating venture capital investment, improving commercialization coordination, reducing transaction complexity, and protecting institutional control over foundational technologies. However, the model has also generated discussion regarding concentration of licensing authority, management of access to foundational research tools, patent aggregation, and the balance between commercialization efficiency and broad dissemination, overlapping patent claims, and legal disputes over patent priority. This Case Study demonstrates that precision-medicine licensing increasingly functions as ecosystem governance rather than simple patent transfer and illustrates how licensing

structures may require consideration of multiple objectives, including commercialization efficiency, investment incentives, scientific collaboration and dissemination of research tools.

Case Study 10: The University of Cape Town (UCT) HPV Vaccine – adaptive licensing (South Africa)

This licensing Case Study from The University of Cape Town (UCT) provides an illustrative example of how academic institutions can use adaptive licensing structures to balance commercialization objectives, pre-existing research-consortium commitments, public-health and commercialization considerations, and the needs of industrial partners in the health technology sector. UCT licensed a plant-produced Human Papillomavirus (HPV) vaccine technology, including patents, patent applications, know-how, and proprietary manufacturing expertise, to a large international pharmaceutical company. Because an international vaccine consortium already held certain commercialization-related rights, the parties adopted a co-exclusive licensing structure rather than the exclusive license initially requested by the company. The agreement incorporated milestone obligations, sublicensing rights, confidentiality and dispute-resolution provisions, and a contractual mechanism allowing conversion to a fully exclusive license if the consortium elected not to pursue commercialization. This approach enabled the university to honor existing commitments while providing sufficient certainty for industrial investment. The Case Study demonstrates how flexible licensing arrangements can reconcile competing stakeholder interests, address freedom-to-operate and regulatory challenges, and facilitate the commercialization of early-stage university inventions (Bailey, 2026a).

Case Study 11: The MARAVAS - Medical Training and Vascular Care Standardization Program- K/TT of trade-secrets, know-how and regulatory sandbox (Thailand)

This Case Study licensing from Mahidol University, Thailand demonstrates that effective technology transfer in the Health Sector is not limited to patent licensing. Through a sole-license agreement granted to a large private healthcare provider in Thailand, Mahidol University transferred clinical know-how, operational expertise, service methodologies, trademarks, and standardized vascular-care protocols aimed at improving healthcare quality and supporting the establishment of specialized vascular centers. The primary challenge was the transfer of tacit clinical knowledge from an academic environment into a commercial healthcare network while maintaining consistent service standards. A sole-license structure was selected to provide the licensee with sufficient exclusivity within Thailand while allowing the university to retain ownership of the underlying know-how and brand assets. The agreement included confidentiality, ownership, dispute-resolution, and termination provisions, and was supported by a one-time upfront payment of THB 10 million without ongoing royalties or milestone payments. The Case Study highlights how structured transfers of clinical expertise, training systems, and service standards can create substantial value and may be more appropriately commercialized through fixed-fee licensing arrangements than traditional royalty-based patent licenses. The arrangement is best characterized as knowledge and technology transfer rather than merely training, consultancy, service standardization or brand licensing because its principal objective was to enable the licensee to absorb, reproduce and apply an integrated clinical and operational system. The arrangement enabled rapid deployment of specialized vascular-care standards while avoiding the complexity of long-term royalty monitoring. The Case Study demonstrates that fixed-fee licensing can be an effective remuneration mechanism when the primary value lies in clinical expertise, training, and operational know-how rather than future product sales (Rungwattanagit, 2026).

Case Study 12: The nutraceutical management of polycystic ovary syndrome-commercialization through spin-off (Malaysia)

This Malaysian licensing Case Study from Malaysian Research Accelerator for Technology & Innovation (MRANTI) illustrates how universities can commercialize health innovations through spin-off companies using exclusive know-how licensing arrangements rather than patent-based

royalty models. The technology involved a clinically validated, halal-compliant nutraceutical formulation for the management of Polycystic Ovary Syndrome (PCOS), developed by a university and licensed exclusively to a university spin-off for commercialization within Malaysia. The agreement granted rights to proprietary know-how and trade secrets, while requiring the spin-off to commence commercialization within six months, maintain an active marketing program, obtain regulatory approvals, and comply with quality standards established by the university. Key contractual provisions included milestone-based commercialization obligations, sublicensing controls, confidentiality requirements, quality oversight, and performance-linked renewal conditions. This Case Study also illustrates the use of deferred remuneration structures to reduce commercialization risk in university spin-offs. Rather than relying on running royalties, the remuneration model used deferred licensing fees, with only nominal payments during the first two years and larger fixed payments commencing once commercialization activities were established. The agreement also incorporated commercialization milestones, including a requirement to enter the market within six months, performance-linked renewal provisions, and quality-control obligations. The Case Study demonstrates how exclusive licensing of university know-how, combined with performance-based obligations and deferred payment structures, can reduce early-stage commercialization risk while encouraging rapid market entry for health-sector innovations (Sokmum, 2026).

The product is registered with Malaysia's National Pharmaceutical Regulatory Agency. A completed safety trial is being followed by an ongoing Phase 2 trial assessing efficacy and health outcomes. Under a technology license with Universiti Sains Malaysia, the researcher retains distribution and commercialization rights, supported by patent and trade-secret protection. After approximately two years of B2C sales, the product is expanding into pharmacies, clinics, and digital channels. Human studies and user reports suggest improved hormonal balance, menstrual regularity, and PMS symptoms; however, pending Phase 2 results, these remain observed rather than definitive clinical outcomes.

2. Case Studies in green technology sector

There are different investment needs for technologies at different stages however, clean energy companies have considerable time and capital requirements, which limit their growth rates and/or profit margins and make for poor fits with most venture capital. The public sector has thus stimulated commercialization indirectly by supporting an "innovation ecosystem," (via policies, including regulations, tariffs, taxes; research funding) as well as promoting cooperation and open shared resources between public and private organizations or by being a critical first customer for a new technology (Engel-Cox, et al., 2022).

Generally, there are three common characteristics for commercialization for new energy technologies: 1) good fit between the technology, R&D infrastructure, and public-private partnership models; 2) high degree of alignment of government regulations and R&D priorities with market forces; and 3) compatibility between time scales required for R&D, product development, and opportunities.

Case Study 13: Fuel-cell technology – UCT spin-offs (South Africa)

This commercialization Case Study demonstrates how university-developed green technologies can transition from traditional licensing arrangements to equity-based commercialization through academic spin-offs. To commercialize a portfolio of patents, software, know-how, and trade secrets relating to hydrogen fuel-cell components, the university established a dedicated spin-off company and initially granted it an exclusive license. As the company matured and attracted investment, the licensing arrangement evolved into a full IP assignment in exchange for equity, aligning the university's interests with the company's long-term growth. The agreements included milestone obligations, sublicensing rights, royalty deferral mechanisms, minimum annual royalties, and recovery of historical patent costs. An important feature was the spin-off's first right to future IP generated within the government-funded hydrogen research program, creating a pipeline of innovations for future commercialization. The Case Study illustrates how

adaptive IP strategies can reduce commercialization risk in early-stage green technologies while supporting long-term company development and investment attraction (Bailey, 2026b). Granting the spin-off preferential rights over future inventions provided commercial certainty and supported investment but also risked restricting competition and access to publicly funded research outputs. Safeguards for consideration may include clearly defined scope and duration, commercialization milestones, fair-value requirements, periodic review, and termination or reversion rights where the company fails to develop the technology.

This Case Study illustrates the use of hybrid remuneration mechanisms to support the commercialization of early-stage green technologies through university spin-offs. To reduce commercialization pressure during the company's early growth phase, a royalty holiday was granted until either a specified period had elapsed or the company achieved positive EBITDA. Royalty rates were designed to reflect the contribution of individual IP assets and varied according to product type, territory, and sublicensing arrangements. As the company matured and attracted external investment, the licensing model evolved into an IP-assignment-for-equity arrangement, allowing the university to participate directly in the company's future value creation. The Case Study demonstrates how combining royalties, deferred payments, patent cost recovery, and equity participation can align incentives between universities and spin-offs while accommodating the long development cycles and financing challenges typical of green technologies (Bailey, 2026b).

Case Study 14: Thin-film photovoltaics (United States of America/European Union/Germany)

This Case Study demonstrates how public-sector R&D, university research, and industrial commercialization interact through staged innovation systems. The commercialization ecosystem relied upon public R&D funding, university research, industrial manufacturing partnerships, pilot-scale validation and open market deployment. The licensing model was a non-exclusive one. Instead, commercialization evolved through collaborative R&D, manufacturing partnerships, industry diffusion and standards-based market scaling (Engel-Cox et al., 2022). Commercialization was achieved through government-funded research and a standardized pathway involving shared infrastructure and testing protocols, illustrating one model through which shared resources, iterative manufacturing learning and standards harmonization contributed to commercialization.

Case Study 15: Integrated Sustainable Farming System (Malaysia)

This Case Study concerns a Malaysian university spin-off established to commercialize an integrated sustainable farming system. The system combines five interdependent modules within a single agricultural ecosystem: primary crops, complementary secondary crops, aquaculture and livestock, natural insect control, and agricultural-waste processing. By connecting these activities, the system seeks to increase agricultural productivity, reduce reliance on chemical pesticides, convert waste into useful products, improve soil and environmental health, and provide farmers with diversified income streams. The licensed assets include a granted patent, software or source code, and trademarks.

In 2024, the university granted its spin-off a three-year, non-exclusive license covering the full field of use within Malaysia. The license authorizes the spin-off to use, develop, produce, manufacture, market and distribute the system, while the university retains ownership of the underlying IP and reserves the right to use the system for research and educational purposes, subject to prior notification. The university also provides technical information and establishes applicable quality standards. The agreement contains confidentiality obligations, IP ownership representations, indemnification provisions, assignment restrictions, Malaysian governing law, and termination rights covering circumstances such as breach, insolvency, national-interest considerations and anti-corruption violations. Sublicensing is possible subject to the university's consent and a separate agreement.

The remuneration model was designed to reduce the initial financial burden on the university spin-off. Instead of imposing a substantial upfront payment or immediate running royalties, the agreement requires a fixed license fee of RM10,000 for each of its three years. Additional royalties become payable on sublicensing revenue, with the applicable rate to be agreed separately. If the agreement is renewed, the parties will negotiate a commercialization royalty in good faith, taking the spin-off's sales performance into account. This staged structure illustrates how a public research institution can preserve ownership and academic-use rights while giving a spin-off time to validate the business model, develop the market and build commercial capacity before assuming sales-based royalty obligations.

[End of Appendix]