# SET4BIO

## RENEWABLE FUELS AND BIOENERGY FOR A LOW-CARBON EUROPE – ACCELERATING THE IMPLEMENTATION OF THE SET-PLAN ACTION 8

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# EXECUTIVE SUMMARY

As part of catalysation and implementation of the SET Plan Action 8 – Renewable Fuels and Bioenergy in Europe, the SET4BIO Innovation Challenge has been developed and mobilised to support creation of innovations that stimulate increased production and use of bioenergy and renewable fuels. Thus, contributing to the implementation of the EU Green Deal vision.

Innovation contests play a crucial role in fostering progress and stimulating creativity across different stages of development. This report aims to provide a detailed description of various schemes that effectively organize innovation contests. By analysing the relationship between these schemes and the Technology Readiness Level (TRL) scale, we can better understand how to support innovation at each stage of an innovation journey. Additionally, we propose a model that assists in selecting the most appropriate schemes for specific scenarios. This model draws on valuable insights gained from the innovation challenges undertaken in the SET4BIO project, as well as relevant theoretical findings pertaining to innovation contests, TRL levels, and open innovation.

For the SET4BIO project two contest schemes were developed and tested. For the instalment of the 2021 challenge, a one-year staged contest driven process were developed, including contest rules, outreach plan, challenge prize, event approach, assessment criteria as some of the key building blocks. For the 2023 instalment, a significant shorter challenge with an event-based jam was developed to catalyse team to introduce ideas on innovation with significant low readiness level. In addition to these two schemes, a third novel scheme is introduced in the report that showcase how innovation can be supported on higher readiness levels, i.e. when the solution in focus has surpassed a proof-of-concept stage. Consequently, SET4BIO proposes three contest schemes to catalyse innovations throughout the TRL scale. These are:

- Innovation Jam: a scheme to rapidly source and stimulate innovative concepts (TRL 1-3);
- Innovation Challenge: a scheme to accelerate innovative concepts to prototypes (TRL 3-5);
- Innovation Pressure Test: a scheme to check the relevance and reliability of the evolving technology - from prototype to solution (TRL 4-7).

Building upon the insights gathered from the three additional reports (D3.1, D3.2, and D3.4) in WP3, this report contribute to a systematically crafted and highly replicable process to support innovation activities. Its purpose is to mobilize vital support for the SET Plan Action 8, and establish a strong foundation for future endeavours.

The comprehensive deliverables within WP3 offer a detailed and cohesive blueprint, ensuring seamless re-use and widespread adoption in the years ahead. These reports together guarantee its viability and effectiveness, providing a complete description of the methodology to be leveraged for continuous progress and innovation.

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**Content**

# Introduction

The aim of D3.3 “Summary report with challenge schemes and lessons learned“ is to provide descriptions of different schemes for how to organize innovation challenges to support the progress of innovation at different readiness levels. It constitutes an exploration of the activities that have been performed in Work Package 3 (WP3) “Innovation Challenge” during M22-M36 in the project, with a focus on the scheme development performed via Task 3.3 “Consolidate Innovation Challenge Schemes”.

Innovation contests play a crucial role in fostering progress and stimulating creativity across different stages of development (Hjalmarsson et al. 2017). The report delves into different schemes used to organize innovation contests, each uniquely suited for various stages of technological development. These schemes are meticulously mapped against the Technology Readiness Level (TRL) scale, which allows for a nuanced understanding of their applicability and impact. By leveraging this alignment, future initiatives can effectively channel resources towards advancing innovations at their respective TRL levels, ultimately promoting overall technological progress.

To guide decision-makers in designing successful innovation contests, the report also introduces a comprehensive model for scheme selection. By considering factors such as technological maturity, available resources, and target objectives, this model assists in making informed decisions about the most suitable contest schemes. Furthermore, the model considers the learnings gathered from the SET4BIO project's innovation challenges, ensuring practical and effective implementation.

In the three prior completed reports, D3.1 “Innovation Challenge in SET4BIO” D3.2 “Experiences from the SET4BIO challenges“ and D3.4 “Identification of topics for SET4BIO Innovation Challenge”, the design of the Innovation Challenge is presented as well as an account of the model used to set the objectives for the challenge, and an account of the experiences from running a one-year staged innovation challenge within the field of renewable fuels and bioenergy in Europe.

D3.3 is structured as follows. Chapter 1 offers an overview of the SET4BIO Innovation Challenges meticulously organized within the project. Moving forward, Chapter 2 introduces the Technology Readiness Level (TRL) framework and delves into its role in supporting an organization's innovation journey. Additionally, the chapter explores the crucial link between TRL and innovation contests. In Chapter 3, the systematic work conducted to define three generic schemes for innovation contests is presented. This chapter also includes the mapping of these schemes to the TRL framework, accompanied by set of criteria for selecting the most suitable contest scheme, taking key factors into account. Chapter 4 in brief outlines future application directions built upon the foundation of the introduced schemes. This forward-looking perspective aim to stimulate continuous growth and development in the context of innovation.

The report concludes with final notes and a comprehensive list of references, offering a solid knowledge base for further exploration and understanding.

Together with the three additional reports from WP3 (D3.1, D3.2 and D3.4), this report constitutes a repeatable toolbox component developed from the SET4BIO project to be re-used to mobilise additional support for the SET Plan Action 8. The deliverables in WP3 thus together provide a complete description of the model to support re-use and adoption in future initiatives and projects.

# Chapter 1 –Two Innovation Challenges in SET4BIO

The SET4BIO project, funded by the European Union, is dedicated to advancing Action 8 of the EU Strategic Energy Technology Plan (SET-Plan), with a specific focus on Bioenergy and Renewable Fuels for sustainable transport. Operating as a coordination and support action, SET4BIO receives funding under Horizon 2020. The project has successfully crafted a comprehensive framework known as the Implementation Toolbox, tailored to invigorate and nurture stakeholders and technologies within the sector.

The Implementation Toolbox comprises several pivotal components, including the Mapping of National Bioenergy Projects, Financing Opportunities for Bioenergy, an Industry Stakeholder Map, Global Outlook, and an innovative platform named the Innovation Challenge. Within the toolbox, WP3 and D3.1-D3.4 encompass the Innovation Challenge component. Throughout the project's duration, two distinct Innovation Challenges have been meticulously orchestrated to showcase the effectiveness of the contest format in stimulating and nurturing innovation within this dynamic sector.

By embracing this inventive approach, the SET4BIO project effectively empowers participants in the bioenergy and renewable fuels realm to explore novel opportunities, conceive ground-breaking solutions, and collectively contribute to the sustainable evolution of the transport industry. Consequently, SET4BIO as a project assumes a key role in propelling progress and shaping a greener, more sustainable future for Europe and beyond.

## The Purpose with Innovation Contests in SET4BIO

The primary purpose of organizing innovation contests over time, known as an Innovation Challenges in SET4BIO, is to foster the advancement of mature concepts and prototypes, moving beyond mere ideas (Hjalmarsson et al., 2017). As such, these contests represent a distinctive category within the realm of open innovation competitions. Their overarching goal in SET4BIO has been to catalyse the development process, transforming initial ideas or design sketches into emerging tangible products or services.

An essential characteristic of an innovation contest is that regardless of its specific aim, the outcome must be materialized as a prototype or concept. This materialization allows for a thorough assessment of its novelty, business potential, and scalability. Achieving such maturity level necessitates the operation of the innovation contest over an extended

period rather than as a one-time event.

By providing this ongoing platform for participants to refine their concepts and prototypes, an innovation contest becomes a powerful catalyst for innovation, driving continuous improvement and refinement. It encourages participants to push the boundaries of their creativity, ingenuity, and problem-solving abilities, ultimately fostering a culture of sustained innovation and development (Hjalmarsson et al 2017).

### Contest 1: SET4BIO INNOVATION CHALLENGE ANNO 2021

The design and running of the SET4BIO Innovation Challenge anno 2021 is described in-depth in D3.1 "Innovation Challenge in SET4BIO" and D3.2 "Experiences from the SET4BIO challenges" and is accessible via the ETIP Bioenergy webpage[1]. As an open innovation contest, the challenge was directed towards creating innovations that stimulate increased production and use of bioenergy and renewable fuels. It sets out to engage innovators in developing innovative proposals for solutions that stimulate and increase the possibility of producing and using bioenergy and renewable fuels by also implementing the EU Green Deal.

To selected innovators (i.e. participating teams or entrants), the SET4BIO Innovation Challenge 2021 provided the following major opportunities:

- Accelerating the development of their solution via virtual events;
- An assessment of the solution with a final demonstration day;
- Opportunities of being matched with potential funding opportunities.

The challenge was divided into three major phases: pre-challenge, accelerating phase and beyond-the-challenge. As depicted in Figure 1, the challenge, took place between April 2021 and January 2022, and provided a set of virtual events to support participating teams to develop their concepts throughout the challenge process towards the final. Each event was preceded by a preparation phase in which the teams worked with their concepts in association to the theme of the event.

[1] www.etipbioenergy.eu/set4bio/innovation-challenge

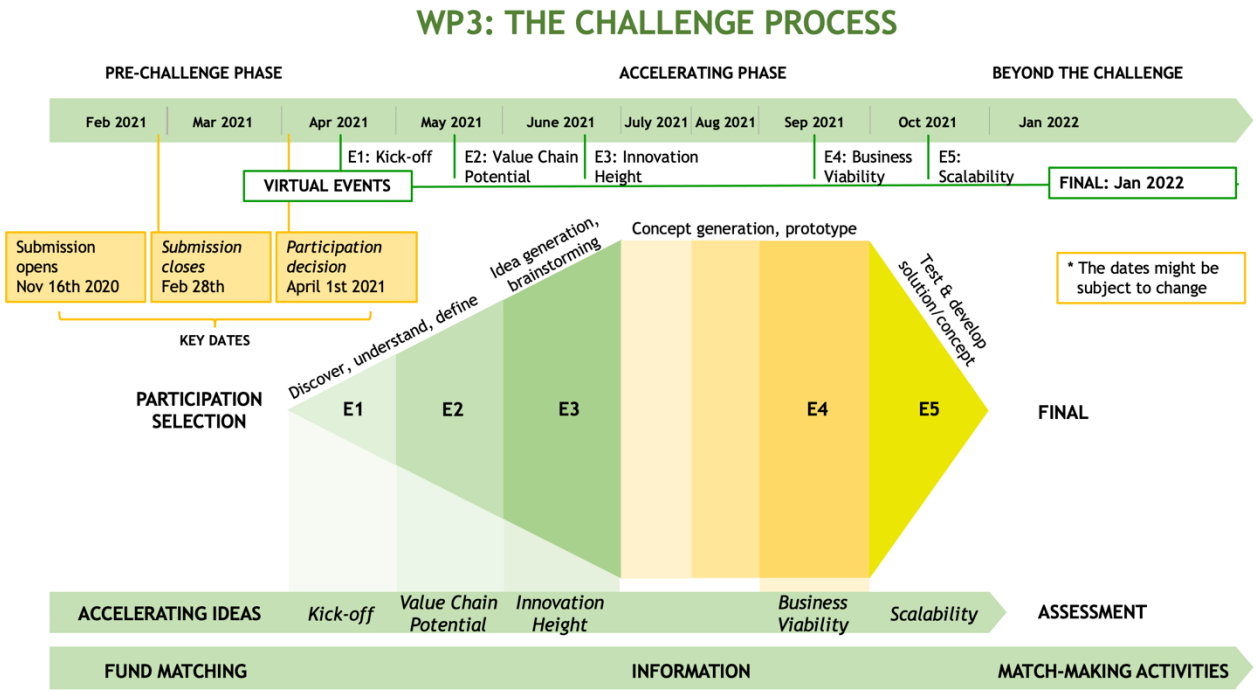


*Figure 1: SET4BIO Innovation Challenge anno 2021*

The challenge process comprised several significant activities that facilitated the development and selection of innovative concepts:

1. Application for Participation: Innovators interested in the challenge submitted their applications for consideration.

2. Screening of Applicants: The organizers meticulously reviewed the concepts submitted, selecting the most promising ideas to advance to the challenge.

3. Virtual Kick-off: A dedicated event served as a virtual kick-off, providing entrants with crucial information about the SET4BIO initiative, the specific challenge to be addressed, and insights into the key value chains in focus.

4. Virtual Events: Four virtual events were thoughtfully scheduled to support and nurture entrants in refining their concepts. These events centered on essential aspects such as value chain contribution, innovation height, business viability, and scalability. Prior to each virtual event, a preparation phase allowed teams to fine-tune their concepts, while a post-event phase ensured continued concept acceleration.

5. Final Event: Entrants presented their refined concepts to a discerning jury. The jury diligently evaluated the concepts and identified the most outstanding solutions. The winners were officially announced and communicated to all stakeholders.

During the final event, the participating teams and their solutions underwent thorough

evaluation, resulting in a ranking that identified the top three solutions worthy of the esteemed "Seal of Excellence." This prestigious recognition is a testament to the solutions' potential, evaluated against four key criteria: value chain contribution, innovation height, business viability, and scalability.

Throughout the year-long process, the selected teams were provided with continuous support and valuable opportunities, including:

1. Feedback from Key Stakeholders: Acting as mentors, prominent figures within the sector offered insightful feedback on the teams' solutions, guiding them towards refinement and excellence.

2. Access to Relevant Funding Information: Gradually, the teams received crucial information regarding funding opportunities, laying the groundwork for future collaborations and partnerships.

Apart from gaining visibility across various media channels and communication materials, the Seal of Excellence also includes vital supporting documentation that empowers the teams in their ongoing development endeavours. This documentation proves invaluable when engaging with funding agencies, potential customers, and prospective partners.

The one-year virtual challenge process provided an engaging platform for innovation and collaboration, enabling participants to transform their ideas into impactful solutions. Through a structured and well-supported approach, the SET4BIO Innovation Challenge contributed to the advancement of bioenergy and renewable fuels, driving sustainable progress in line with the goals of the SET-Plan and the EU Green Deal.

### Contest 2: SET4BIO INNOVATION CHALLENGE LIGHT ANNO 2023

In contrast to the robust one-year staged innovation challenge in 2021, the project in 2023 organized a more streamlined and light innovation challenge. The objectives of this second initiative were twofold. Firstly, it aimed to test and demonstrate a rapid pop-up scheme, distinct from the initial approach. Secondly, it sought to provide stakeholders with an expert evaluation of their technologies and guidance on aligning their technology development projects with appropriate financing instruments.

This light version was devised to swiftly source and assess innovative concepts, leveraging a panel of experts from both the SET4BIO project and the European Commission. Prior to the event, participants prepared pitches describing their technologies and ideas, which were presented during the event and jam-based evaluated by the expert panel.

The innovation jam approach facilitated a dynamic exchange between stakeholders, enabling them not only to present their solutions but also to offer their own suggestions on how the funding framework could be enhanced to boost investments in biofuels

research, development, and innovation.

The light innovation challenge showcased a responsive and collaborative atmosphere, fostering valuable insights and synergies among the participants. By aligning with this rapid approach, the project effectively provided stakeholders with a supportive platform to accelerate their technological advancements and enhance their access to appropriate funding avenues.

The event was held on June 27th, 2023, as a one-day online gathering hosted from a studio in Brussels. The unique setup involved a physically co-located panel of experts, who adeptly integrated online contributions from participating teams attending remotely. This dynamic arrangement facilitated a seamless and engaging experience for all participants, promoting effective collaboration amongst the experts, and knowledge exchange throughout the event with participants.

Having the panel of experts co-located brought several valuable benefits, including efficient assessment of the innovative concepts and collaborative support extended by the experts to the participants. The close physical proximity of the experts allowed for real-time interactions, enabling them to offer immediate feedback and guidance, which significantly enriched the quality of the event and the overall experience for all stakeholders involved.

In summary, the 2023 innovation challenge light instalment exemplified the SET4BIO project's commitment to agile and adaptive methodologies, ensuring ongoing progress and driving innovation in the bioenergy and renewable fuels domain. It created an encouraging environment for stakeholders to make strides in sustainable technology development and contribute to the realization of the EU Strategic Energy Technology Plan's goals.

# Chapter 2 – Technology Readiness Levels and Innovation Management

In this chapter, technology readiness as framework is described. The chapter also includes an account of how readiness levels can support the management of companies' innovation journeys, As a final part, the chapter links the readiness level framework to innovation contests and how readiness levels can support a contest over its lifecycle.

## Introduction to the Technology Readiness Level Framework

Technology Readiness Levels (TRLs) originated in the 1970s through NASA's pioneering efforts, aiming to establish a structured approach for evaluating the maturity and preparedness of technologies earmarked for space missions (Mankins 1995). This concept was subsequently embraced by numerous government entities, including the Department of Defence, and has transcended the realms of space exploration to find widespread

application across diverse industries and sectors, even gaining recognition from the European Union (Héder 2017).

The underlying drive behind the conception of TRLs was to create a unified framework that enables consistent evaluation and communication of technological advancements. Serving as a standardized scale, TRLs facilitate tracking the progress of a technology from its nascent stages of conception and fundamental research to its eventual full-scale deployment and operational utilization (Mankins 1995).

The original TRL scale consisted of nine levels, each representing a specific stage of technology development:

> **TRL1 - Basic principles observed and reported**: This is the lowest level, indicating that scientific research has just begun, and there is no practical application of the technology.
> **TRL2 - Technology concept formulated:** At this stage, the basic principles are understood, and a technology concept is developed.
> **TRL3 - Experimental proof of concept:** The concept is validated through experimental testing, demonstrating its feasibility.
> **TRL4 - Technology validated in a lab environment:** The technology is further tested and validated in a controlled laboratory setting.
> **TRL5 - Technology validated in a relevant environment:** The technology is tested and validated in a relevant environment, simulating real-world conditions.
> **TRL6 - Technology demonstrated in a relevant environment:** The technology is demonstrated in an operational or near-operational environment.
> **TRL7 - System prototype demonstration in an operational environment:** A prototype system is developed and demonstrated in an operational environment.
> **TRL8 - Actual system completed and qualified through test and demonstration:** The technology is fully developed, tested, and qualified for its intended purpose.
> **TRL9 - Actual system proven through successful mission operations:** The technology is successfully deployed and operated in its intended mission or application.

Over the years, Technology Readiness Levels (TRLs) have undergone significant evolution, with the introduction of additional sub-levels and refinements to enhance the precision of technology maturity assessments (Uren & Edwards 2023). To cater to various technology applications, including intelligent systems, adjustments have been made to the level descriptions (Meystel et al. 2003).

Moreover, alongside the traditional TRL scale, alternative scales have emerged, each catering to specific technological domains. Notably, digital readiness levels (DRLs) and cyber TRLs account for the digital maturity and cybersecurity aspects of technologies, while service readiness levels (SRLs) address the readiness of technologies related to service delivery (Uren & Edwards 2023). In the context of the SET4BIO project, which focuses on enhancing renewable fuel production and bioenergy utilization, the TRL scale

has been chosen as the preferred framework. This decision underscores the relevance and versatility of TRLs in evaluating the readiness of novel technologies, aligning with the SET Action Plans objectives.

TRLs have proven to be a valuable tool for technology developers, funding agencies, and policymakers to assess the readiness of technologies, make informed decisions about resource allocation, and understand the remaining challenges before widespread adoption and deployment (Héder 2017).

### Technology Readiness and Innovation Journey Support

TRLs can play a key role in facilitating the innovation journey of a company as they evolve an idea into a practical solution. In a contemporary empirical investigation by Uren & Edwards (2023), the authors explore how TRLs can effectively support an organization's path towards AI adoption. Their paper presents an extended model of the technology adoption process, skilfully integrating the perspectives of technology readiness and socio-technical factors. The model emphasizes the dynamic interplay between data and other crucial elements throughout the adoption and implementation process.

TRLs offer a standardized framework that enables companies to assess the maturity and readiness of their technologies (Mankins 1995). By utilizing TRLs, organizations can effectively measure the progress of their innovations and make well-informed decisions at various stages of the innovation journey. This robust approach equips businesses with the tools they need to gauge the viability and success potential of their AI initiatives.

- Staged assessment
- Setting objectives
- Project planning
- Risk assessment
- Continuous improvement
- Collaboration and partnership facilitation tool
- Decision making
- Funding and investment sourcing
- Market entry

The TRL framework provide a standardized framework for *staged assessment* of the technological feasibility of an innovation at different development stages. By assigning a TRL to a technology, innovators can understand its current state, identify gaps, and determine the necessary steps to advance it further (Uren & Edwards 2023).

TRLs offers valuable assistance to companies in defining and *setting clear objectives* for their innovation projects based on their current stage of development. By setting specific TRL targets, companies can precisely outline the desired level of technological maturity for each stage, fostering a systematic and structured approach to innovation (Meystel et al 2003). This strategic use of TRLs helps ensure that progress is well-measured and controlled throughout the development process. Moreover, the TRL framework can serve as a practical roadmap for *project planning* and resource allocation. Companies can

effectively identify the key steps, activities, and milestones required to advance from one TRL to the next, enabling efficient project management and seamless scheduling of activities. This well-structured approach enhances the organization's ability to reach the defined objectives within the desired timeframe (Mankins 1995).

TRLs allow companies to *manage the risks* associated with each stage of technology development, e.g. by supporting stakeholders to state and answer diagnostic questions (see figure 2).

| TRL-level | TRL stage output | Examples on diagnostic questions to assess output TRL |
|---|---|---|
| TRL1 | Basic principles and broad vision | • Have the innovator researched the solution in principle?<br>• Have the innovator a vision for the solution? |
| TRL2 | Conceptual design | • Have the innovator proposed components which need to be part of the solution?<br>• Have the innovator crafted a conceptual design for the solution? |
| TRL3 | Theoretical and experimental analysis; proof-of-concept | • Have the innovator experimented with subcomponents of the solution?<br>• Have the innovator vetted the innovative components? |
| TRL4 | Component validation in laboratory conditions | • Have the innovator integrated subcomponents of the solution to check that they will work together.<br>• Have the innovator considered issues such as interoperability, maintainability, scalability etc? |
| TRL5 | Component validation in more realistic conditions | • Have the innovator developed a high-fidelity prototype of the solution with realistic components?<br>• Have the innovator verified the prototype in terms of functionality? |
| TRL6 | Subsystem or prototype demonstration | • Have the innovator demonstrated a complete prototype solution in a relevant environment; e.g. test and demonstration facility with realistic data or performed test in simulated environment? |
| TRL7 | System prototype demonstration in operational conditions | • Do the innovator have an operational solution that can be demonstrated in its operational environment?<br>• Are there processes in place to support implementation of the solution? |
| TRL8 | Actual system completed and demonstrated | • Do the innovator have a solution which is in its final form and meets its design specifications?<br>• Is the solution ready to function in its intended application? |
| TRL9 | Actual system proven through operational use | • Has the innovator proven the solution through use under operational conditions for an extended period?<br>• Does the solution reliably generate the effects it is intended to generate? |

*Figure 2 – TRL stage output and examples on diagnostic questions (based on Uren & Edwards 2023)*

As technologies progress through the TRL scale, the associated risks can change. By assessing the current TRL, innovators can identify and address technical, operational, regulatory, and market risks at each stage, thus minimizing potential setbacks. As TRLs advance, the level of technical and commercial risk generally decreases as the new technology through tests and demonstrations are validated not only from a technological perspective but also from use and business perspectives. By understanding the risks at each TRL, companies can make informed decisions about resource allocation, investment, and risk mitigation strategies (Mankins 1995). As such TRLs promote a culture of

*continuous improvement* by enabling companies to monitor and evaluate the progress of their innovations. Regular assessment of TRLs allows for feedback loops, lessons learned, and the refinement of development processes, leading to more efficient and effective innovation practices (Uren & Edwards 2023).

TRLs facilitate *collaboration and partnerships* between companies, research institutions, and other stakeholders. By sharing a common understanding of technology maturity, companies can identify potential partners at compatible TRL levels, fostering synergies and knowledge exchange. For example, the use of TRL assist in the efficient allocation of resources, such as funding, manpower, and time, by providing a common language for stakeholders to discuss the readiness and risk associated with a technology (Mankins 1995). This helps decision-makers prioritize investments in technologies with higher TRLs, ensuring that resources are directed towards innovations with a higher chance of success. Collaborative stakeholders can use TRLs as a reference point for *decision making*, evaluating the readiness of technologies, determining whether to proceed with further development or terminate projects that do not meet the desired TRL targets.

The TRL-scale may in addition to the above also serve as an essential tool for *securing funding* and attracting investments (Héder 2017). Investors and funding agencies often use TRLs as a basis for evaluating the readiness and potential of technologies. Advancing through higher TRLs demonstrates progress, increases credibility, and enhances the likelihood of securing financial support. TRLs can assist companies in transitioning technologies from the research and development phase to *commercialization* (Mankins 1995). Advancing through higher TRLs indicates increased readiness for market entry, helping companies identify the necessary steps to scale up production, address regulatory requirements, and launch products or services successfully. For example, when licensing a technology, the TRL can help potential buyers or licensees assess the maturity and potential value of the technology. Similarly, investors and venture capitalists often consider TRLs when evaluating startups or innovation projects for funding, as higher TRLs generally indicate reduced technical and market risks (Héder 2017).

In summary, the TRL scale provide a structured framework that supports innovation by facilitating assessment, resource allocation, risk management, collaboration, decision-making, and technology transfer. By leveraging TRLs, innovators can navigate the complexities of the innovation journey more effectively and increase the chances of successfully bringing their technologies to market.

### Technology Readiness Levels and Innovation Contests

According to Hjalmarsson et al. (2017), digital innovation contests are dynamic processes with the primary objective of fostering the creation of novel services and technologies. Building on the research by Hjalmarsson and Rudmark (2012), these contests can be defined as sets of activities where external innovators are challenged and engaged in a compelling race to design and develop innovative and robust outcomes, leveraging resources provided by the organizing entity. The definition comprises three crucial elements. Firstly, the participants in these contests are external developers, meaning developers from outside the organizing organization. By inviting external developers into

the innovation system, these contests open new avenues for fresh perspectives and novel ideas, invigorating the innovation journey either by starting or advancing it. Secondly, the core aim of these contests is to develop tangible digital service prototypes. Merely suggesting a new idea or creating an outcome without implemented components' does not fulfil the contest's objectives. The emphasis lies on generating functional and demonstrable digital solutions that showcase the potential for innovation. Finally, the success of these contests relies on the provision of resources by the organizing entity. These resources facilitate and support the participants' innovation journey, providing them with the necessary means to bring their creative ideas to fruition.

As observed in the SET4BIO project, innovation contests can serve as vital platforms that encourage external innovators to contribute their expertise, leading to the development of practical digital service solution with an ambition to reach a market to create impact. By integrating diverse talents, focusing on tangible outcomes, and offering essential resources, these contests, well designed, can play a vital role in driving innovation within a field and support individual innovation journeys for specific companies and/or consortia. Hjalmarsson et al. (2017) offer organizers a comprehensive model to design and execute innovation contests, encompassing not only the contest itself but also the post-contest management process (see figure 3).

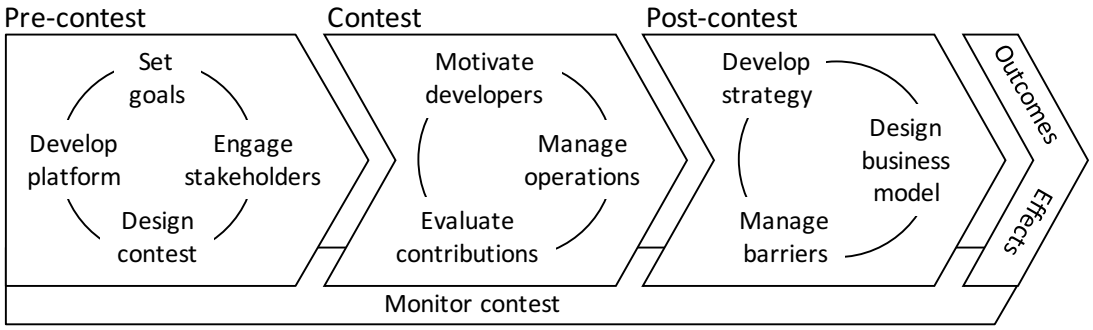


*Figure 3: Approach for organising innovation contests*

The organizing approach is arranged into three distinct phases, complemented by supporting activities for each phase, alongside an underlying cross-phase activity (Hjalmarsson et al 2017). The primary objective of this approach is to effectively monitor the contest while facilitating continuous improvement and learning throughout the entire process. It is important to note that the approach serves a pedagogical function and should not be rigidly constrained by temporal boundaries. For instance, goals are established early on, but they remain flexible and subject to change as the contest progresses and new stakeholders become involved in the organizing team. Furthermore, the contest support platform, initially established before the contest, can be augmented during the contest's duration to take advantage of additional resources that become available to support the participants in their journey.

As the overall aim of SET4BIOs has been to effectively empower stakeholders in the bioenergy and renewable fuels domain to explore new possibilities and develop groundbreaking solutions, it became essential during the project to investigate how TRLs could be combined with the innovation contest model to support and enhance innovation journeys at different stages. By comparing the areas of TRL application with the approach for organizing innovation contests, the following links were identified in relation to the phases when organizing an innovation contest.

How TRLs can support *pre-contest* phase:

- **Defining Contest Goals:** TRLs can help set specific objectives for innovation contests. An organizer can specify desired TRL targets for participants to achieve with their proposed solutions. This ensures that the contest focuses on technologies that align with the company's innovation needs and are at an appropriate stage of development.
- **Designing Guiding Contest Phases:** TRLs can inform the different phases or stages of an innovation contest. An organizer can design contest stages based on TRLs, such as an initial ideation phase, followed by prototyping, testing, and demonstration phases, aligning with the progression of TRLs. Each phase can have specific evaluation criteria tied to the corresponding TRL.
- **Formulate Evaluating Technological Maturity Criteria:** TRLs provide a standardized framework to assess the maturity of technologies. When an organizer runs the innovation contest, they can incorporate TRL criteria as part of the evaluation process. Contest participants can be required to demonstrate the technology's readiness level, showcasing its feasibility, performance, and potential for commercialization.

How TRLs can support in *contest* phase:

- **Progress Monitoring and Milestones:** TRLs offer a structured approach for monitoring progress and setting milestones during the innovation journey. In the context of innovation contests, TRLs can serve as milestones that participants need to achieve at different stages of the contest. This allows the organizer to track the advancement of technologies and assess their potential for further development when managing contest operations.
- **Identify Collaboration Opportunities:** TRLs can facilitate collaboration and partnerships resulting from innovation contests. Participants with complementary technologies or similar TRL levels can be encouraged to collaborate, combining their expertise to advance their innovations collectively. TRLs provide a common language and understanding to assess compatibility and potential synergies, when participants are motivated to contribute during the contest.
- **Evaluate Contest Contributions**: TRLs provide a standardized and acknowledged framework which can support the assessment of outcomes from the contest. When an organizer organizes innovation contests, they can incorporate TRL criteria as part of the evaluation process. Contest participants can be required to demonstrate the technology's readiness level,

showcasing its feasibility, performance, and potential for commercialization.

- **Selecting Winners and Define Prizes:** TRLs can be used as a criterion for selecting contest winners and award suitable prizes. The organizer can prioritize technologies that have achieved higher TRLs or demonstrated significant progress during the contest. This ensures that the winning solutions have a higher potential for successful implementation and commercialization.

How TRLs can support in the *post-contest* phase:

- **Supporting Post-Contest Development:** After the innovation contest, TRLs can continue to guide the post-contest development process. Winning participants can be guided to or receive actual support, mentorship, and resources to advance their technologies further along the TRL scale. This helps bridge the gap between contest success and market readiness.

How TRLs can support in the cross-phase *monitor contest* activity:

- **Assessment, Learning and Feedback:** Innovation contests, in combination with TRLs, offer valuable learning opportunities for both the participants and the organizing company. The evaluation process and feedback provided based on TRLs can help participants understand the gaps and areas for improvement in their technologies. The organizing actor can gain insights into emerging technologies and market trends, which can inform future innovation strategies.

To summarize, by integrating TRLs into an innovation contest format, an organizer can strengthen the contest process through systematic evaluation of technologies, defining appropriate and meaningful objectives, monitoring progress during the event, and rank emerging solutions with higher potential for success on a market or to reach the next level on the readiness scale. It becomes a tool to complement the generative force that the organizing approach in Hjalmarsson et al (2017) provide, supplying assistance in measurement and assessment. Adopting the TRL framework when using the contest design approach tend to increase the effectiveness and efficiency of innovation contest development, ensuring development of technologies that align with the organiser's strategic goals with the contest.

In the forthcoming chapter, we will introduce three generic contest schemes developed during the SET4BIO project. These schemes are designed to provide valuable support for organizers interested in hosting innovation challenges that target specific readiness levels on the TRL scale.

## Chapter 3 – Generic Contest Schemes

In this chapter, generic contest schemes are presented, that aim to support orchestrators of innovation to support innovation at different stages along the TRL scale. The motive behind these schemes is to provide repeatable outlines for innovation challenges that future organizers can use as a starting point in their design of an appropriate innovation contest. First, the framework used to develop the schemes is presented. Secondly, the TRL framework is used to point out requirements for schemes supporting different stages. Thirdly, the schemes are introduced along with criteria to select an appropriate scheme for the task at hand.

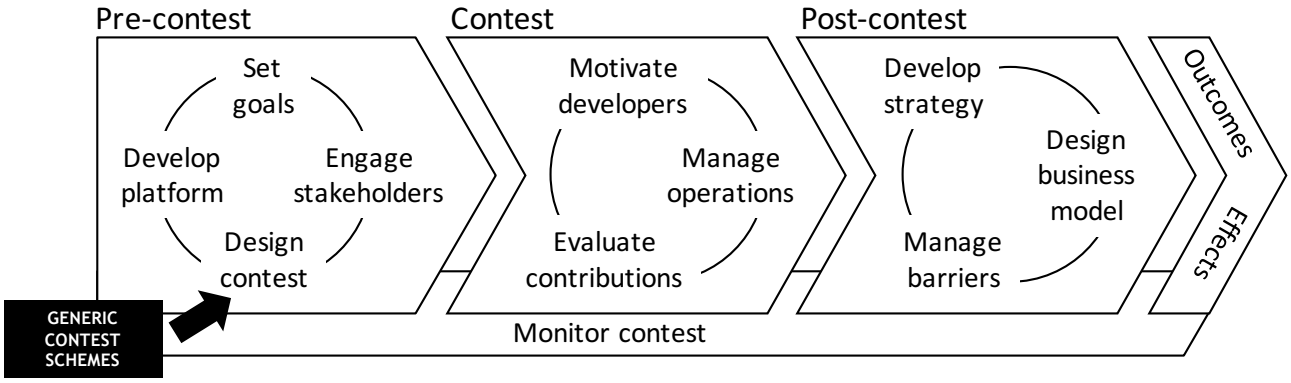


*Figure 4: Generic contest schemes as input in the contest design activity*

As these schemes aim to assist organizers in formulating an apt contest design, they serve as input within the 'design contest' phase of the contest organizing approach proposed by Hjalmarsson et al. (2017), see figure 4. While a generic scheme provides a basic structure, it will require further refinement and specific details to address the unique aspects of each situation it is applied to.

### A framework to define generic contest schemes

Creating an innovation contest embodies a nuanced design process, wherein the organizer in a structured way discerns and assembles an array of essential design elements (Hjalmarsson et al 2017). These elements are purposefully woven together, culminating in a contest blueprint finely attuned to its intended goals and the diverse stakeholders it seeks to captivate. In their toolbox book, Hjalmarsson et al. (2017) outline a compendium of fifteen design components that lend themselves indispensably to the contest's architecture. Among these, media orchestration, contest temporal scope, and task intricacy stand out as quintessential exemplars, underlining their role in crafting a suitable contest framework.

The idea with design elements is that the organisers of innovation contests use them as variables to configure the design of their specific contest. By varying the values of design elements, organisers are able to design digital innovation contests that meet their specific goals and are more likely to have the intended effects. As a generic contest scheme offer a somewhat standardized structure, the framework designed to craft the schemes includes

four of the fifteen design elements provided by Hjalmarsson et al (2017). By pre-setting the values for these design elements given the TRLs framework, generic contest schemes emerge. The four design elements used as a framework to define generic contest schemes are:

- Contest period
- Degree of elaboration
- Task specificity
- Innovation novelty

The element *Contest period* pertains to the duration during which the innovation contest unfolds, encompassing a spectrum ranging from brief intervals to more extensive spans (Hjalmarsson et al 2017). This temporal scope, however, excludes the preliminary pre-contest phase dedicated to orchestrating the event. A condensed contest period could exemplify a rapid 24-hour hackathon, whereas an extended contest might extend its influence over a six-month duration or more. Temporally structured contests commonly delineate multiple phases, each offering an opportunity for filtration and refinement.

Brief contests, with their succinct timelines, serve as catalysts for igniting novel ideas and fostering creative sparks. In contrast, protracted contests provide an expansive canvas conducive to elaborate development, nurturing robust concepts that gravitate toward practicable realization. In essence, the variations within the "Contest period" design element encompass:

- Swift engagements, spanning up to one week
- Concise challenges, encompassing weeks up to three months
- Prolonged processes, spanning several months or even a year(s)

The element *Degree of elaboration* refers to the type of contribution that is expected from the participants. In Hjalmarsson et al (2017) definition of an innovation contest it is presumed that the contribution is more than an idea and is at least materialized in the form of a model of a digital service. However, longer contests might be divided into an idea phase, a prototype phase and a solution development and validation phase. In the first phase, the contribution is in the form of a more or less elaborated idea, while, in the second phase, it consists of a prototype of a digital service. Moreover, a prototype could be more or less mature where a less developed prototype is merely a way to demonstrate a solution concept, whereas a more mature prototype is closer to an implemental digital service, illustrating an emerging solution. The options for Degree of elaboration for the use in relation to technology readiness are:

- Conceptualized idea
- Developed prototype
- Emerging solution

*Task specificity* pertains to how explicitly and precisely participants' tasks are defined (Hjalmarsson et al 2017). In a broader context, lower task specificity cultivates a milieu conducive to engaging a larger and more diverse cohort of participants. Conversely, heightened task specificity within a contest garners a smaller yet more focused assembly of contributors, characterized by their solution-oriented and goal-fixed innovation journey. A fundamental aspect of task specificity is the maturity of the problem and the maturity of available solutions. Hjalmarsson et al (2017) call this "problem–solution maturity" Problem-solution maturity draws inspiration from the notion of technology readiness (Mankins, 1995), serving as a yardstick for evaluating the precision of problem definition and the efficacy of established solutions. If the problem-solution maturity remains low or modest, then achieving a high degree of task specificity proves challenging. Conversely, when problem-solution maturity is high, it might be more fruitful for the outcome of a contest that the task is highly specified. The available options for configuring this design facet encompass:

- Low (open task)
- Defined
- High (Specific task)

*Innovation novelty* means according to Hjalmarsson et al. (2017) that the outcome from a contest should be more innovative than current solutions on the market. In order to promote innovation, the organiser could define rules for intellectual property and evaluation of outcome should include novelty as criteria. The organiser could also provide an innovation baseline with a review of existing services on the market to support assurance of innovation novelty. Moreover, the organiser could ask for a patent survey from the participant in conjunction with the submission of the service prototype to provide some evidence of novelty. Options in relation to technology readiness for innovation novelty are:

- Support to state novely is provided
- Novelty evidence is requested
- Mixed

### Generic contest schemes mapped to the TRL framework

In the context of the SET4BIO project, it becomes evident through the 2021 and 2023 instalment that innovation contests wield substantial influence as dynamic platforms to support innovative progress. As such they effectively can stimulate external innovators, advancing their specialized expertise. The strength in the contest format lies in the fusion of diverse talents, converging toward tangible and impactful results (Hjalmarsson & Rudmark 2012). Through the allocation of indispensable resources, they assume the role of catalysts, propelling innovation within the renewable fuel and bioenergy domain.

| TRL-level | TRL stage output | Generic contest scheme framework | | | | Generic contest scheme | | |
|---|---|---|---|---|---|---|---|---|
| | | Contest period | Degree of elaboration | Task specificity | Innovation novelty | | | |
| TRL1 | Basic principles and broad vision | Swift | Idea | Low | Support to state novelty | Innoovation Jam | | |
| TRL2 | Conceptual design | Swift | Conceptualised idea | Low | Support to state novelty | | | |
| TRL3 | Theoretical and experimental analysis; proof-of-concept | Swift to Concise | Proof-of-concept | Low to defined | Mixed | | Innovation Challenge | |
| TRL4 | Component validation in laboratory conditions | Concise | Emerging prototype | Defined | Mixed | | | |
| TRL5 | Component validation in more realistic conditions | Concise to Prolonged | Verified prototype | Defined | Novelty evidence requested | | | Innovation PressureTest |
| TRL6 | Subsystem or prototype demonstration | Concise to Prolonged | Proof-of-technology | Defined to high | Novelty evidence requested | | | |
| TRL7 | System prototype demonstration in operational conditions | Prolonged | Emerging solution | High | Novelty evidence requested | | | |
| TRL8 | Actual system completed and demonstrated | N/A | | | | | | |
| TRL9 | Actual system proven through operational use | N/A | | | | | | |

*Figure 5: Identification of generic contest schemes vis-à-vis TRL stage output*

In figure 5, the TRL framework on stage-output-level has been analysed using the framework presented above to define generic contest scheme. Three generic contest scheme emerge from this systematic analysis: the InnovationJam (IJ), the InnovationChallenge (IC) and the InnovationPressureTest (IPT).

- **TRL1 - Basic principles observed and reported**: This is the lowest level in the TRL framework, indicating that scientific research has just begun, and there is no practical application of the technology. At this stage a swift and rapid contest with low level of task specificity can be used to catalyse idea development. No requirements on novelty assurance can be stated. Instead, the organizer of the contest may provide support how the participating teams can self-assess the novelty in the ideas that they are crafting.
- **TRL2 - Technology concept formulated:** On this level, fundamental principles have been grasped through the innovation journey, and it is imperative to formulate a technological concept based on the outlined ideas. The application of a swift and agile contest approach could achieve this milestone. While the groundwork for technological ideas might have been laid, a greater level of task precision can be embraced at this juncture. Nevertheless, a key element of a contest during this phase could be granting teams the liberty to conceptualize their ideas with a heightened degree of creative freedom. A baseline for innovation could here stimulate innovation novelty as well as support to the teams to intellectual protect their technology concepts.

Therefore, if the objective of the innovation contest is to initiate innovation journeys at

TRL1 and TRL2 stages, the InnovationJam scheme emerges as highly relevant. The overall idea with this scheme is consequently to encourage and rapidly source innovative concepts.

- **TRL3 - Experimental proof of concept:** At this stage of the innovation journey, innovators are tasked with validating the concept through experimental testing and demonstrating its feasibility. When the scope narrows down to a specific aspect of the concept and necessary inputs like test data or user feedback are accessible, employing a rapid contest approach might facilitate reaching this readiness level for the delimited segment of the concept. Nevertheless, when it comes to substantiating the experimental proof of concept, a streamlined challenge process incorporating well-defined activities and evaluation criteria is likely necessary to ensure thorough verification. The InnovationJam scheme may not align with these requisites; instead, a more extended and precisely delineated contest approach appears to be more suitable.
- **TRL4 - Technology validated in a lab environment:** To attain this level of readiness, the promising technology undergoes further rigorous testing and validation within a controlled laboratory setting, progressing the concept into an emerging prototype. Innovation contests designed to bolster innovators at this juncture of their innovation journey can offer either a physical or virtual environment for laboratory validation. Additionally, they can furnish a well-structured process that enables participating teams to juxtapose their solutions against one another or in relation to existing alternatives. The assurance of innovation novelty is twofold: organizers provide support in assessing novelty, while teams substantiate claims of technological distinctiveness and superiority. This assessment should encompass a sustainability perspective, encompassing not only economic and efficiency facets of superiority, but also the societal and environmental impacts of the technology as it emerges as a prototype.
- **TRL5 - Technology validated in a relevant environment:** To reach this stage technology is tested and validated in a relevant environment, simulating real-world conditions. A contest to support teams on this level could for example be arranged within a living lab or in an environment that simulate real-world situations. Teams at this stage are well motivated and goal driven and to meet these expectations a defined process that is value creating for them at this stage is required. A contest at this stage could also be linked to private equity providers as the innovation journey at this stage if the technology is validated is in phase to leave applied research and development and move into preparation for deployment.

Hence, if the aim of the innovation endeavour is to advance teams from TRL3, TRL4, and TRL5 stages, the InnovationJam scheme may fall short as it too speedily delivers support for such significant advances. What is instead required is a scheme that offers heightened structure, focused value, and a more comprehensive approach throughout the ongoing innovation journey. The InnovationChallenge scheme, as exemplified in the 2021 edition of the SET4BIO challenge, is designed to meet these types of needs, fostering accelerated progression by transforming ingenious concepts into validated prototypes.

- **TRL6 - Technology demonstrated in a relevant environment:** To attain TRL6

readiness, the technology must be demonstrated within an operational or near-operational environment. At this phase of the innovation journey, the proof-of-technology involves a verified prototype system, which significantly surpasses TRL 5. This system is pressure-tested in a relevant environment, marking a substantial advancement in the technology's demonstrated readiness. Instances of this include testing a prototype in a high-fidelity laboratory setting or within a simulated operational context. An innovation contest at this stage aims to support the "pressure testing" of the emerging solution. This involves subjecting it to meticulous and rigorous evaluations, assessments, or simulations to gauge factors like robustness, viability, and performance under diverse and challenging conditions. This process is comparable to subjecting an object or system to extreme pressure or stress to evaluate its durability and to uncover potential weaknesses or vulnerabilities. The specific objective of this type of contest is to facilitate comparisons between teams and ensure that ample contributions attain this readiness level. Utilizing a suitable test and demonstration facility to host the contest presents an option to replicate a relevant environment effectively.

- **TRL7 - System prototype demonstration in an operational environment:** This readiness level requires that the technology has been developed into an emerging solution and demonstrated in an operational environment. From a contest perspective this can also take the form of a “pressure test” similar to the contest on TRL6 but performed in an operational environment; e.g. living lab, vehicle on open road or a production facility. Most likely this would involve one or several industry sponsors providing facilities to use to “pressure test” and validate the emerging solution.

If the goal of the innovation initiative is to propel teams through TRL6 and TRL7, the InnovationChallenge scheme might lack the capacity to promptly provide the essential support required beyond TRL6. To a certain degree a technology can be assessed in terms of business viability and scalability within the InnovationChallenge scheme (as demonstrated in SET4BIO Innovation Challenge 2021), but extensive technology validation requires yet another type of scheme compared to IJ and IC. This motivate the introduction of the InnovationPressureTest scheme to support the assessment of relevance and reliability of evolving and emerging technologies – from prototype to solution.

As a technology advances from TRL7 to TRL8 and 9, the journey shifts from an innovation-focused journey to one centred around deployment and operation. Within this project's scope, the exploration of how contests could facilitate progress at these readiness levels is not addressed. Instead, the focus within SET4BIO has been on examining how contests can support the developmental process, converting initial ideas or design concepts into tangible and emerging products or services from TRL1 to TRL7. How to use contests to support companies with technologies on TRL8 and 9 is consequently omitted in this report.

## Three Generic Innovation Contest Schemes

In the preceding section, the report outlined how three distinct contest schemes effectively can catalyse innovation journeys across the TRL scale. Being schemes they only provide an overall structural framework for the organizer to design the specific contest. In this format they deliver repeatable blueprints to use as a starting point when the objective with the innovation process has been determined, a that objective has been matched with the TRL scale. This section delves deeper into the clarification and examination of these three schemes, employing the SWOT model as an assessment tool. The tool has for this purpose been adopted to identify strengths, weaknesses, opportunities, and threats related to the schemes. These components have been defined as follows for this purpose:

- *Strengths*: reinforcing characteristics of the scheme
- *Weaknesses*: limiting characteristics of the scheme
- *Opportunities*: effects of the scheme that the organizer could exploit to an advantage
- *Threats*: effects of the scheme that the organizer must be prepared to manage

### Generic scheme 1: Innovation Jam (IJ) blueprint

The innovation jam scheme (IJ) is particularly effective in facilitating innovation journeys that are at a preliminary stage of readiness. According to Hjalmarsson et al (2017), this approach is characterized as a swift and highly inclusive contest phase as depicted in the blueprint, see figure 6. Its primary objective is twofold: firstly, to scout and nurture the conceptualization of ideas centred around a particular theme; secondly, to scrutinize and evaluate the resultant ideas, assigning them rankings and gauging their alignment with the readiness scale in its early phases.

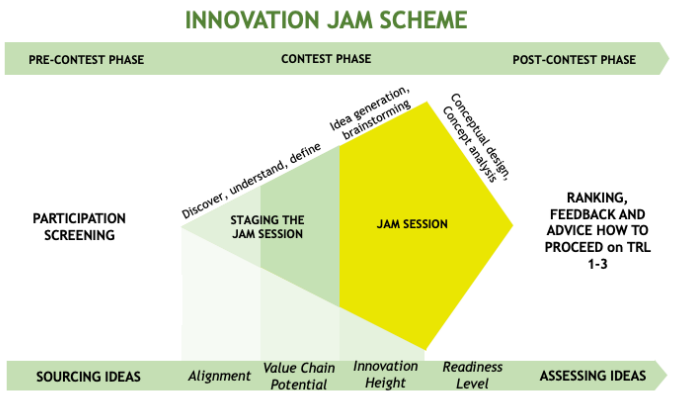


*Figure 6: Innovation Jam Scheme Blueprint*

Being truly inclusive entails ensuring that the screening process for participation is easily accessible and primarily oriented towards accommodating the capacity of the contest to incorporate participating teams into the proceedings. A low threshold for participation, however, does not imply a lack of quality standards. The thematic focus of the innovation jam plays a pivotal role in the participation screening process. Teams contributing their ideas should align with the theme chosen by the organizers for idea exploration.

Moreover, considering the IJ's distinctive attribute of fostering progressive learning and advancement of ideas on low readiness levels, team enrollment should encompass an evaluation of a team's ability to meaningfully engage in the jam session. During this session, ideas are not only generated but also assessed, reframed, and analyzed. Therefore, a team's responsiveness becomes a vital criterion for the participation screening, particularly when adopting the IJ scheme.

Strengths, weaknesses, threats and opportunities for IJs is summarized in figure 7. One significant strength of IJs is that they do not require the same level of organization, resources, and effort as the innovation challenge or innovation pressure test schemes. A jam session is both a swift strategy to adopt for a well-prepared and knowledgeable organizer, as well as an efficient scheme to execute. When executed proficiently, it becomes a mechanism for stakeholder mobilization within the field, which in turn can serve as a key success factor for the innovation jam.

However, an important distinction between this scheme and the other two schemes, innovation challenge and innovation pressure, is that IJs heavily rely on stakeholder engagement for both preparation and execution of the jam. The other two schemes involve, to a higher degree, process components, available infrastructure, and technological support that act as incentives for participants to contribute.

| Scheme type | Strengths | Weaknesses (limitations) | Opportunities | Threats (risks) |
|---|---|---|---|---|
| Innovation Jam (Apt for TRL 1-3) | • Rapid scheme and rapid events<br>• Stakeholder mobilization<br>• Align-Support-Conceptualise-Assess | • Outreach dependency<br>• Stand and falls with level of engagement<br>• Limitation in readiness progress | • Illuminating an emerging area in terms of benefits for the field<br>• Introduce new innovators to the field in focus for the contest<br>• Mechanism to promote a call-to-action | • Too high expectations<br>• No post-contest strategy<br>• Lack of experienced contest process management |

*Figure 7: SWOT overview for the Innovation Jam Scheme*

In an IJ, the success of the jam is largely based on the involvement of contributors in the entire jam process, from aligning ideas to conceptualizing and assessing them, to providing feedback to the participating. Consequently, weaknesses of this scheme are that success depends on effectively reaching out to and engaging participants, as well as maintaining their engagement during the jam session. To mitigate these weaknesses, the organizer must put forth efforts to identify and involve not only motivated teams but also experts within the field that want to engage in the jam. Their involvement can add value to teams when they are shaping their ideas. Collaborative learning and knowledge sharing is of essence here. Additionally, other appropriate resources that enhance the value of the jam

as a constructive event should also be considered. A third weakness of this scheme is that the progress towards higher readiness is relatively low. Advances from an IJ in term of output should be anticipated to occur within the current readiness level, or at the most, from TRL1 to TRL2.

An advantageous effect of implementing the IJ scheme is that could serve as a powerful tool for shedding light on the potential value that could be harnessed within a specific field, such as bioenergy. This can be achieved through the pursuit of technological advancements in emerging areas like AI, or by synergizing various technological domains to create novel products and services. The IJ thus serves a dual purpose: it acts as a catalyst for uniting innovative minds, fostering new collaborations, and facilitating the early-stage development of visionary concepts. Furthermore, it enables the assessment of the feasibility of integrating new technologies into established value chains.

The IJ may also function as a lighthouse for attracting talented innovators from one domain to actively participate in the focal field of the contest. This strategic move not only introduces new perspectives but also unlocks fresh market opportunities, thereby offsetting products and services that have been developed in other domains. Another strategic path available to organizers is the utilization of the IJ as a dynamic mechanism to rally participants into action. This could encompass launching innovation journeys geared towards contributing to technology roadmaps, charting well-defined value pathways, or crafting solutions aligned with ambitious and forward-reaching visions.

As an organizer, it is important not to hold or project excessively high expectations regarding the readiness level leap when implementing the IJ scheme. Furthermore, there is a risk associated with conducting too many IJs without implementing a post-contest strategy after completing the events. This overabundance of IJs may lead to a waning interest in participating in innovation jams. The enthusiasm to engage and contribute during the initial stages of innovation journeys is fostered by the knowledge that past journeys have yielded successful outcomes.

Using the IJ scheme as a tool without a comprehensive post-contest strategy, including the organizer's long-term plan for leveraging IJs and potential support for participating teams as they progress in their journeys, jeopardizes the potential long-term benefits and positive effects of utilizing IJs. The absence of experienced contest process management within the organizer's skill set may exacerbate the impact of such a potential threat.

## Generic scheme 2: Innovation Challenge (IC) blueprint

In comparison to the Innovation Jam, the Innovation Challenge (IC) scheme establishes a systematic process over time to enable organizers to determine the potential scalability of emerging technologies. Aligned with the Technology Readiness Level (TRL) framework, the IC scheme proves particularly well-suited for adoption when competing teams are transitioning from a conceptualized idea to a thoroughly vetted and assessed proof-of-concept. Similarly, it finds relevance between TRL levels 4 and 5, as teams progress in their innovation journey, transforming concepts into component-level prototypes.

The SET4BIO Innovation Challenge 2021 exemplified the operationalization of this scheme

through a staged process. Its overarching objective is to empower teams in accelerating their concepts into tangible prototypes. A significant hallmark of this scheme is its structured progression, which encourages participating teams to evolve their solutions within predefined themed activities. This collaborative evolution of the outcome serves as a catalyst, propelling teams to achieve a readiness level at the culmination of the IC that surpasses their initial status upon entering the innovation challenge.

As depicted in Figure 8, the implementation of the blueprint for this scheme entails a combination of supportive events and evaluative activities. This approach fosters both competitive and collaborative stages within the innovation challenge.

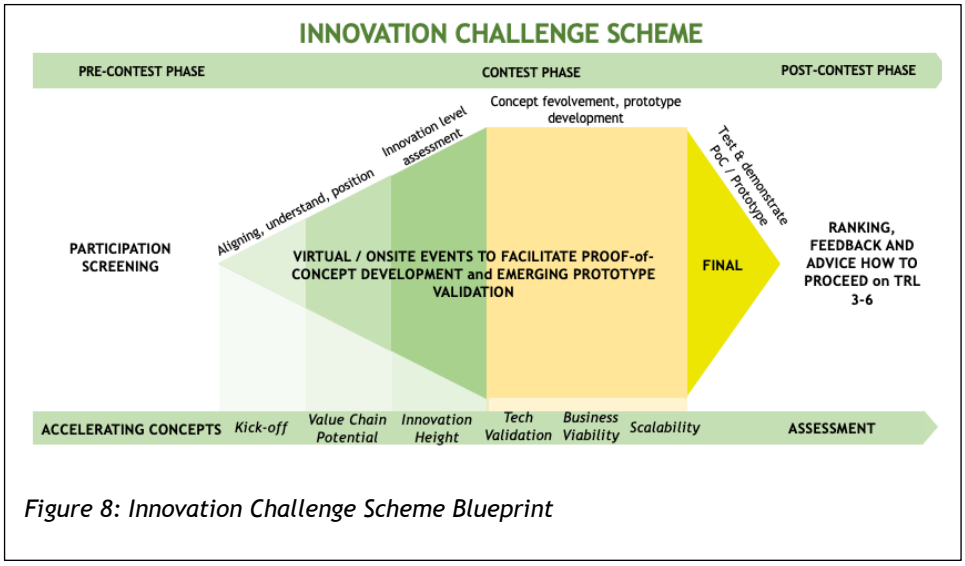


*Figure 8: Innovation Challenge Scheme Blueprint*

A key characteristic that sets Innovation Challenges (IC) apart from innovation jams is the scheme's longer time frame. This extended duration serves as a strength, allowing participating teams to effectively execute and showcase developmental outcomes. By structuring the process as a sequence of staged virtual and/or onsite events, the evolving concept undergoes thorough vetting from multiple angles. This approach facilitates advancements in technology readiness, encompassing not only the technical dimension but also considerations related to business viability and potential market adoption.

During the operationalization of the scheme prior to the contest phase, organizers must adopt a strategic mindset aligning the themes for the events with the appropriate Technology Readiness Level (TRL). This strategic design decision will during the operation of the contest phase assure that the gradual assessment and acceleration of concepts into emerging prototypes have a fit with the TRLs in focus for the IC.

Strengths, weaknesses, threats and opportunities for ICs is summarized in figure 9. One limitation of the IC scheme is that participating teams must possess an appropriate Technology Readiness Level (TRL) to fully benefit from the process. This places an onus on the organizer to discern, attract, and screen teams whose concepts align with the requisite TRL level. The SET4BIO Innovation Challenge 2021 offers insights into addressing this limitation, demonstrating a dual approach of expansive marketing endeavours and targeted recruitment initiatives to draw in suitable teams for the challenge. This serves

to underscore that organizing an IC is inherently less resource-efficient compared to orchestrating an innovation jam.

For an IC, the organizer must most likely ensure adequate funding capacity not only for the pre-challenge phase but also for sustained operation throughout the challenge duration. One strategic approach to manage this is to secure separate funding for the initial design of the innovation challenge. The results of this design project can then guide the determination of the funds necessary for marketing, operations, and post-event follow-up of the IC itself.

By conceptualizing the IC design as a distinct, separate project decoupled from the contest's operation, resources can also be devoted to identifying and preparing accessible support mechanisms to assist participating teams in advancing their solutions throughout the IC process. However, in comparison to the innovation jam, the IC becomes a substantially larger endeavour to manage. Conversely, this expanded scope presents the potential to cultivate tangible solutions that signal the capacity to exert an impact on a market or society. This capability empowers organizers to catalyse specific fields with new solutions and provide support to innovators in navigating the "innovation valley of death," which characterizes a challenging stage in the innovation process where promising ideas or technologies struggle to progress from the research and development phase to actual implementation. These gaps arise between the early stages of innovation, where concepts are developed and proven in a controlled environment, and the subsequent stages where they are transformed into viable products, services, or businesses. An IC provides a facilitated effort to support innovation teams to bridge the initial gaps in this part of their journey.

| Scheme type | Strengths | Weaknesses (limitations) | Opportunities | Threats (risks) |
|---|---|---|---|---|
| Innovation Challenge (Apt for TRL3-6) | • Time is provided for development<br>• Collaborative actions combined with competitive ranking<br>• Evolving concept vetting from multiple perspectives | • Requires teams that are at an appropriate TRL level.<br>• Not as resource efficient as an Innovation Jam<br>• Accessible building blocks to accelerate innovation, which most likely require separate funding to ensure availability | • Foster tangible solutions with potential to make an impact<br>• Strengthen a field with new solutions<br>• Enabler for teams and initiatives to survive the innovation valley of death | • Intellectual property concerns<br>• Teams runs out of funding or focus<br>• Lack of contest process management skills |

*Figure 9: SWOT overview for the Innovation Challenge Scheme*

A potential threat that emerges as a solution takes shape is the concern surrounding intellectual property. More so than in an innovation jam, the contest's design necessitates the implementation of rules and procedures aimed at assisting teams in safeguarding their intellectual property. Simultaneously, these measures must support a collaborative and open process characteristic of an IC. Consequently, it becomes apparent that the contest

process management skills required for an IC only partially coincide with those needed to organize an innovation jam. The dynamic creative environment inherent in an innovation jam must be complemented by a systematic and structured process within the IC. This process ensures that proprietary background knowledge introduced and evolving intellectual property generated throughout the process are adequately protected by the participating teams. One approach to accomplish this, complemented by explicit rule about intellectual property rights in the participation rules for the IC, is to support teams on TRL3/4 to increase their capacity to protect their solution as it evolves.

## Generic scheme 3: Innovation Pressure Test (IPT) blueprint

Within the SET4BIO project, the innovation jam and innovation challenge schemes were individually adopted to enhance the realization of the SET Action Plan 8. However, this third scheme remains untested within the SET4BIO project framework. Nevertheless, with the intention of exploring and proposing the design of a contest that effectively supports innovation journeys within TRLs 5-7, this report introduces a more tentative innovation pressure testing scheme.

Our perspective underscores the notion that achieving readiness levels of 5, and undoubtedly TRL 6 and 7, requires subjecting emerging solutions to a "pressure test" to assess their functional capabilities and intended effects. In the context of innovation, pressure testing involves a contest that pushes the boundaries of the innovation, evaluating diverse scenarios, potential obstacles, and real-world challenges it might encounter. We argue that this process benefits both the solution's team and the contest organizers by revealing any shortcomings, limitations, or areas in need of enhancement. This enables innovators to refine and strengthen their innovation before full implementation or market introduction (ultimately reaching TRL 8 and 9).

The goal of the Innovation Pressure Test (IPT) scheme is to design a competition that serves to ensure the innovation's resilience and effectiveness under the pressures and uncertainties of operational environments. The aim of the process is to validate the emerging solution's ability to efficiently deliver the anticipated outcomes and to rank it relative to competing contributions within the same category of solutions. The implementation of this aim becomes evident in the blueprint of the IPT scheme, see figure 10.

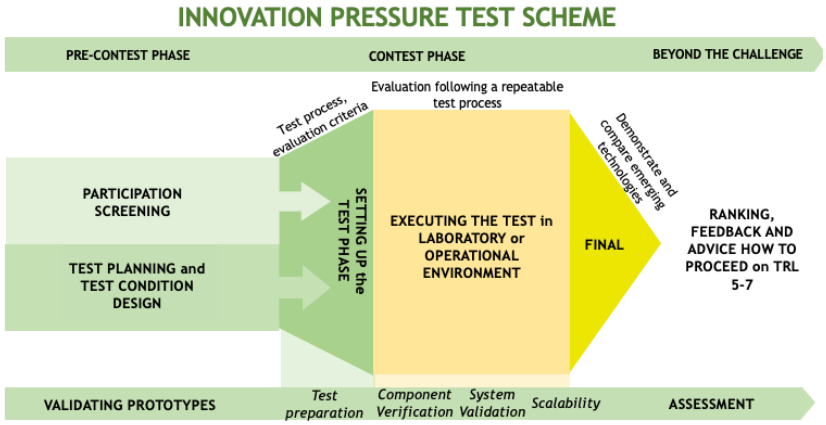


*Figure 10: Innovation Pressure Test Scheme Blueprint*

The objective of this scheme is to establish the foundation for a process where emerging technologies are demonstrated and compared at TRLs 5-7, requiring a repeatable testing process that can be reused for each contribution. The high level of rigor and precise repetition of each evaluation form the basis for a comparable and equitable assessment of each contribution. While the innovation jam and innovation challenge assessment rely on criteria-based subjective evaluation, focusing on the idea, concept, and prototype as outputs, the IPT places automated criteria-based evaluation at the forefront as the method for assessing contest contributions. A driving factor for this approach is that, at this stage, the evolving technology is the central focus in terms of the solution. Questions pertaining to the technology's functionality and the most suitable technical approach to address the challenge take precedence. Consequently, in parallel with encouraging teams to participate in an IPT contest, careful planning of the actual test and definition of test conditions are imperative. This planning forms a component of engaging teams in the contest, as the testing and ranking process is likely viewed as an incentive for participation in the evaluation.

The opportunity to subject a solution to a pressure test within a test-and-demonstration facility or within a living lab under operational conditions is undeniably valuable for teams that have reached this stage in their innovation journey. To attract participants to attend an IPT, this opportunity could serve as a key selling point to advertise the chance to demonstrate and compare emerging technologies at TRLs 5-7. Strengths, weaknesses, threats and opportunities for IPTs is summarized in figure 11.

| Scheme type | Strengths | Weaknesses (limitations) | Opportunities | Threats (risks) |
|---|---|---|---|---|
| Innovation Pressure Test (Apt for TRL5-7) | • Establish connections between entrepreneurial innovation journeys and test and demonstration facilities or well-established living labs.<br>• Validate and enhance the quality of emerging technology solutions.<br>• Support the transition from the innovation phase to the industrialization phase of a solution, bridging the gap effectively. | • The scheme depends on the availability of test and demonstration facilities.<br>• Rigorous and time-consuming preparations are necessary.<br>• IPT requires a culture as well as novel business models where open innovation is used as an intermediary between R&D and industrialization. | • Accelerate the process of bringing viable solutions to the market more rapidly.<br>• Create additional value from previous investments in test and demonstration facilities, as well as living labs.<br>• Foster an innovative climate in Europe, fostering collaboration between countries, SMEs, large corporations, and national research and innovation agencies. | • The evaluation process is not perceived as fair and comparable<br>• Lack of resources to organize and participate in IPT based contests<br>• Intellectual property concerns |

*Figure 11: SWOT overview for the Innovation Pressure Test scheme*

## Contest scheme selection criteria

A generic contest scheme, as referred to in this report, encompasses a versatile framework that can be applied across various situations, contexts, or scenarios. It serves as a flexible template, providing a foundational structure while allowing customization and adaptation to specific needs or conditions as determined by the organizers' objectives and ambitions. The generic contest scheme offers a standardized approach that should be tailored to suit the specific goals of the contest. It aids the organizers in streamlining processes, promoting consistency, and facilitating communication by establishing a common structure that all involved stakeholders can comprehend and work with.

When organizers are in the process designing a contest and thus selecting a scheme, the guiding criteria should, on one hand be the objectives to be achieved through the contest. On the other hand, consideration should be given to the readiness level that participating teams possess at the outset of the contest and the level to which the teams should aspire to reach during the contest, see figure 12.

If the goal is to swiftly source and stimulate innovative concepts, then an innovation jam is likely the most suitable scheme to adopt. However, if the aim is to support teams in accelerating concepts to prototypes that demonstrate the technology's value, then the innovation challenge scheme is more appropriate. This scheme allows teams to work with

extended time and focus. For impact at higher readiness levels, a generally more structured approach is required. In these cases, if the objective is to further expedite the design and construction of emerging prototypes, then the innovation challenge scheme can also be appropriate up to TRL6 as a blueprint. Nonetheless, if the objective is to demonstrate effects and rank solutions in terms of efficiency, then the innovation pressure test scheme is the appropriate blueprint to employ.

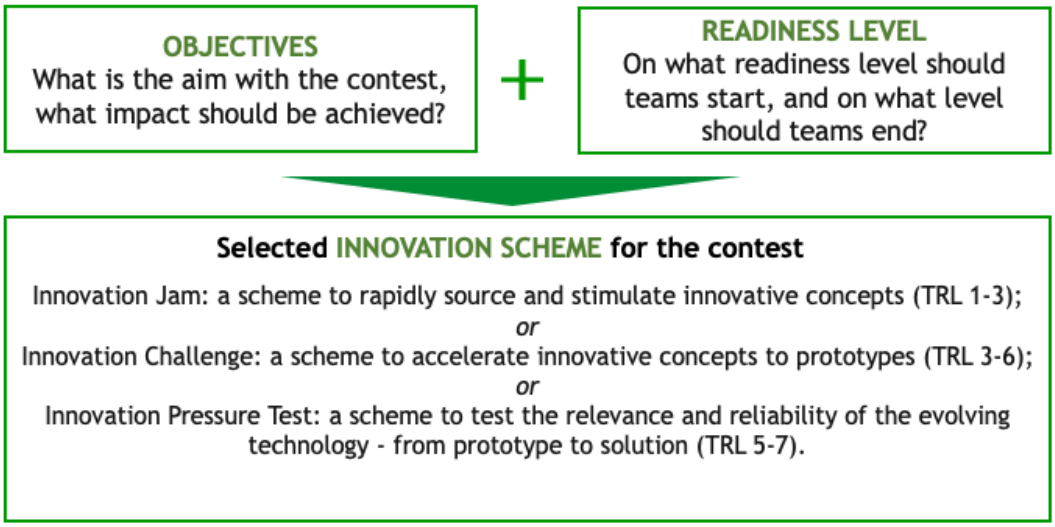


*Figure 12: Criteria to select appropriate innovation contest scheme*

These three schemes aim to assist organizers in developing a suitable contest design, they serve as input within the 'design contest' phase of the contest management approach proposed by Hjalmarsson et al. (2017). The generic scheme selected provide a basic structure for the contest process, it will require further refinement and specific design to address the unique aspects of each situation it is applied to. In Hjalmarsson et al (2017) fifteen design elements are provided to transform the selected contest scheme to a proper process from start to end.

## Chapter 4 – Outlook and concluding notes

Many different labels are used for denoting innovation contests, e.g., innovation competition, innovation tournament, idea jam, design contest and design price. SET4BIO proposes in this report three contest schemes to catalyse innovations throughout the TRL scale. These are:

- Innovation Jam: a scheme to rapidly source and stimulate innovative concepts (TRL 1-3);
- Innovation Challenge: a scheme to accelerate innovative concepts to prototypes (TRL 3-6);
- Innovation Pressure Test: a scheme to test the relevance and reliability of the evolving technology - from prototype to solution (TRL 5-7).

Within SET4BIO, the Innovation Jam scheme was adopted for the 2023 instalment of the SETI4BIO Innovation Challenge Light. The Innovation Challenge scheme was previously adopted for the SET4BIO Innovation Challenge in the year 2021 and is described in detail in documents D3.1 and D3.2. For future initiatives, the Innovation Pressure Test is of interest for adoption and testing. Additionally, there is an interest in investigating how the different schemes could be interconnected to form a comprehensive innovation support structure, providing assistance to teams from the idea stage (TRL 1) to the assessment of emerging solutions (TRL 7).

Commonly, innovation challenges are employed as isolated events to catalyze innovation within a specific field at a given time. The experiences gained from the SET4BIO project suggest that it is likely that extended and sustainable value could be generated if a program is established, utilizing contests on a regular basis with various schemes to support innovative teams throughout their innovation journeys. Such approach enable also investigating the dynamics when managing innovation within a field over time. Given the ambition in Europe to boost the production and use of bioenergy and renewable fuel in different applications, systematic use of innovation challenges along the TRL scale can complement the provision of funding when innovative initiatives are supported.

Together with the three additional reports from WP3 (D3.1, D3.2 and D3.4), this report, D3.3, constitutes a repeatable toolbox component developed from the SET4BIO project to be re-used to mobilise additional support for the SET Plan Action 8. The deliverables in WP3 thus together provide a complete description of the model to support re-use and adoption in future initiatives and projects. D3.2 “Experiences from the SET4BIO challenges“ provides an account of the instalment of the SET4BIO Innovation Challenge anno 2021, from early development and design to the final assessment and last assessment. It serves as a continued display of the architecture of the SET4BIO Innovation Challenge anno 2021 and is presented as a repeatable model to be re-used to further mobilise support the implementation of the SET Plan Action 8 – Renewable Fuels and Bioenergy in Europe. For preparing this report, the following deliverable/s have been taken into consideration. D3.1 “Innovation Challenge in SET4BIO“ provide an account of the design and launch of the challenge and D3.4 “Identification of topics for SET4BIO Innovation Challenge“ provide an in-depth account of the process to design the specific topic for the first instalment of the challenge, and thus a more detailed description of the process to set the goals for the challenge.

| D# | Deliverable title | Lead Beneficiary | Type | Dissemination level | Due date (in MM) |
|---|---|---|---|---|---|
| D3.1 | Innovation Challenge in SET4BIO | RISE | Report | Public | M24 |
| D3.2 | Experiences from the SET4BIO challenges | RISE | Report | Public | M30 |

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| D3.4 | Identification of topics for SET4BIO Innovation Challenge | RISE | Report | Public | M12 |

## References


Héder, M., (2017): From NASA to EU: The evolution of the TRL scale in public sector innovation. The Innovation Journal, 22(2), 1–23.

Hjalmarsson, A., Juell-Skielse, G., Johannesson, P. (2017): Open Digital Innovation: A Contest Driven Approach. Springer-Verlag, Berlin Heidelberg, Germany.

Hjalmarsson, A., Rudmark D., (2012): Designing Digital Innovation Contests in K. Peffers, M. Rothenberger, and B. Kuechler (Eds.): DESRIST 2012, LNCS 7286, pp. 9–27, 2012.

Mankins, J., C., (1995): Technology Readiness Level, a white paper. Washington, DC: NASA.

Meystel, A., Albus, J., Messina, E., & Leedom, D., (2003): Performance measures for intelligent systems: Measures of technology readiness. Gaithersburg, MD: National Inst of Standards and Technology.

Uren, V., Edwards, J., S., (2023): Technology readiness and the organizational journey towards AI adoption: An empirical study. International Journal of Information Management 68 (2023) 102588.