Toolkit
Using Inventions in the Public Domain

Tool 10
Technology Forecasting

WIPO

Tool 10/ Technology Forecasting

The Technology Forecasting tool is used to examine the technology selected for the preliminary design of a product or service and explore what other options may exist, either today or in a relevant time frame going forward, that are superior and thus should replace a technology when preparing the final design specifications. This time frame is usually the period in which the product or service will be produced and sold or provided.

What is technology forecasting?

Technology forecasting requires a clear understanding of the core benefits and tangible and intangible features desired by customers and end-users, as these together constitute the first criterion that is used to determine what is, or is not, a superior option for the final design. Another way to think of this first criterion is to ask: what is the performance, cost and ease of use being sought by your intended customers and end-users? A second criterion asks: what reduces the cost or difficulty of producing, selling, distributing, supporting and, in general, conducting the activities in the value chain? In other words, what drives technology forecasting is the importance of searching for ways to increase the value of your product or service for its customers and end-users, and/or for the entities developing, making, selling and supporting it.

In the process of technology forecasting, you identify the systems, subsystems and components to be used in the product or service. In the rest of this document, and in the associated workbook, the term “parts” will be used to encompass all of these.

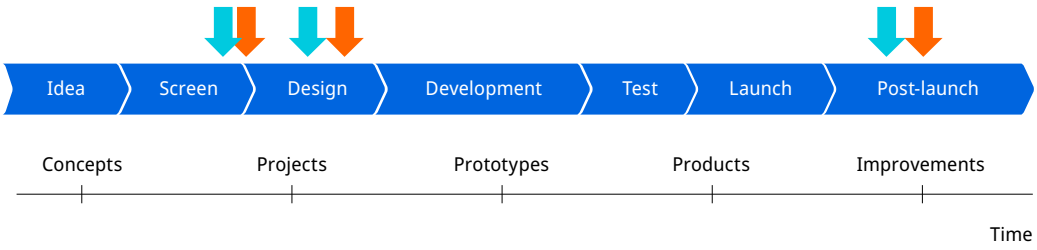
A good forecast always considers three time periods: near term, mid term and long term. It identifies the technologies to be used in the product or service design to improve its attractiveness to customers and end-users. It recognizes that the time to start thinking about the last step in new product development (NPD), post-launch improvements, should be no later than the end of the Screen stage, because you want to ensure that your product or service does not become obsolete as new technology enters the market and your product design does not allow incorporating and integrating the kinds of upgrades necessary to remain competitive.

Through its focus on how options for meeting requirements for core benefits and providing desired tangible features may change over time, technology forecasting is critical for designing a product or service that is likely to have a competitive advantage both upon launch and for the necessary period of time for generating the financial returns desired. Without conducting at least one round of technology forecasting, you risk being blindsided by the emergence of products that incorporate technology which can better satisfy customer and end-user needs.

Technology forecasting is done when entering the Design stage, shortly after initiation of a formal design project. It facilitates determining the systems, subsystems and components to be included in the design. In other words, it is a tool for identifying the parts out of which the product or service will be made. When diligently done, it requires

considering various options for parts and whether the currently preferred option will need to be replaced later in the life of the product or service in order to maintain a competitive advantage.

Figure 1: **NPD stages and gates. The blue arrow shows the Technology Forecasting tool being used when entering the Design stage. It is reviewed and revised as needed shortly after the Business Model Canvas tool is completed in the Design stage. Another process of review and revision is done in the Post-launch stage to assess how to proceed with product or service upgrades and develop new products or services in the line or family.**



Technology foresting is done using the product, patent, and research and development (R&D) searching methods used in the Competitive Advantage tool. If you are unfamiliar with those methods, you should review them before proceeding. When using those methods here, you may not always find a specific deployable technology. This type of result may nonetheless be worth noting and tracking because you are looking for future options that enable competitive advantage. If you do not find anything, that suggests the currently selected technology is a good one to use in your design.

Because this analysis considers future options, be aware that you cannot assume the tangible features, or even the core benefits, sought by customers or end-users are static. Those too may change over time. Additional market research may be needed to confirm this, and the Voice of the Customer tool may provide insights. The methods described there can be adapted to seek further information on current customer and end-user requirements and how they might change.

These points can be illustrated by looking at the example of electric bicycles. Globally, the electric bike (e-bike) market was valued at USD 40,312 million in 2019 and is expected to grow to USD 118,657 million by the end of this decade. That is a compound annual growth rate (CAGR) of 10.5 percent over the next 10 years.[1] The market is currently divided between three types of batteries: lead acid, lithium-ion and other. The cost of the battery is a major factor in the cost of the e-bike, which in turn is a major factor in consumer purchasing.

A better performing, less expensive battery would deliver a major competitive advantage. Better performance could be defined by distance per charge, time to charge and cost to charge. Searching on "Electric Battery Roadmap" turns up several transportation hits which could be relevant for bicycles. These include a U.S. DRIVE report from September 2017 called Electrochemical Energy Storage Technical Team Roadmap (available from www.energy.gov). U.S. DRIVE is a US Department of Energy-led government–industry partnership. U.S. DRIVE focuses on lithium-sulfur and lithium-air as well as various lithium-metal approaches in addition to improvements to lithium-ion. The European Union's EUROBAT also has a battery roadmap called E-Mobility Battery R&D Roadmap 2030 (available from www.eurobat.org). In it, they focus on three existing battery technologies (advanced lead-based, lithium-ion and sodium nickel chloride batteries), which they believe have the greatest potential for improvement over the next decade.

For the purposes of this illustration, two things are important.

First, the e-bike is a relatively new product for which there was no demand until the combination of aging populations, climate change and air pollution, and technological progress made them

1 Allied Market Research, Electric Bike Market Size, Share, Competitive Landscape and Trend Analysis Report, by Product, Drive Mechanism and Battery Type: Global Opportunity Analysis and Industry Forecast, 2020–2030 (www.alliedmarketresearch.com), 2021, accessed September 20, 2021.

feasible. Only when they reached a performance and price threshold did buyers start to switch from traditional bikes or motor scooters to e-bikes. If you looked at customer and end-user needs prior to that threshold being attained, you would have found little interest in battery power as a tangible feature for a bicycle for local transportation.

Second, the batteries on the market today are not likely to be the best options within the life span of an electric bicycle product line. Further, some of the battery types being developed may not even be in existence today, but they still may be important options so you should include them in your technology forecast. Their inclusion means management may wish to determine who is likely to license them, so they can be approached about licensing or buying these future battery types. The NPD team will probably want to become beta testers of the batteries to determine if they should adopt them in the future. Finally, the team may even consider licensing a new battery technology for the e-bicycle field of use and making it under a sublicense to secure a future competitive advantage.

The Technology Forecasting tool is designed to be used in connection with Module III "Integrating public domain knowledge into product development processes," section 8 "Screening product concepts" and sub-section 8.5 "Technology intelligence through patents to study evolving technology trends and innovation" of the WIPO publication *Using Inventions in the Public Domain: A Guide for Inventors and Entrepreneurs* (2020). It also supports Module III "FTO Search: Finding sources of information to identify inventions in the public domain and carrying out an FTO search" and section 2 "Preparing for search: Deconstructing the invention" of the WIPO publication *Identifying Inventions in the Public Domain: A Guide for Inventors and Entrepreneurs* (2020).

How do you enter data in the Technology Forecasting tool?

Data is entered into the Technology Forecasting tool and analyzed in three steps. In the first step, you conduct a functional decomposition to identify the systems, subsystems and components that comprise your product or service. In the second step, you scan the horizon for current and future technologies for those parts that can provide the tangible functionalities desired by customers and end-users. In the final step, you select which technologies will be incorporated into the product or service design, and which will be stored for future deployment.

Functional decomposition of the product or service to identify desired functionalities

The first step begins with a functional decomposition of the product or service so you can identify what kinds of technology you are searching for. The framework for doing a functional decomposition is described briefly in connection with the Freedom to Operate (FTO) tool in this Toolkit, and in more detail in Module III "FTO Search: Finding sources of information to identify inventions in the public domain and carrying out an FTO search" and section 2 "Preparing for search: Deconstructing the invention" of *Identifying Inventions in the Public Domain: A Guide for Inventors and Entrepreneurs* (2020). That framework is shown in Figure 2, reproduced from the guide.

Figure 2: Framework for a functional decomposition.

Features

- **Device**
  - Form
  - Parts, structure
  - How it functions
  - The effect it produces
- **Process**
  - Sequence of steps
- **Combination of devices and process**
  - Has an end product
  - Does not have an end product
- **New chemical substance**
- **New use for a known substance**

To develop your functional decomposition, four methods are helpful.

The first method is to search the patent literature for related inventions. This method leverages public domain information in the patent literature.

Both the description of the invention and the drawings in a patent document can provide suggestions for your functional decomposition. Figure 3 was found by searching the WIPO PATENTSCOPE database using the search string "biofuels from biomass." Additional drawings and the description are found in the patent document.

Figure 3: Example of a functional decomposition contained in a patent document on the WIPO PATENTSCOPE database.

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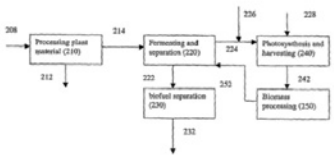
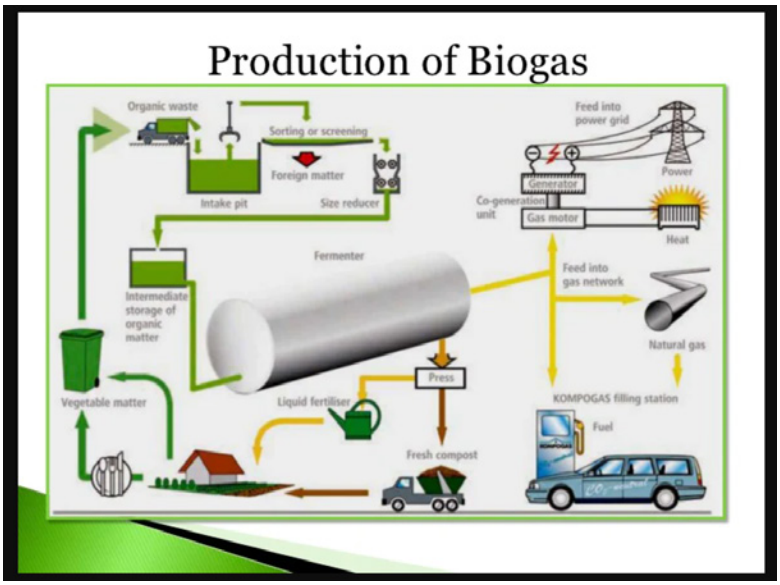
Title
[EN] BIOFUEL PRODUCTION
[FR] PRODUCTION DE BIOCARBURANT



Abstract
[EN]
A method for biofuel production is disclosed. The method includes providing a first photosynthesis product. The method also includes processing the first photosynthesis product to form a product mixture comprising a first biofuel and CO_2. The method also includes separating CO_2 from the product mixture. The method also includes growing biomass in a photosynthesis process, which biomass comprises a second photosynthesis product. The method also includes providing CO_2 to the growing biomass, wherein at least part of the CO_2 is consumed in the photosynthesis process. The method also includes optionally harvesting the grown biomass.
[FR]
L'invention concerne une méthode pour produire du biocarburant. Cette méthode consiste à obtenir un premier produit de photosynthèse. Cette méthode consiste également à traiter ce premier produit de photosynthèse pour former un mélange de produits comprenant un premier biocarburant et du CO_2. Cette méthode consiste également à séparer le CO_2 du mélange de produits obtenu. Cette méthode consiste encore à créer une biomasse par un processus de photosynthèse, cette biomasse comprenant un second produit de photosynthèse. Puis la méthode consiste à fournir du CO_2 à la biomasse en cours de formation, au moins une partie de ce CO_2 étant consommée pendant le processus de photosynthèse. La méthode consiste éventuellement à récolter la biomasse formée.

The second method is to search for a schematic or diagram of the part of interest. Figure 4 is an example of diagram found on the web by using the search string "biofuel refinery diagram."[2]

Figure 4: Biofuel refinery diagram found through web research.



The third method is similar to the second. In this case, you are looking for videos and multimedia presentations. Figure 5 is an example found using the search string "biofuels refinery." This video explains the one-step conversion of waste to biofuels using a microorganism.[3]

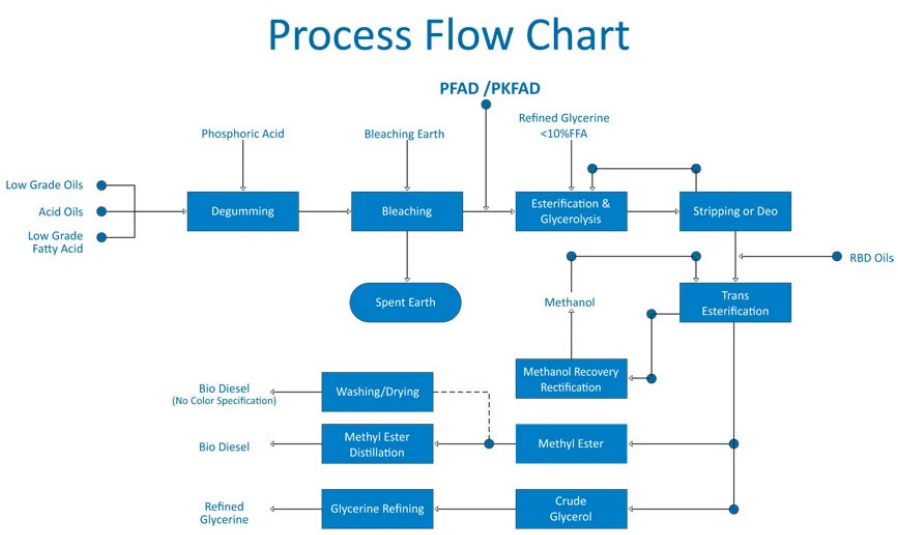
Figure 5: Example of a video found through web research that can provide suggestions for your functional decomposition.

2 biofuel refinery Diagram - Bing images, accessed September 20, 2021. The image is from Ybañez, "Vegetable oil and biofuel industry," November 21, 2011, on Slideshare, Vegetable oil and biofuel industry [autosaved] [autosaved] [autosaved] (slideshare.net).

3 "Breakthrough: Using Microbes to Make Advanced Biofuels, JointBioenergyInst, https://www.youtube.com/watch?v=oFH56nvzYQk, February 25, 2013, accessed November 5, 2023.

The fourth method is to look at the websites of biofuels companies for schematics and parts lists. Figure 6 is an example of a biofuel plant from the manufacturer Mectech Process Engineers in India.[4]

Figure 6: A flow chart that provides a functional decomposition of a vendor's plant found through web research.



After viewing several examples, begin developing the functional decomposition of your product. Repeat the process as necessary to drill down to systems, subsystems and components. As you develop your functional decomposition, record the results in the first four columns (A, B, C, D) of the matrix provided on the "Forecasting" tab of the Technology Forecasting workbook. During this search process, you can store the location of webpages and other information on the "Notes and references" tab of the tool.

Figure 7 is an example of functional decomposition of a mini-refinery using the Technology Forecasting tool with the biofuels example.

4 https://wakelet.com/wake/R6DIcWGvPwVd03UWr1ZtB, accessed August, 8, 2024.

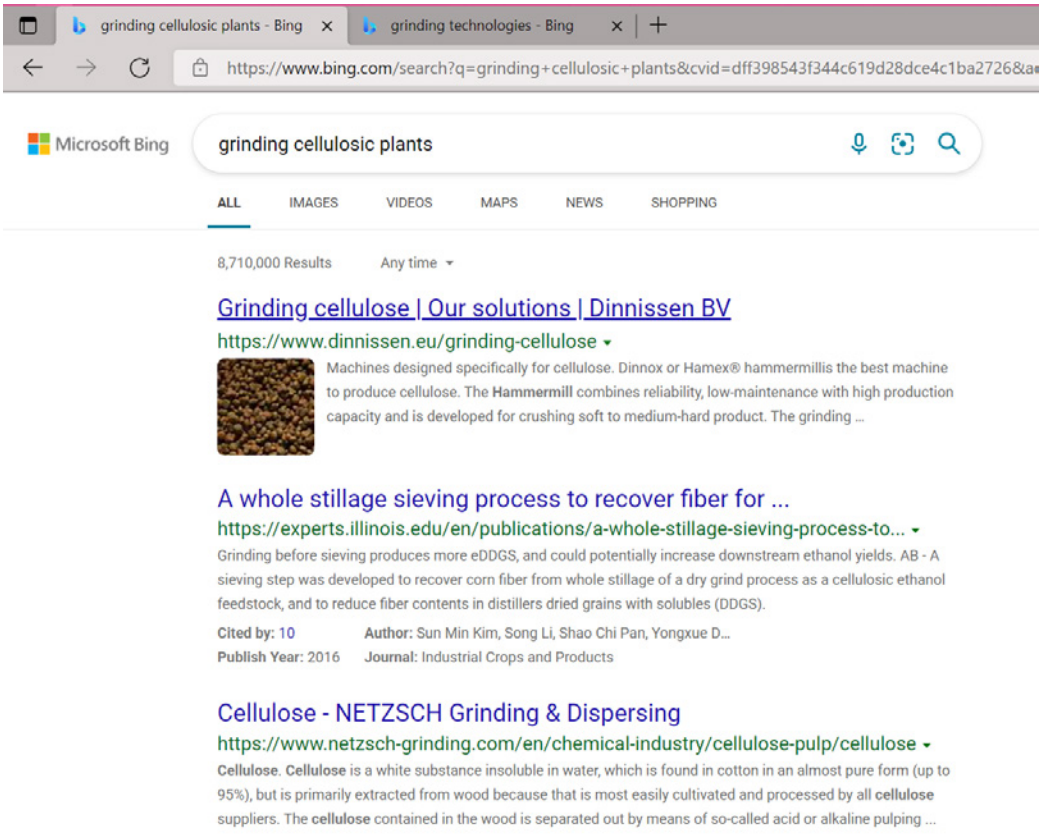
Figure 7: A part of the functional decomposition of the mini-refinery using the biofuels example on the "Forecasting" tab of the Technology Forecasting workbook.

Functional decomposition of product or service			
Product or service name		**Mini-refinery**	
Key subsystems or standalone components	**Function of subsystem or component**	**System, subsystem or component**	**Function of system, subsystem or component**
1. Chipper	Cut up biomass so it can be mulched		
		1.1. Blades	Cutting
		1.2. Conveyer or feeder	Carry biomass to blades
		1.3. Hand, arm, and face protector	Ensure user safety while allowing biomass to pass onto the feeder, and prevent pieces that are too large from entering the chipper.
		1.3. Grating	Percentage of biomass that is too large to enter the mulcher
		1.5. Conveyer or feeder	Transport biomass to the mulcher
		1.6. Power electronics	Control, monitor, and supply power to the unit.
		1.7. Blade resistance sensor	Clog detector
		1.8	
		1.9	
		1.10.	
2. Mulcher	Grind and pulverize biomass to dimensions suitable for digestion by organisms		
		2.1. Blades	Cutting
		2.2. Conveyer or feeder	Transport biomass to the blades
		3.3. Pulverizer	Grind biomass and break up its cells
		2.4 Grating	Prevent unfinished slurry from entering the mulcher
		2.5. Size sensor at grating	Determine if slurry is suitable for entry into the processing vat
		2.6. Door	An automatic door that remains closed until the sensor confirms the slurry meets the criteria. The door then repositions itself if the slurry fails to meet the requirements.
		2.7. Power electronics	Control, monitor, and supply power to the unit.

Search for technological options that can provide desired functionalities

Next, search patent databases, the trade press, press releases on innovative research results, and the refereed literature for technological options which can provide the desired functionalities. You are searching on the desired functionalities, or the name of the part, or both. Examples of functionality searching that would be relevant to processing biomass to use in the mini-refineries of the biofuels example are "grinding cellulosic plants" or "grinding technology" (see Figure 8).

Figure 8: Example of searching by functionality.



In general, start to search more broadly and then refine your search to focus on the results you seek. The search string “industrial grinder for plants” is a general part-based search. It turned up the non-intuitive result of grinders for cannabis. In the biofuels example, a small-scale, low-cost system is being developed so this option is worth exploring to see if it meets the customers’ and end-users’ needs. Broader searches have a higher likelihood of turning up serendipitous results.

By revising the search string to the more precise “industrial grinder for biomass,” more focused technologies and parts are found. Another revision to the string, “innovative grinders for biomass,” returns newer and emerging technological solutions. Adding “low-cost” to the string (“low-cost innovative grinders for biomass”) brings even more interesting results.

Note that the methods used for searching in the Competitive Advantage tool are similar to the methods being discussed here. The Competitive Advantage tool can be used concurrently with the Technology Forecasting tool, if desired, to evaluate various alternatives and select the three with the greatest potential for enhancing the competitive advantage for the product you are designing. As before, you can store the location of webpages and other information on the “Notes and references” tab.

When you are ready to enter interesting technological options you have found, move to the second section of the “Forecasting” tab, entitled “Technological options for providing the functionality” (columns E, F, G and H). Enter the results from your searches in these columns. Column E is for the technology you anticipate using. The other columns are for recording up to three current or future alternative technologies you might substitute or add.

Figure 9 provides an example from the biofuels example workbook for this tool.

Figure 9: Options for providing the desired functionalities using the biofuels example. Note that some columns have been hidden in this example from the workbook for better readability.

Functional decomposition of product or service		Technological options for providing the functionality	
Product or service name	**Mini-refinery**		
Key subsystems or standalone components	**Function of subsystem or component**	**Technology anticipated to be used**	**Alternative one**
1. Chipper		Offset-helix rotor-based system by Terex CBI	Truck-based system that can be shared by multiple users, similar to the Jenz unit.
	1.1. Blades		
	1.2. Conveyer or feeder		
	1.3. Hand, arm, and face protector		
	1.3. Grating		
	1.5. Conveyer or feeder		
	1.6. Power electronics		
	1.7. Blade resistance sensor	Electrical resistance sensor and accelerometer	Add image sensors
	1.8		
	1.9		
	1.10.		
2. Mulcher		Offset-helix rotor-based system by Terex CBI	Truck-based system that can be shared by multiple users, similar to the Jenz unit.
	2.1. Blades		
	2.2. Conveyer or feeder		
	3.3. Pulverizer		
	2.4 Grating		
	2.5. Size sensor at grating	Ultrasound sensor with processing	Add image sensors with processing capabilities

For the final step, move to the third section of the "Forecasting" tab, entitled "Component, subsystem or system to be used as a part" (columns I, J, K and L). These are where you specify the parts to be used in the design of your product or service and record any notes for the future. The Competitive Advantage tool can be used to evaluate options, if you are having trouble deciding which is best for your design. Use the currently selected technology as the benchmark against which the newly discovered options are evaluated.

Figure 10 illustrates how data for parts options is entered in this section of the "Forecasting" tab using the biofuels example.

Figure 10: Parts selection recording in the Technology Forecasting workbook using the biofuels example. Note that some columns have been hidden in this example for better readability.

Technological options for providing the functionality		Component, subsystem or system to be used as a part			
Technology anticipated to be used	**Alternative one**	**Performance specification reference sheet number or name**	**Part number or other identifier for current product or service**	**Vendor for current product or service**	**Possible replacement for future product or service**
Offset-helix rotor-based system by Terex CBI	Truck-based system that can be shared by multiple users, similar to the Jenz unit.	Pre-processor	Custom mobile Grizzly Mill	Terex CBI	Smaller and more efficient unit
Offset-helix rotor-based system by Terex CBI	Truck-based system that can be shared by multiple users, similar to the Jenz unit.	Pre-processor	Custom mobile Grizzly Mill	Terex CBI	Unit integrated in chipper

How do you interpret the data from the Technology Forecasting tool and use it in your NPD process?

The parts options recommended in the tool should be examined in light of value creation, both for customers and end-users and for the entities involved in developing, making, selling and supporting the product or service. Just because a part gives a performance advantage does not mean it should be selected over a substitutable part. For example, the performance advantage may be irrelevant for users, and the part may make the product or service too expensive for customers. For example, if someone never rides their e-bike more than 20 miles in a day and recharges it every night, they may not care if a more expensive battery lets them ride it 50 miles before it needs a recharge. They might simply prefer a cheaper battery.

Second, as mentioned previously, neither technology nor customer and end-user needs are static. The data needs to be considered in relation to the trajectory of needs as well as technology.

Another issue is whether a part which at first glance appears superior hinders plans for future products or services found in the entity's NPD portfolio because it cannot be deployed in those future products or services. For example, suppose one battery option for an e-bike requires a custom-made charging device, while the other option uses an off-the-shelf charger. At first glance the one needing only a commercially available charger might seem preferable. But now consider that choice if the battery requiring a custom-made charging device can carry far more power and would work not only in e-bikes but for tricycles and paddle boats as well, and the company's NPD portfolio calls for developing a wide range of land- and water-based electric-powered vehicles targeting seniors. Now developing the custom charger seems preferable, so long as it does not make the price for the customer unattractive.

When looking at the data in the Technology Forecasting workbook, realize that it contains, at best, a set of design recommendations that must be considered with regard to the business model canvas as well as the entity's value chain and its NPD portfolio. (See Tool 12: Portfolio Construction.) This consideration is a job for upper management, not the NPD team, unless that team is tasked with developing a product family. Making design recommendations is however always the responsibility of the NPD team.

Once the data entry has been done, you are ready to develop your design specification. A design specification, also called a specification sheet, is simply a document that specifies the design requirements for an NPD project. It describes how the product or service will perform and for what users, the functional requirements required to provide the desired tangible and augmented features and their functionality, all hardware and software interfaces, operating constraints (including environmental ones), how the product or service will be tested to ensure the requirements are met, configuration settings, and any constraints, assumptions and interdependencies between parts or parts and users. The functional requirements include all relevant dimensions and weights both for the overall product and for its parts, the specific materials of which they are made, the tolerances for any measurements (if relevant), colors for products or services (if relevant) and all performance requirements (such as durability, temperature range, power consumption and so on). It includes not only hardware but also software, including any software interface functions and capabilities and the code needed to operate the product or conduct the service.

There is no specific tool in this Toolkit for developing a design specification. This is because the best format for a design specification and related documents can vary widely depending on what product or service is being developed, and what works for your company or organization. If you are uncertain what your design specification should look like, the easiest way to determine which format might work for your NPD project is to see what design specifications for similar products or services look like. These are found through web searching for "design specification" or "specification sheet" in relevant technology areas. After you have chosen a format, you are now ready to develop your design specification for the product or service you plan to develop.

Finally, it is wise to simultaneously develop a manufacturing specification (also called a production specification chart), which describes how the product or service will be produced, including the equipment and labor necessary to carry out production at each of the steps in

the production process, so that identical products or services can be produced at the scales anticipated. The design specification and the manufacturing specification for that product or service will need to cohere to support production.

The Technology Forecasting tool provides confidence that the technology and parts incorporated in the design are likely to be useful for a specifiable period. Including technology forecasting as part of creating a design specification can reduce execution and co-innovation risk because you have considered what parts and processes may be the best choice for the product or service you are developing, both now and in the future. Technology forecasting can also reduce adoption risk because your design process has considered consumer and end-user requirements, both now and in the future, which should increase the likelihood of purchase and use. Having this confidence is important, since changing the parts list for the product or service during development can be expensive, and then other aspects of the design may be affected. As you will be in the so-called "Valley of Death" during the Design stage, where soaring costs can only be justified by reduced risk, anything that increases risk unnecessarily will make it difficult to proceed through the gate to the Development stage. Using the Technology Forecasting tool, especially in combination with other Design-stage tools, should lead to better-informed strategies for optimizing the product or service while mitigating risk, which should make it easier to proceed to the Development stage.

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