

Article

Assessing the Legitimacy of Technological Innovation in the Public Sphere: Recovering Raw Materials from Waste Water

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Abstract: This paper researches legitimacy creation in a publicly-funded trajectory of innovative technological development. It develops a framework of input, throughput and output legitimacy. The framework is developed based on a review of the literature on the creation of legitimacy in innovative technological development. The framework assists in further exploring the potential of the integrated assessment of the legitimacy of technological innovation trajectories in the public sphere, in terms of (1) public accountability (ensuring input legitimacy); (2) science, technology and innovation policy (ensuring throughput legitimacy); and (3) the potential for the implementation of the technology itself in practical contexts (ensuring output legitimacy). The framework is used to analyze a case study about the publicly-funded development of innovative technology for the retrieval of raw materials from waste water. Theoretically, the value of a more processual approach to the conceptualization of legitimacy becomes apparent. Furthermore, the framework assists in the development of practical recommendations on the ways in which to optimize the legitimacy in an earlier stage in the innovation's trajectory. However, due attention should also be paid to the role of regulatory arrangements in the optimization of the legitimacy of publicly-funded technological innovation. This is an avenue for further research.

Keywords: legitimacy; technological innovation; raw materials; waste water treatment; circular economy

1. Introduction

The available amount of industrially-important raw materials, such as phosphorus, will rapidly decrease in the coming decades [1]. Ecological engineering techniques have been developed to retrieve raw materials from waste water [2]. Such technologies are currently being experimented with on an increasingly large scale [3]. This paper deals with a specific aspect of such processes of technological development, namely the legitimacy of such experiments. Legitimacy as a concept is closely related to concepts such as acceptance [4]. It is part of larger attempts to design functioning innovation systems through policies and business management strategies on the regional, national, supranational and global level [5]. Zimmerman and Zeitz [6] define legitimacy as crucial “for mobilizing resources, articulating demand and acquiring regulatory support”.

Pouring money into the, sometimes seemingly bottomless, pit of R and D—since a societally and/or commercially valuable outcome can never be predicted with complete certainty [7]—must, up to a certain extent, be deemed to be a legitimate endeavor by the surrounding institutions, participating organizations and private parties, and the tax payer as well. Little attention has been directed towards the legitimacy of publicly financing technological development [8,9].

The legitimacy of technological innovation is particularly important in the public sphere. Cases in many countries exist in which public money is spent on innovation projects that primarily relate to either

the ambitions of a single public organization, or the ‘hobbies’ of a dominant fraction of the stakeholders. In particular, in the highly fragmented water management sector in the Netherlands, this risk is existent; in other (partly) public sectors that are largely dependent on technological innovation, such as health care and the energy sector, this risk is non-negligible. A method to systematically assess the legitimacy of such innovation trajectories is a means to mitigate that risk. This paper aims to contribute to the development of such a method.

This paper studies to what extent the legitimacy of the development of technologies for the retrieval of raw materials is created in the process. The research question of this paper is: how is the legitimacy of innovative technological development created in the public sphere, and which lessons can be drawn from an analysis for the publicly-funded trajectories of technological innovation?

By addressing this question, this paper aims to address a relatively under-discussed topic in the debate about the legitimacy of technological innovation [8,9]. Empirically, it contributes to the development of a method to systematically assess the legitimacy of technological innovation in the public sphere. Theoretically, it contributes mostly to the fourth and most recent literature body identified on legitimacy creation in technological innovation trajectories [4,10,11], by pointing out the value of a conceptual understanding of legitimacy in terms of input-throughput-output legitimacy for the assessment of legitimacy in the public sphere.

The paper first shows the ways in which the concept of legitimacy, over the years, has been stretched from its original meaning in terms of legal compliance, towards conceptualizations in which subsequently institutions, organizations, new ventures, and technological development play a prominent role. It does not aim to provide a comprehensive overview of the vast literature on legitimacy. We point out four research streams leading to the elaborated choice for a particular perspective on legitimacy that assists in, tentatively, the development of a method to assess the legitimacy of publicly-funded innovation in empirical settings.

A case study based approach is adopted, which requires the clarification of specific methodological choices. After a discussion of the methodology, the results of the case study are discussed, followed by a discussion of these results in the light of the literature review. Finally, concluding comments are made and avenues for further research are identified.

2. Theoretical Background

Legitimacy stems etymologically from *lex*, ‘law’, in Latin. It is perceived to be the extent to which a certain activity is in compliance with existing laws and regulations. The conceptual understanding of legitimacy has, since the 1970s, been extended in the academic literature towards the legitimacy of (1) institutions, e.g., [12,13] (2) organizations, e.g., [14,15] (3) private companies and new ventures e.g., [6,16] and (4) technological development, e.g., [17,18].

2.1. Literature Review

2.1.1. Institutionalism

Institutional theory researches the legitimacy of institutions. Stinchcombe [19] laid an important foundation for this institutionalist perspective on legitimacy by pointing out the importance of keeping in mind the ‘liability of newness’ of new ventures. The classical work of Pfeffer and Salancik [12] states that the importance of institutional legitimacy is not noticed until there is a lack of it. They state that legitimacy is transacted between parties. Weber et al. [20] argue that legitimacy is a product both of formal laws and social norms. Dacin, Oliver and Roy [21] developed a new take on institutionalism and legitimacy by proposing a framework to discuss legitimacy through strategic alliances between actors on an institutional level. Until halfway through the 1990s, legitimacy as a concept was frequently explored, but in a very differentiated way and via diverse disciplinary angles, e.g., by Meyer and Rowan [22], Hirsch and Andrews [23], and Knoke [24], resulting in a rather eclectic body of literature.

2.1.2. Management and Organizational Sociology

It was only around 1995 that the research on legitimacy became popular in one particular discipline, namely in the management and organizational sociology literature [25]. Management theorist Suchman published the seminal paper ‘Managing Legitimacy: Strategic and Institutional Approaches’ [15], and Scott’s book *Institutions and Organizations* [26] was firstly published in 1995 as well. The popularity of these books provided the sparks to light the interest of academics in the field of management and organizational sociology in the subject of legitimacy. The following authors have produced prominent papers and books in this field of research. Aldrich and Fiol [27] highlighted the challenges entrepreneurs in emerging industries encounter due to liability of newness. Kostova and Zaheer [28] evaluated the legitimacy of a multinational enterprise. Zimmerman and Zeitz [6] addressed attempts to create legitimacy for new ventures in the market. Greenwood and Suddaby [14] researched the ways in which the proponents and opponents of a new organizational form of a big US law firm tried to create legitimacy for their viewpoints. Bitektine [29] studied the ways in which evaluators of organizations make judgements based on bounded rationality, and how that affects the legitimacy of organizations. Bitektine and Haack [30] explored the ways in which institutional stability is created through the suppression of alternative judgements. More recently, Yu et al. [31] stressed the importance of legitimacy in new ventures, and the relationship between entrepreneurship and work-family conflict. Chan and Makino [32] discussed legitimacy in relation to the ownership strategy of multinational companies. Peng [33] stressed the tension between competition and legitimacy that is created when multinational companies venture abroad, and its effect on the ownership structures of the company and expatriate staffing. Shepherd and Zacharakis [34] stressed the need for new companies to create legitimacy through their stakeholders and customers. Stone and Brush [35] analyzed a paradox for new companies that are trying to acquire legitimacy: informality in their organizational culture creates room to move and to grow for these companies, whereas stressing formal aspects enhances their legitimacy. Drori and Honig [16] address legitimacy as a result of concerted action within a company, through which both internal and external legitimacy is created.

2.1.3. Governance Perspectives on Legitimacy

In political science, legitimacy is understood, broadly, as a matter of politics and ways of distributing authority within society, transcending the level of an individual organization. The neo-institutionalist theory of Powell and DiMaggio [13] highlights the importance of institutional legitimacy in creating institutional isomorphism. Democracy theory studies the legitimacy of democratic systems (see, e.g., [36]). Especially in the field of European studies, legitimacy is deemed to be an important research topic, with regard to the democratic deficit of the EU [37–39]. From 2000 onwards, in the field of policy studies and environmental governance, Kalfagianni and Pattberg [40] focused on the legitimacy of environmental governance, via the researching of the output legitimacy of regulations in fishery. Ball et al. [41] researched Environmental Protection Agencies and eco-innovation, and coined a new term: ‘voluntary reciprocal legitimacy’ (VRL). Bansal and Clelland [42] stressed the importance of the legitimacy of firms in environmental respects in order to create an advantageous stock market position. Other studies highlighting the importance of legitimacy for environmental measures and organizations have been performed by Cashore [43], Eden [44], Francesch-Huidobro [45], Kronsell [46] and Herbert [47].

2.1.4. Legitimacy of Technological Innovation

Most recently, scholars in (technological) innovation studies, such as Rao [48], started to publish on the legitimacy of the automotive industry. Kwak, Zhang, and Yu [49] recently emphasized the importance of creating legitimacy for e-commerce platform development. Hekkert et al. [18] see legitimacy as a function of a Technological Innovation System (TIS). Bergek, Jacobsson, Carlsson, Lindmark, and Rickne [10], and Bergek, Jacobsson, and Sandén [17] further explored this particular

function of a TIS. Geels and Verhees [50] emphasized the cultural dimension of legitimacy, and highlighted the importance of framing. Markard et al. [11] researched the legitimacy of the transition towards biogas in Germany.

This section shows the ways in which the original meaning of legitimacy has, over the last five decades, been stretched into a meaning in which—on top of its original meaning in terms of legal compliance—(also) brings in to play institutions, organizations, private companies and new ventures, democracies and technological development in prominent roles in the creation of legitimacy for a certain set of activities.

2.2. Conceptual Framework: Input, Throughput and Output Legitimacy

This paper borrows a conceptual understanding of legitimacy based on input, throughput and output legitimacy [37]. Input, throughput and output legitimacy is to be understood as a feature of a particular type of organization. Scharpf [37], and later Schmidt [38], developed the terms in order to address the democratic deficit in the organization of the European Union.

Input and output legitimacy are determined by (via direct input) and for their stakeholders (via concrete and relevant output). Throughput legitimacy relates to the means to optimize the inclusion of the stakeholders in processes whereby their direct input materializes into concrete output, such as an innovative technology. The framework is operationalized with the help of insights from the literature that has been discussed in the previous section.

Input legitimacy is created through the formal procedures on which an organization is based, mostly involving some sort of democratic participation [36]. Legal task formulation, regulations and rules for cooperation between, for example, public and private parties are also part of this input dimension. In relation to innovative technological development, it involves a procedural understanding of legitimacy development during the process of the development of a new technology [16].

Output legitimacy refers to the effectiveness of the organizational model chosen, and the extent to which the outcomes of actions resonate with values and ideals within this model. It refers to normative aspects of legitimacy, and the perceived consonance with dominant ideas and frames within an organizational scheme. Output legitimacy in relation to technological development refers to the creation of legitimacy as an outcome of, for example, the participation and inclusion of these stakeholders in a certain manner. It is operationalized here via the indicators ‘public acceptance’ [15] and ‘cultural factors’ [50].

Schmidt [38] adds a third dimension to this understanding of legitimacy, namely throughput legitimacy: representation via involvement and participation. This adds an understanding of the inclusive quality of the process as a factor to assess in the scheme, as it also determines the level of output. This enables a more processual understanding to the notion of legitimacy—the process of gaining it through the indicators ‘inclusion institutional stakeholders’, ‘inclusion general public’, and the ‘presence of systematic learning processes’ through inclusion of stakeholders and their expertise [51]. Throughput legitimacy is generated through the inclusion of stakeholders in the relevant processes and the acknowledgement of their interests in decision making processes, either with or without their direct involvement.

3. Materials and Methods

3.1. Case Description

On a global scale, our natural resources for raw materials are declining. The amount of phosphate available is, for example, rapidly decreasing—which is worrisome, because it is a vital element to keep worldwide food production at a sufficient level [2]. Alginate is produced in China, but it is of a relatively low purity—too low, at least, to exploit the material to its full potential in, for example, the building industry, where it is used to make concrete harden faster. The development and use of bioplastics are currently on the rise, but are not yet seen as a worthy replacement of plastic fabricated on the basis of

fossil materials. Since 2008, water managers in the Netherlands have developed the knowledge and technology to retrieve energy and raw materials from waste water. Phosphate, cellulose, alginate and bioplastics—and also CO₂, biomass and nitrogen—are examples of these materials.

This case study is representative of the innovation in the public sphere, and hence for the research and assessment of the legitimacy of innovation trajectories in public organizations. The national organization of water management in The Netherlands is highly fragmented, leaving ample space for water managers to develop initiatives that only relate to the ambitions of one single organization, or even to the ‘hobbies’ of a dominant fraction of stakeholders within the organization. The risk of the illegitimate spending of public (tax) money on innovation is high. This is the case not only in water management but also in other (partly) public sectors, such as the health sector or the energy sector.

3.2. Case Study Research Design and Data Sources

The method employed here is qualitative single case study research, based on a retrospective description and analysis. It contains a within-case analysis based on the conceptual framework. The data represents a set of internal and public documents and interviews that are written and/or used in the building and management activities of the network organization *Energie-en Grondstoffenfabriek*. This organization supports regional water managers in their initiatives to employ and upscale the existing technology to retrieve raw materials from waste water. Figure 1 visualizes a common understanding of the stages of innovation processes. From the demonstration phase onwards, the creation of legitimacy becomes important. All of the initiatives studied within the context of the case study are either in the development or demonstration phase.



Figure 1. The R&D-induced innovation chain.

The data for the case study was collected via semi-structured interviews with key stakeholders in the initiatives studied. Furthermore, desk research was conducted of advisory reports, research programs and policy programs, and meetings and presentations. References to the data can be found in the footnotes. For an overview, and the availability of the data, see Appendix A.

The interviews were used as a factual input. The principal of data triangulation was used [52]. The data was triangulated by cross comparing these documents and identifying the data points. The transferability of the research was further increased via the strategy of member-checking [53]. A representative actor involved in the activities that were researched via the case study checked the results for factuality.

3.3. Data Analysis

The gathered data was analysed by qualitative content analysis [54]. Input, throughput and output legitimacy were used as analytical constructs in the analysis. The indicators in Table 1 were used to conduct a within-case analysis.

The analysis provides a general view of the extent to which legitimacy is created. Thereafter, the results of the case study were reviewed in relation to these concepts. The within-case analysis was guided and performed by means of the description and comparison of the empirical data with regard to the theoretical elements, as discussed in the literature review [52]. The description concentrates on

the identification of the procedural, processual and outcome-related aspects of legitimacy building, i.e., within-case pattern identification and matching [52].

Table 1. Indicators of the strategies employed for the creation of input, throughput and output legitimacy.

| Input Legitimacy—Indicators (Procedural) | Throughput Legitimacy—Indicators (Processual) | Output Legitimacy—Indicators (Outcome Related) |
|--|--|--|
| I1. Democratic procedures in place, democratic legitimacy is sufficiently in place | T1. Inclusion of institutional stakeholders in relevant processes of R and D and policy making | O1. Public acceptance of overall initiative |
| I2. Part of legal task formulation of organization | T2. Inclusion stakeholders general public in relevant processes of R and D and policy making | O2. Normative consonance with dominant values and ideas in society |
| I3. Formal aspects cooperation with private parties covered | T3. Systematic learning processes | O3. Cultural factors in acceptance of new technology |

4. Results

4.1. Input Legitimacy

Input legitimacy refers to the procedural dimension of the creation of legitimacy: democratic procedures, existing legal frameworks, and other formal aspects of cooperation. In Dutch regional water management, water managers are democratically elected. The organizations managing water at a regional level are subjected to legal formulations of their tasks. They are legally obliged to formalize cooperation with other (private) parties. The legitimacy creation on the input side in the case study is affected by the following contextual circumstances.

4.1.1. Low Voter Turnouts (I1)

The boards of the water management organizations—which support the development of technologies financially—are democratically elected. The voter turnouts are low, however. The actors involved in technological development for the retrieval of raw materials from waste water have a problem with their organizational input legitimacy. Thus, from an input perspective, the initiative of the organizations in question is, in principal, democratically supported, although the extent to which this is the case remains questionable (*Juridische handreiking duurzame energie en grondstoffen*).

4.1.2. The Legal Formulation of Tasks Leaves No Room for the Retrieval of Raw Materials from Waste Water (I2)

Legally, the organizations involved have a task to process waste water. The retrieval of raw materials from waste water is not part of this task. There is no legal ground and legitimacy for the initiative to retrieve raw materials. The public organizations are, strictly speaking—that is, within the legal formulation of their tasks—not allowed to spend tax money on these activities (*Juridische handreiking duurzame energie en grondstoffen*, p. 23).

4.1.3. Dutch and European Waste Legislation Views Raw Materials Predominantly as Waste (I2)

Most of the raw materials that can be retrieved from waste water are legally perceived as waste. If the regional water authorities are of the opinion that these materials should no longer be seen as waste, they have to bring in evidence that proves their point. They can file a request for an end-of-waste status for the particular raw material. The parties involved have to provide evidence for its value, in order to convince the national and supranational governments to change their waste legislation. The burden of proof lies with the actors involved in the innovation processes (Presentation Energy and Raw Materials Factory: From waste to value. 10 February 2016, by ir. Hans Geerse at University of Amsterdam, Faculty of Sciences; Network meeting: On creating commercial value from raw material).

4.1.4. Lack of Legitimacy Due to Cooperation with Private Parties (I3)

When particular forms of cooperation with private parties are chosen to provide the optimal conditions for the development of new knowledge or technologies, there is a question of the extent to

which democratic legitimacy is still guaranteed. This has been evaluated as worrisome, from a legal perspective (*Juridische handreiking duurzame energie en grondstoffen*, p. 84). When the authorities decide to cooperate with private parties, they have to share their decision making authority with these parties. This affects the democratic legitimacy of the choices and decisions made within these cooperations.

4.1.5. Disruption of Market of Waste Processors (I3)

When does the formal responsibility of the governmental organizations involved—to process their own waste, which formerly was outsourced to a third, private party—end? Up to what point can legally legitimate governmental organizations invest tax money in the development of knowledge and technology to process their waste (*Naar een Onderzoeksprogramma Grondstoffenwinning 2015–2017*, p. 7)? Here, European Competition Laws come into play (*Juridische handreiking duurzame energie en grondstoffen*). The lack of a definitive answer to this question creates a threat to the input legitimacy of the organizations involved, and thus especially to the relatively vulnerable, new, innovative initiatives they develop, such as the one concerning the retrieval of raw materials from waste water.

4.2. Throughput Legitimacy

Throughput legitimacy refers to the participatory arrangements in the development of interventions and policy to further develop the innovation, and thus to the processual level. In Dutch water management, such participatory arrangements are not uncommon. The inclusion of institutional stakeholders through cooperative arrangements, the acknowledgement of the interests of the general public as a stakeholders, and the quality of the policy programs to propel the technologies developed are focal points here in the analysis of the creation of throughput legitimacy in the innovation process.

4.2.1. Including Institutional Stakeholders (T1)

In line with trends in national and supranational (e.g., EU) innovation policies, the focus of the processors of technological development in order to enable retrieval of raw materials from waste water is on the formation of consortia for innovation (*Blik op innovatie, deel 2, rapportage hernieuwbare energie. STOWA report Verkenning Mogelijkheden Grondstof RWZI*). The way these collaborations are shaped, practically, administratively and legally, entails administrative choices. Laws and regulations may otherwise eventually obstruct such forms of cooperation, either in an early stage via procurement laws, or later via fiscal regulations concerning, for example, VAT-regulation (*Juridische handreiking duurzame energie en grondstoffen*). Currently, such choices for particular forms of cooperation are not, *ex ante*, systematically thought through or, *ex post*, evaluated. They have been made in a more or less organic fashion. From an organizational perspective, the choice is understandable, since it ensures the cooperation and commitment of the organizations in the network by not asking for formal, e.g., financial, commitment. This, thus, guarantees a certain degree of the inclusion of public organizations that are looking for a way to participate in the initiative without too many (financial) strings attached.

4.2.2. Acknowledging the Interests of the Public (T2)

Several organizations provide the financial means for experiments with the retrieval of raw material from waste water. They do so because they expect that, eventually, these investments will (at least) return themselves on the middle to long term. The returns expected may mean that taxes do not have to be raised exponentially. Otherwise, this exponential rise of costs is to be expected with regard to the fact that water management in the Netherlands will become increasingly expensive due to the necessary adaptation to climate change [36]. Thus, by keeping the processes of innovative technological development going for the achievement of the goals specified, in the long run, the interests of the tax-paying public stakeholders are safeguarded.

Also from the viewpoint of the general decline worldwide of raw materials, the network communicates the urgency of their activities in this domain. Through their activities, they make a

plea for a more circular economy, and actively communicate that, by continuously doing so, they take responsibility in the lights of the general interest (Personal communication Evert-Jan Veldhoven).

The network organization actively reaches out to the general public, which can be seen as a way to acknowledge its interest in the activities of the organization. The network is particularly eager to spread their ideas and knowledge by accepting invitations for lectures at higher education institutions. In 2016, 2017 and 2018, representatives of the organization gave guest lectures at the University of Amsterdam and at VU University Amsterdam.

4.2.3. Quality Policy Program (T3)

The several trajectories for technological development are in different stages of development concerning the possibilities for the retrieval of raw materials. Some are still struggling with the technological possibilities; others are moving beyond this stage in the knowledge chain, and are currently developing business cases based on the large scale retrieval of raw materials (LCA Grondstoffen duurzaamheid grondstoffenfabriek gekwantificeerd).

Potentially, phosphorus (P) is a highly marketable product. Outside the Netherlands, phosphorus is becoming increasingly scarce. In the Netherlands, however, there is a surplus of P in the soil and surface waters due to the country's agricultural activities and the use of chemical fertilizers. Thus, for a successful business case for phosphorus, the organizations involved would need to broaden their scope internationally. However, in other countries, the regulations for the use of phosphorus differ. Phosphorus from waste water has a formal status as waste, which complicates the search for an international market for phosphorus (brochure De Pearl Technologie, Grontmij, STOWA report Fosfaatruigwinning in communale afvalwaterzuiveringsinstallaties, Project idee: Onderzoeksthema Fosfaatgebruik Wetsus; Projectidee 2—Reversibele adsorptie van fosfaat uit de rwzi. STOWA report Fosfaatruigwinning in communale afvalwaterzuiveringsinstallaties).

Furthermore, specifically in the case of phosphorus, the organizations involved feel the need to carefully consider every step taken, as they may be accused by environmental organizations of offering an end-of-pipe solution to the problem of a surplus of P in the soil as a result of the manure problem, thereby implicitly supporting the agricultural industry in their lobbying for less strict manure policies. This is not in line with the image of sustainability that the organizations aim to express via their involvement in the initiative (Personal communication Evert-Jan van Veldhoven).

Next to phosphorus, there is the technological possibility to produce alginate (commercial brand: Kaumera) using a technology called Nereda. Alginate is currently produced on a pilot scale, and is highly promising in terms of its commercialization as well. Currently, alginate is fabricated in China only. It can be used in the building industry, the textile industry, and the paper industry (Onderzoeksprogramma NAOP).

The purity of the Chinese alginate is less than that of the alginate that is currently produced on a pilot scale in the Netherlands. Its purity is a crucial component of alginate in order to upscale its use in the industries mentioned. The technique to retrieve alginate from sludge was developed in the Netherlands as well, by a large engineering bureau together with Delft University of Technology (Personal communication Coert Petri).

Private sector parties are currently participating in the upscaling of alginate production. A national research program has been set up (Onderzoeksprogramma NAOP). In terms of business, alginate is, just as phosphorus, not successfully commercialized yet; not because of a lack of market possibilities, however, but as a result of technological limitations, i.e., a lack of full scale experiments and the large scale production of alginate (Project idea LIFE-TKI, project idea NAOP 2015).

The development of business cases has been attempted, both in the case of phosphorus and in the case of alginate. None of them proved to be successful yet. Phosphorus from waste water has only recently been acknowledged in European regulations as a valuable product, instead of as waste. The production of alginate needs to be upscaled, but there the initiative runs into trouble in terms of technology and financial resources (Personal communication Coert Petri).

The lack of successful business cases is a result of regulations, and a lack of financial and/or technological possibilities to upscale the initiatives. In general, the governmental organizations are still learning to adopt a more entrepreneurial attitude, of which the development of successful business cases is an important part. It is pivotal here to have an articulate view of what the market needs, and to what extent waste water needs to be purified in order to sell a particular product of a specified quality (Presentation Green Deal Raw Materials).

Systematic learning and evaluation is currently not taking place. However, the core team regularly meets and invites representatives of the working groups to update the core team of their progress (Personal communication Erwin de Valk).

4.3. Output Legitimacy: The Legitimacy of Innovation as Normative Consonance with Dominant Ideas and Frames in Society

Output legitimacy refers to the legitimacy of the outcomes of the innovation process. The issue at hand is: does the technology comply normatively with the dominant ideas and frames—simply put, with what the tax payer wants? Four aspects of the case study deserve attention in this respect: the piloting and upscaling of technology, the congruence of the outcomes of the innovation process with existing policy for the stimulation of a circular economy, the public acceptance of the technologies developed, and culturally determined ideas about waste.

4.3.1. Piloting and Upscaling (O1)

The efficacy of the developed techniques is, for some materials, currently being tested via attempts to upscale the pilot experiments. Examples are alginate, through the research proposal ‘Waste 2 Algin 4 Life’ (Research proposal Waste 2 Algin 4 Life.), and bioplastics, through the development of demonstration projects. In February 2015, a research proposal was developed called ‘Phario’, in which they defended the need and relevance of upscaling these activities (Research proposal PHARIO). By further increasing the effectiveness of the technologies, the overall output legitimacy is eventually increased. The organizational structure of the organizations in the working groups enables learning on several levels, both within and between working groups.

4.3.2. Congruence with Policy Ambitions (O2)

The Dutch Government is currently investing in the realization of its ambition of establishing a circular economy, for example, through supporting a so-called Green Deal in November 2014 (Presentation Green Deal Raw Materials). However, in practice, the factual commitment of the central government, paying off in, for example, financial support, remains a point of concern for the regional governmental bodies involved. This is also the reason why they are constantly trying to comply as much as possible with the overall governmental schemes to stimulate the establishment of a circular economy.

4.3.3. Public Acceptance: Keeping Taxes Low (O2)

One avenue of the overall legitimization of the initiative is that the future costs of water management are kept at acceptable levels due to the marketization of raw materials. Taxes may not have been raised that much in the near future, as would otherwise be the case due to rising costs resulting from climate change. The expected return of investment is thus speculative, and is not built on solid business cases. The Dutch public is currently largely ignorant of the activities of the water managers in general, let alone their activities concerning the retrieval of raw material from waste water. Waste water consciousness in the Netherlands is notoriously low, and innovation within the sector remains largely low profile in the public eye [55].

However, visibility is seen as being crucial. A separate working group on communication was established, occupying itself with increasing the visibility of the activities developed. A television show recently broadcast the reuse of cellulose in the road building industry. Such popular attention assists in the communication of the results, and thus in enhancing the visibility and understanding

of the activities of the water authorities, thereby increasing their output legitimacy, although very incrementally (Personal communication George Zoutberg).

The knowledge developed in the initiative is considered to be in part the rationalization of those norms and values, which the stakeholders currently involved in regaining raw materials from waste water find important. The processes of knowledge development thus resonate with the dominant norms and ideals of the advocates of a sustainable society and a circular economy. As such, they play a part in facilitating normative choices. The priorities set by the scientists, funding agencies and (supra) national governments are normatively informed. As the initiative appeals to the common wish to establish a circular economy, the knowledge development needed for this reflects common values and interests.

4.3.4. Cultural Dimension: Waste or Valuable Resource? (O3)

General public acceptance remains a challenge. The existing ideas on ‘clean’ and ‘dirty’, what is waste and what is not, are another factor of importance here. The materials retrieved from waste water are still perceived as waste. Bioplastics may be used to fabricate cups to drink from, but the idea that the biologically degradable cup one is drinking from has been extracted from sewage water, however clean the bioplastic of which the cup is made is now, is not very appealing as research (Bioplastics uit zuiveringsslib, LIFE + Environment Policy and Governance project application, Demonstration of an innovative process to produce biobased plastic out of cellulose recovered from domestic waste water; Posterpresentation Bioplastics en Vetzuren).

The cultural dimension partly boils down to waste legislation. The question of when waste stops being waste is also relevant from a legal, policy, and legitimacy perspective. On the legal side, a body of laws and regulations on waste exists. The Dutch government offers assistance to check if a particular material is waste or not by providing guidelines and assistance via a special desk (*Helpdesk Afvalbeheer*). As long as there remains discussion about the status of the retrieved material, there is risk involved in the further upscaling of these activities, as solid business cases will be hard to build (Presentation Green Deal Raw Materials).

5. Discussion

The results of the previous section show that, especially on the input side, the legitimacy of these activities is low (Table 2). The turnout for the elections for the boards of the regional water authorities is low. The legal task formulation does not allow room for the retrieval of raw materials. The law in place on the extent to which public organizations are allowed to develop their own business models does not allow the regional water authorities room to sell the raw materials they retrieve from waste water. Thus, procedurally speaking, the legitimacy of their activities is low.

Table 2. Assessment of input legitimacy.

| Input Legitimacy—Indicators | Assessment Input Legitimacy |
|--|---|
| I1. Democratic procedures in place? | Low voter turnouts |
| I2. Part of legal task formulation of organization? | Legal task formulation leaves no room for retrieval raw materials by RWAs Waste legislation is in principal not allowing for selling the retrieved raw materials on the market |
| I3. Formal aspects cooperation with private parties covered? | No legal base for cooperation Disruption of waste processing market |

For the assessment of the throughput legitimacy, the contribution of ongoing knowledge and technological development to policy programs, research programs, pilots, and demonstration, projects and the development of business cases is assessed (Table 3). Learning processes are indeed taking place, but their upscaling remains difficult. Successful business cases have not been developed yet.

The upscaling of the pilot is problematic due to a lack of financial support to realize bigger projects. The financial risk management of the demonstration projects is not present. In terms of processes, the legitimacy is higher than the input, procedural legitimacy.

Table 3. Assessment of the throughput legitimacy.

| Throughput Legitimacy—Indicators (Processual) | Assessment throughput Legitimacy |
|---|---|
| T1. Inclusion institutional stakeholders in relevant processes of R and D and policy making? | Acknowledgement interests of stakeholders via making explicit expected revenues |
| T2. Inclusion stakeholders general public in relevant processes of R and D and policy making? | Inclusion of institutional stakeholders is strived for but is only reached up to a limited extent |
| T3. Systematic learning processes? | Financial risk management not present Upscaling problematic |

For the assessment of the output legitimacy—i.e., the effectiveness of the network organization in establishing a circular economy in waste water treatment, and the resonance of its activities with values and ideals—concrete results and successes are mentioned in relation to communication, new partnerships, public and legal perceptions of the thin line between waste and valuable resources, and their congruence with the dominant ideas concerning sustainability (Table 4).

Table 4. Assessment of the output legitimacy.

| Output Legitimacy—Indicators | Assessment Output Legitimacy |
|---|--|
| O1. Public acceptance of overall initiative? | Acknowledgement interests of stakeholders via making explicit expected revenues |
| O2. Normative consonance with dominant values and ideas in society? | Compliance dominant public norms and values present Compliance governmental ambitions present |
| O3. Cultural factors in acceptance of new technology? | Cultural perceptions waste need changing |

The processes of innovative technological development are assisting in accelerating processes from experimentation, to upscaling, to the full scale retrieval of raw materials from waste water. The initiative is largely compliant with governmental ambitions, and the norms and values of the public. The processes of innovative technological development help to materialize and visualize these ambitions; norms and values and assist in translating them into technologies.

In summary, input legitimacy is low, throughput legitimacy is higher, and output legitimacy is rather high. Of course, this assessment of legitimacy is relative, and cannot be represented in absolute terms. It is about the extent to which a broad range of actors deems these activities legitimate, given regulations, policy frameworks and ideology.

Greater input legitimacy is needed in order to grant a chance to the implementation of the technology on a bigger scale. Especially then, laws, regulations and financial arrangements need to be in place. Tentatively, the choice for an informal organization of the activities here renders great efficiency, but less legitimacy, which is in line with the findings of Stone and Brush [35]. They argue that informality in organizational culture creates room to move and to grow for these companies, whereas stressing formal aspects enhances their legitimacy. In that sense, the network organization has made a clear choice.

The paper thus shows a tension between legitimacy in the original sense of the word, referring to legality, and legitimacy as it is understood in the broader sense, as it has been developed in institutional theory, organizational sociology, democracy theory and innovation sciences. The legitimacy of innovation in the public sphere is built partly through institutional support and new types of organizations, by assessing the inclusiveness of the technological development processes methodically and succinctly, and via attempts to generate public support.

The ‘tragedy’ of innovation in the public sphere lies in the fact that innovation in this sphere is eventually mostly hampered by the lack of legitimacy in terms of the traditional sense of the word. In other words, most of the ‘liability of newness’ [19] is thus situated in the legal sphere. The results of this study show that overcoming the liability of newness via the development of ways to build throughput and output legitimacy, apart from in the legal sphere, is only possible up to a certain extent.

The academic literature has stretched the meaning of legitimacy, pointing out the essentially distributed nature of legitimacy-building processes. It is not only created through democratic procedures, laws and tax money, but through other channels as well, including institutional and organizational components, and through trajectories of technological development.

After a certain amount of legitimacy is created through the channels of institutions, organizations, democratic systems and processes of technological development, gaining legitimacy via laws and regulations needs to be achieved via pronouncedly political channels—for example, by lobbying for a change in laws and regulations, or by initiating a change in the dominant policy paradigms with, for example, an increased emphasis on circular economy, whereby the legal arrangements are also put in place to reach those policy goals.

There thus seems to be a certain ‘legitimacy threshold’. The highly cited paper of Zimmerman and Zeitz [6] expresses that the authors “feel that such a phenomenon [i.e., a ‘legitimacy threshold’] exists”; however, they also “freely admit that what constitutes this threshold is difficult to identify and probably unique to each new venture” (p. 428). The threshold in innovative technological development in the public sphere is currently being determined mostly by the potential of the innovative technology to overcome legal barriers.

6. Conclusions

The framework to assess the input, throughput and output legitimacy assists in the development of a more processual understanding of the creation of legitimacy, as opposed to the more static definitions developed by Bergek et al. [10,17] and Markard et al. [11]. It adds a processual perspective to the literature on technological innovation and legitimacy. Due attention is needed for strategies to create legitimacy for the implementation of the developed technologies. The research presented in this paper shows the importance of overcoming the mostly legal legitimacy threshold that is often in place in such trajectories. It also shows a poignant lack of attention for the creation of other forms of legitimacy, such as legitimacy through participation, and legitimacy through appealing to cultural aspects and social norms.

Sustainable, innovative technological development is more likely to be successfully up-scaled when it is recognized that legitimacy is processual in nature, and is produced through many dimensions other than only the legal one. We recommend to policy makers in the field of science and innovation policy to, as a condition for funding, ask public organizations to assess the legitimacy of the proposed sustainable technological development.

As a means to actively stimulate the creation of legitimacy in the process of technological development, policy makers should look for an integral perspective on legitimacy. An avenue for academic research is to further define the nature of the legitimacy threshold that is in place. A multi-criteria of fuzzy logic analysis could potentially further increase our understanding of that threshold.

Based on the empirical research for this paper, it can be stated that the threshold seems to mark the phase in which a pure focus on technological development shifts towards a focus on gaining political and regulatory support as well, in order to be able to use the technology on a bigger scale in society. Further research may aim for the development of a method to accurately assess the stage the publicly-funded, goal-oriented innovative technological development trajectory is in, in terms of gaining legitimacy and overcoming the ‘legitimacy threshold’. Such a focus would also be of value for the analysis of the policies of a private company with regard to investments in technological innovation.

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Appendix A

Table A1. Overview of Data Sources.

| Type of Data Source | Title Document in English (If Applicable) | Details, Availability |
|--|--|---|
| <i>Personal communications:</i> | | |
| 1. Coert Petri | | Working group alginate, 17 Februari 2015, 30 April 2015 |
| 2. Evert Jan Veldhoven | | Working group phosphate, 23 April 2015 |
| 3. George Zoutberg | | Working group biomass, 24 Februari 2015, 23 April 2015 |
| 4. Erwin de Valk | | Working group Market and logistical chains, 9 Februari 2015 |
| <i>Reports and meetings:</i> | | |
| Naar een Onderzoeksprogramma Grondstoffenwinning 2015–2017 | Towards a research programme for the recovery of raw materials 2015–2017 | https://www.stowa.nl/sites/default/files/assets/PUBLICATIES/Publicaties%202015/STOWA%202015-36.pdf |
| Onderzoeksprogramma NAOP | Research program NAOP | Working group Alginate, internal document |
| Project idea LIFE-TKI | | Working group Alginate, internal document |
| Project idea NAOP 2015 | | Working group Alginate, internal document |
| Bioplastics uit zuiveringsslib | Bioplastics from sewage sludge | Working group bioplastics, internal document |
| LIFE+ Environment Policy and Governance project application, Demonstration of an innovative process to produce biobased plastic out of cellulose recovered from domestic waste water | | Working group bioplastics, internal document |
| Posterpresentation Bioplastics en Vetturen | Poster presentation bioplastics and fatty acids | Working group bioplastics, internal document |
| Haalbaarheid PVC-vervanger uit reststromen | Feasibility PVC replacement from residual currents | Working group bioplastics, internal document |
| Pilot Ontwikkeling Waardeketen PHA uit rioolslib (PHARIO) | Pilot development value chain PHA from sewage sludge (PHARIO) | Working group bioplastics, internal document |
| Bioplastic uit slib STOWA rapport | Bioplastic from sewage sludge | http://m.stowa.nl/publicaties/publicaties/bioplastic_uit_slib_verkennings_naar_pha-productie_uit_zuiveringsslib_grondstoffenfabriek_ |
| brochure De Pearl Technologie, Grontmij | Brochure on Pearl Technology | Working group Phosphate, internal document |

Table A1. Cont.

| Type of Data Source | Title Document in English (If Applicable) | Details, Availability |
|--|---|---|
| Project idee: Onderzoeksthema Fosfaathergebruik Wetsus Projectidee 2—Reversibele adsorptie van fosfaat uit de rwzi | Research theme recovering phosphate- reversible adsorption of phosphate from the waste water treatment facility | Working group Phosphate, internal document |
| Blik op innovatie, deel 2, rapportage hernieuwbare energie | Vision on innovation, part 2, report reusable energy | RVO, Ministry of Economic Affairs. https://www.rvo.nl/file/rapportage-hernieuwbare-energie-2013-deel-2-blik-op-innovatie-webpdf |
| STOWA report Fosfaatterugwinning in communale afvalwaterzuiveringsinstallaties | Recovering phosphate from community based waste water treatment facility | https://www.stowa.nl/publicaties/fosfaatterugwinning-communale-afvalwaterzuiveringsinstallaties |
| STOWA report Verkenning Mogelijkheden Grondstof RWZI | STOWA report Exploring the potential of raw material recovery at waste water treatment plants | Working group Market and Logistics https://www.stowa.nl/publicaties/verkenning-mogelijkheden-grondstof-rwzi |
| LCA Grondstoffen duurzaamheid grondstoffenfabriek gekwantificeerd | LCA Quantifying the sustainability of the recovery of raw materials | CE Delft, report |
| Network meeting: On creating commercial value from raw materials | | 11 March 2015. Precipitation of discussion on three posters. Scoring model was developed on commercial potential of raw materials (excel sheet) |
| Juridische handreiking duurzame energie en grondstoffen | Legal guidance on sustainable energy and raw materials | https://www.uvw.nl/publicatie/juridische-handreiking-duurzame-energie-en-grondstoffen/ |
| Presentation Energy and Raw Materials Factory: From waste to value. 10 February 2016, by ir. Hans Geerse at University of Amsterdam, Faculty of Sciences | | Internal document |
| Presentation Green Deal Raw Materials. 6 April 2015, by ir. Cora Uijterlinde | | Internal document |

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