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Article

Resource Targets in Europe and Worldwide: An Overview

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Abstract: For 20 years, the number of resource policy approaches with direct and indirect relations to raw materials, resource and material efficiency has grown enormously at national and international level. This discussion paper makes an inventory of different political and regulatory approaches that contain a direct or indirect reference to resources such as construction materials, industrial minerals, or metals. They are examined and evaluated regarding foci and resource priorities as well as further categories such as target lines, governance levels, indicators used, integration into wider target systems, specification, and implementation. The aim is to provide an overview of the spectrum of resource objectives in international, European, and national strategies, programs, and initiatives. The closer analysis of raw material targets embedded in the policy programs and legal approaches reveals that most goals lack a time frame and a concrete vision, thus remain at a strategic level. To complement the overview, the state of research in the field of modeling and simulation is briefly discussed. Concluding remarks concerning their relation to the objectives identified and the task of target setting complete the discussion.

Keywords: resource management; resource policy; resource efficiency; material efficiency

1. Resource Objectives—Definition and Scope

Natural resources like abiotic raw materials (fossil fuels, metals, and minerals), biotic raw materials, water, and land are the backbone of the economic production and consumption systems. The major environmental problems, such as resource depletion, climate change, degradation of global ecosystems, substance-specific and other emissions, and waste arise from the usage, production, and consumption of resources. In parts of science, politics, and civil society concerned with environmental and resource issues, it is increasingly accepted that the current degree of resource consumption and its growth cannot continue in the future [1–3]. Consequently, aspirations to relieve the input side of the resource system have appeared on the political agenda as calls for the increase of resource efficiency or resource productivity. A great variety of efforts are made at international and European level, *inter alia*, comprising the formulation of tangible objectives and targets [4,5]. These efforts build on the assumption that reducing resource consumption [6,7] or decisively increasing resource productivity [8,9] will relieve the environment. The multiple and complex interdependencies between the use of raw materials and a wide range of environmental impacts underpin the quest for "resource protection" as a central topic equal to "climate protection" [10–12].

Experiences from the energy and climate sector have shown that the impacts on (eco-)innovation evolving from targets should not be underestimated [13,14]. Targets are essential within the scope of technological and social developments on the one hand, and they support the relevant instrumentation on the other hand. Many countries have implemented qualitative and operational objectives at different levels of action for the reduction of fossil fuel use and energy and the associated emissions, thereby favoring and accelerating innovations for energy efficiency and the use of renewable energies [15]. Yet, the majority of resource flows of the socio-industrial metabolism is not constituted by energetically used, but rather unenergetically used abiotic and biotic raw materials (and water), as well as a growing land use for settlement and transport infrastructures [16,17]. Therefore, a number of countries, as well as the EU, have started to develop and implement objectives for increasing resource efficiency/productivity in their economies.

For derivations of targets for resource policy, policy makers frequently refer to the physical limitations of the raw material base and/or the physical limits of the absorption capacity of ecosystems [18,19]. Another basis for goal formulation is the societal tolerance threshold of resource depletion, the impacts of resource use and the subsequent wastes and emissions, the distribution of resources within societies (in terms of an intergenerational justice), the preservation of the raw material base for future generations (in terms of an intragenerational justice), and/or the precautionary principle [20,21]. Against this background, a distinction can be made between strategic and operational goals. Strategic goals refer to rather broad policy objectives of a general nature, such as the improvement of the environmental quality or the reduction of environmental pressures. They are neither quantified nor further specified in terms of time frames or any other milestones. Operational targets, however, are specific, quantifiable, and measurable, and they apply deadlines for the achievement of the objectives [4]. A further distinction between the two main types of targets is:

- **Efficiency targets** strive for increasing a specific value or physical quantity, e.g., resource productivity = gross domestic product : resource use (in analogy to labor productivity) or resource intensity = resource use : gross domestic product (as the inverse of productivity).

Thereby, resource efficiency is the overarching concept achieved by increasing resource productivity or reducing resource intensity [22].

- **Absolute targets** limit resource consumption or specify a reduction scale with specific figures for the whole economy, sectors, regions, or per capita.

In addition, there is a broad range of objectives that may affect resource consumption indirectly. Examples are waste-related goals (reduction of waste, increase of recycling, minimum recycling quotas, minimum recovery rates) or general objectives for a green economy (increase of investments, restrictions of exports). Almost all countries formulate some type of environmental goals, often comprehensive but vague and qualitatively based on broad but divergent definitions of resources [23,24]. Even less specific ideas can over time evolve a consensus. It typically takes several policy cycles until a forceful combination of long-term and short-term, vertically and horizontally integrated targets is found, equipped with precise and robust indicators, and accompanied by measures and clear responsibilities [25]. Besides, short election periods hamper the development of long-term objectives and visions, which might be one reason why objectives lag behind the development of indicators, which can be made irrespective of political processes. This paper acknowledges the decisive role targets hold with regard to the economic and political development of societies.

2. Brief History of Resource Objectives at International and European Level

Resource policy has become a dynamic policy area due to a strongly grown conglomerate of international, European, and national political and regulatory approaches, programs, strategies, and initiatives that are directly and indirectly related to resource consumption [4]. Green Growth and Green Economy approaches contribute to this [26–28].

Since the 'Stockholm Declaration' of the United Nations Conference on the Human Environment [29] in 1972, goals have been increasingly formulated for resource protection and resource conservation at international level. Over the course of time, they have been confirmed, varied, revised, and differently accentuated or interpreted. Those non-binding qualitative goals are part of many principles and articles of various declarations and agreements today. While the "Rio Declaration on Environment and Development" of 1992 [30] emphasized the national sovereignty concerning the treatment of domestic resources, Agenda 21 as a part thereof first mentioned the term "material efficiency" in technical sense. The General Agreement on Tariffs and Trade (GATT) (1994) and the World Trade Organization (WTO), at the time of its foundation in 1995, focused on an optimal exploitation and allocation of resources by means of global trade [31]. Since the "Johannesburg Declaration on Sustainable Development" and the "Johannesburg Plan of Implementation" of 2002, [32] the vision of a sustainable use of natural resources can be regarded as incorporated, at least in a qualitative manner. The G8 action plan of the World Economic Summit in Evian (2003) decided on the development of appropriate indicators and indices for resource efficiency within the OECD area [33]. The Marrakech Process further pursued the approach since 2003 and developed a technical definition of material efficiency for products: "*Material efficiency can be defined as achieving the minimum material input per unit output of a particular product, given existing technologies. Material efficiency can be improved either by reducing the amount of the material contained in the final product ("lightweighting") or by reducing the amount of material that enters the production process but ends* *up in the waste stream*" [34]. This definition however refers to "a particular product", while macroeconomic indicators such as the "raw material productivity" relate, for instance, to the Gross Domestic Product (GDP) [23].

Since the foundation of the International Resource Panel (IRP) of the United Nations Environment Program (UNEP) in 2007, sustainable resource use has been established as an academic field and is now evaluated systematically. As a consequence, the resource issue was upgraded, but has not received a similarly high level of focus as climate issues for the time being [35]. The rhetoric of the G8's 3R Action Plan of 2008, which was developed under the lead of Japan, explicitly opposed wastage ("*mottainai*") and unsustainable use of natural resources. However, in the following years insufficient use was being made of the opportunity to further specify and implement the concept at the international level [36]. Hence, the Rio+20 (2012) outcome document "The future we want" again stresses the priority of sovereign rights of the nation states and mentions resource efficiency improvements only vaguely [37]. None of these documents formulates any absolute reduction targets.

The high complexity and (continuing) lack of transparency of resource-related value chains, the different interpretations of the notion of resources by national, economic, and other interests, as well as highly challenging normative, political, and administrative requirements for the development of a shared vision within complicated institutional frameworks [38] constitute strong barriers to substantial progress within an international discourse on sustainable development that has persisted for 40 years, after all, and always entailed resource protection and conservation. At the international level, qualitative targets emerge that are torn between national sovereignty rights, enshrined in WTO-law concerning the use and trade of resources, and a growing awareness that resources are being over-used globally [39,40], while their use and benefits are being unfairly distributed inter- and intra-generationally [41]. A "conflict of laws" between international trade law and national environmental laws and other international and national legal regimes becomes apparent, and the inherent jurisprudential hierarchy is assessed quite differently [42]. The resulting conflicts of interests are mirrored by overly cautious and shallow requirements to resource efficiency improvements, which provide a directional orientation at best.

At the European level, the European Commission published a communication on Integrated Product Policy (IPP), arguing for a reduction of resource consumption building on environmental life-cycle thinking [43] in 2003. Although the Thematic Strategy on the Sustainable Use of Natural Resources (2005) [24] was more explicit, the quantification of targets remained untouched—with the exception of a decoupling objective ("*decoupling of resource consumption from economic growth*"). The Action Plan for Sustainable Consumption and Production (SCP) and Sustainable Industrial Policy (SIP) (2008) [44] aims to "*encourage an optimal resource use and recycling*" without introducing any quantitative specifications. Henceforth, a division into foremost economically motivated resource protection in terms of a security of access to raw materials and a resource protection resulting from environmental concerns emerged at the European level [31], often accompanied by a division of responsibilities between ministries. Such a division can be detected in many other countries such as Germany, Finland, and Japan [45,46]. Unresolved conflicts of interests between safeguarding raw materials, access problems, and the opportunities of a green economy with material requirements for an energy transition and rare and critical metals and raw materials from conflict areas favor the further emergence of inconsistent structures [47,48].

The “EUROPE 2020—Strategy for Smart, Sustainable and Inclusive Growth”, the Flagship Initiative “A Resource-Efficient Europe” and the “Roadmap to a Resource Efficient Europe”, all formulating long-term goals for 2050, have attracted great attention for resource efficiency and resource conservation in recent years [49–51]. Nevertheless, the unresolved issue of the relevant jurisprudence for resources slows down ambitious attempts and is now, in view of the renewed EU priority of “growth and jobs,” in great danger of fizzling out.

3. Resource Targets in National Programs, Strategies, and Regulations

The Roadmap has constituted progress in terms of introducing some quantitative reduction targets and consumption caps, including e.g., the reduction of non-recyclable waste to zero until 2014; the reduction of water extraction to an amount below 20% of the available renewable water resources until 2020; the reduction of resource inputs into the food chain by about 20% until 2020; and a 70% recycling rate of non-hazardous construction and demolition waste until 2020 [51]. Also, efficiency targets like recovery quotas, the formulation of priority sectors and priority raw materials, and interim targets and milestones such as “*abolish all environmentally harmful subsidies until 2020*” point in a similar direction. Further specification of waste targets was carried out by the Circular Economy Program, which also recommends an increase of resource productivity by 30% between 2014 and 2030 [52].

Coincidentally or consequently, resource efficiency and resource conservation have also gained in importance in single states and are increasingly being specified. The majority of the European member states have implemented EU regulations referring to resource efficiency, for example concerning electronic equipment, batteries, end-of-life vehicles, and packaging [4].

Further strategic goals that can be found in the national programs and initiatives are mainly generic, qualitative, and do not set timed obligations and deadlines. Although it can be noticed that declaring the efficient use of resources has become a common practice, studies reveal that most countries still focus more on energy efficiency and waste targets than on resource efficiency. Examples are the terms “sustainable,” “efficient,” or “rational” use of natural resources and resource conservation. Typically, operational targets refer to the domains of energy, waste, water, and land use, thus constituting the fulfillment of EU requirements or implementation of relevant EU directives [4,20,53].

In an EEA survey conducted in 2011 [4], 31 European countries named four strategic goals that refer to resources: decoupling of economic growth from resource consumption (mentioned five times), the efficient use of resources (mentioned 22 times), the reduction of resource consumption (mentioned six times), and the cutback of the input of mineral raw materials (mentioned 10 times). The countries that seek to limit the use of mineral resources are Belgium, Denmark, Germany, Estonia, Finland, Great Britain, Lithuania, Austria, Sweden, and Slovenia. Three countries regard metals as priority resources (France, Finland, and Austria), while five give priority to construction minerals (Estonia, Finland, Austria, Portugal, and Hungary).

Some countries have introduced resource taxes for a particular raw material group [54] (see table 1 below).

Economic instruments such as taxation, however, are frequently introduced without any time frames and not supported by quantitative targets. Moreover, many taxes listed in Table 1 were introduced in the 1990s, when resources policy was not yet an issue. Examples of application with marginal tax rates that hardly generate any steering effects are Bulgaria, France, Croatia, Cyprus, Latvia, and Lithuania. They serve the generation of public income rather than steer behavior in line with a particular environmental goal. Countries that collect verifiable amounts of taxes are Estonia, Denmark, Sweden, and the United Kingdom, with impacts on resource use evident for the latter three. These were introduced mainly in the context of shortages of certain raw materials (e.g., Sweden for the reduction of gravel extraction, the United Kingdom to reduce extraction of aggregates, and Denmark to stimulate recycling of construction minerals). The measurable effects are diverse and do not only depend on the level of price incentives but also on the inclusion of further instruments such as landfill taxes in a policy mix [55,56]. Since levying taxes or fees, in general, creates an incentive to reduce consumption, requires data concerning the extracted resources, and monitors the related activities, these countries can be regarded as being in an intermediate area between a qualitative and a quantitative policy approach to resource use.

Table 1. Taxes and levies on minerals in EEA countries 2013 (in the order of implementation). Source: OECD/EEA database on environmentally related taxes, fees and charges, other economic instruments and voluntary approaches used in environmental policy and natural resources management 2013.

Country	Tax/Fee [1]	Object of Taxation [2]	Year of introduction	Taxation rate [3]
Cyprus	Materials extracted from quarries	Extracted Material	1990	0.26 € per ton
Denmark	Duty on raw materials	Mineral raw materials	1990	Since 1990 fixed on 5 DKK pro m^3 = 0.67 €/m^3
Estonia	Mineral resources charge	Dolomite, Granite, Gravel, Sand, Limestone, Clay, Peat, Phosphate Stones, Oil Shale	1991	Between 0.57 €/m^3 for rubble and 3.03 €/m^3 for high-quality Dolomite
Lithuania	Minerals extraction charge	Plaster, Chalk, Limestone, Clay, Dolomites, Sand, Gravel, Soil	1991	0.04–0.22 €/m^3
Czech Republic	Fee for extracted minerals	Minerals	1992	Up to 10% of market price
Latvia	Materials extraction charge	Clay, Ton, Dolomites, Sand, Gravel, Limestone, Quartz Sand, Plaster, Soil	1995	0.01–0.35 €/m^3
Croatia	Extraction charge Mining charge	Gravel, Sand Mineral Raw Materials	1996 1959	0.41 and 0.55 €/m^3 2.6% of revenue
Sweden	Natural gravel tax	Gravel, Sand, Boulder, Pebble	1996	1.44 €/ton
Bulgaria	Mining charge	Clay, Quarry stone, Sand, Gravel	1997	0.05–0.15 €/m^3 0.03–0.08 €/m^3
France	Tax on extracted minerals	Granulate	1999	0.20 €/ton
UK	Aggregate levy	Aggregates	2002	2.30 €/ton
Poland	Tax on the extraction of minerals	Copper Silver	2012	992.7 €/t 122 €/kg

Notes: [1]: Designation used in the database; [2]: The German "resource tax" is decentralized and therefore no uniform federal resource tax (the same is true for other countries, such as Italy). The beneficiaries are the federal states. In addition, the tax only exceptionally involves construction materials such as gravel and sand, namely, when it is stipulated by the "Länder" legislation; [3]: Conversion factor of sand, gravel, pebble ≈ 1.8 ton per m^3, limestone ≈ 2.8 ton per m^3.

Within Europe, only Germany, Italy, Austria, Romania, and Sweden formulated quantitative targets for material *efficiency*; quantitative targets addressing material *input* exist in Italy, Austria, Sweden, Switzerland, and Hungary [4,5]. In addition, resource targets have gained in importance in non-European countries. While genuine macroeconomic consumption reduction goals are either rare or sector-orientated, or their realization is fairly unrealistic due to lack of implementation, it is not true, however, that there are no or only few quantitative or operational resource-related targets. Due to the lack of a profound country screening, it is not possible to provide a complete overview of all objectives that theoretically refer to resources or have an impact on them within the scope of this paper. This step rather aims at describing the variety of targets that either directly or indirectly refer to resources and in that way prepare the ground for further discussions.

4. Classifying Input-Oriented Resource Targets

4.1. Evaluation Criteria and Points of Discussion

Objectives can be ranked in accordance with various criteria, differing in priority. This section will briefly discuss why certain criteria are regarded as useful for a target formulation and in what way they are used for priority setting. As a first step, the approaches identified were sorted by governance levels (international, European, national, regional), raw material groups (e.g., critical minerals, metals, construction minerals, general abiotic; referring to what is mentioned as a target material in the program or measure), regions, target and base years, and the target perspective, *i.e.*, short-, mid-, or long-term. While long-term objectives provide an orientation, short- and mid-term objectives are helpful indicators in the implementation progress. As such they might be of a higher priority. However, when long-term goals are not supplemented with interim targets they tend to lead to inactivity. Consequently, further specification by short- and mid-term targets is advisable.

Another distinction has to be made between targets on a national and sectoral level. The level of governance is the level of observation on which the objectives can be placed. The academic discussion includes global equity targets that might be helpful for orientation. There is no example of an implemented equity target.

(a) Quantitative *vs.* qualitative goals: Due to their controllability and higher liability, quantitative targets must be regarded as more effective than qualitative targets that often remain vague and tend to lead to inactivity. Hence, it is recommendable to prefer targets that are quantitative and, thus, can be operationalized and reviewed in contrast to possibly soft, qualitative visions of the future. Thus, the matrix represents a quantitative target shaded in green and a qualitative one in yellow.

(b) Absolute consumption reduction targets *vs.* efficiency targets: Even though it is largely beyond question among academics that the resource consumption of industrial countries is far from being sustainable and has to be reduced in absolute terms [19,40], most targets address a more efficient use of resources, thus giving priority to the reduction of environmental impacts. The decoupling of material consumption from GDP growth is a common suggestion. The main argument against efficiency targets is that while objectives can be achieved, resource consumption may still grow in case of a correspondingly high GDP growth rate (rebound effects). Since efficiency targets can be achieved despite increasing resource consumption and environmental impacts and while the rate of GDP growth is high, absolute reduction targets are rated more positively (green) than efficiency targets (yellow).

(c) Disclosure of problem shifting (regional, sectoral, between material categories): The more specific a target is—e.g., in relation to the selection of specific resources—the more likely a problem shift is, *i.e.*, in the case of a successful implementation, unintended transfer effects can arise, which question the overall benefit of the target. Yet more specific targets facilitate monitoring and implementation. Whether a target will or will not provoke a shift of problems cannot be determined easily in advance. On the one hand, a national reduction target for specific materials, such as phosphate, can be useful from an environmental perspective. One the other hand, phosphate cannot be substituted easily, *i.e.*, the target could initiate a transfer of agricultural activities to other countries. Another recent example is the blending quota for biofuels and their effects on resource consumption and land use (e.g., the use of fossil fuels drops nationally—the input of biotic raw materials and land use increases internationally). This kind of complex interaction has to be taken into account in further supporting measures and targets.

(d) Indicator applied: Due to their scope, the applied indicators expose whether such problems have been considered [57]. For example, DMC targets only cover the total domestic extraction and could not disclose a domestic shift of problems between raw material groups, regions, or sectors. However, they could reflect a transfer of primary extraction abroad only partially by the amount of imports. It is thus suggested to evaluate the shift of problems on the basis of the indicator "scope." The scope should be chosen in such a way that possible transfer effects could be observed. Therefore, targets whose monitoring is able to consider international shifts are rated green, while targets that are able to illustrate national transfer effects are rated yellow. Targets whose scope cannot analyze transfers are rated red. Therefore, targets whose monitoring is able to reveal international shifts are rated green, while targets that are able to illustrate national transfer effects are rated yellow, and targets whose scope cannot analyze transfers are rated red.

(e) Integration into the target system: Targets for resource reduction or resource productivity improvement often form parts of a sustainability strategy and are thus embedded in a whole set of different sustainability goals. The integration of resource reduction goals into a target system can help to observe problem shifting and other unintended side effects. Yet, the literature indicates, too, that targets are seldom consistently coordinated and even often oppose each other. This paper can only touch upon this very complex and essentially interdisciplinary discussion; there is no systematic approach that allows a comprehensive assessment of trade-offs and multi-level issues of targets so far.

(f) Specification (addressing the economy, sectoral objectives, milestones): Higher goals, especially, are frequently less precise. Therefore, quantitative or qualitative interim targets or operational targets sometimes guide the process of implementation (e.g., ProgRess). Objectives for 2050 that lack further milestones and implementation strategies run the risk that no actions in terms of further specification or operationalization of goals will occur. The criteria addressing the economy, sectoral objectives, and milestones will each be labeled green if the answer is "yes" and red if the answer is "no".

(g) Implementation—reporting duties: With regard to long-term goals, reporting duties are seldom met and implementation strategies rarely developed. If voluntary or legally binding reporting duties exist or have been agreed upon, comparison becomes possible and is desired (see e.g., the German Sustainability Strategy). If a mostly qualitative goal has been defined, but neither indicators nor an implementation strategy have been described, the goal will remain a statement of intent rather than a politically manageable objective. However, as soon as appropriate milestones, responsibilities, operationalized indicators, and legally binding instruments have been arranged, one can speak of implementation (green shading). Instruments such as the taxation of mineral resources, which were sometimes introduced without specific reduction targets, are assigned a mixed rating (yellow). This mixed rating is due to their firm legal basis and successful implementation, which is regarded positively within the given context, on the one hand, and the lack of estimations about the reduction effects, on the other hand.

(h) The final category is the current validity.

4.2. Summary of the Identified Objectives

The screening of the programs, measures, initiatives, and regulations in 35 regions, countries, and governmental scopes altogether identifies a relatively limited number of decided, specific resource targets. *Absolute reduction targets* do not exist at the national level but various *relative reduction targets* have been introduced. Additionally, some *absolute reduction targets* have been implemented at a sectoral or regional level. Five countries formulated specific goals aiming at increasing resource productivity/ resource efficiency (Austria, China, Germany, Hungary, and Japan). The majority of the goals described in sustainability strategies or environmental programs are formulated qualitatively. Out of 44 goals identified here, 10 can be classified as reduction targets, while 18 aim at increasing resource productivity/resource efficiency (eight of them are quantitative; ten are qualitative). In addition, the evaluation found 12 waste-related goals (one final disposal amount, eight recovering and minimum recycling quotas, one minimum input quota, and four further qualitative goals) and more resource-relevant goals addressing green economy and investment programs (especially from South Korea, China, and Finland).

In total, 29 of the goals are quantitative and 15 qualitative; six are absolute and 36 are efficiency goals. Thereby, the design of 29 of the goals can be classified as short-term, three as medium-term, and four as long-term. Information on possible supra-regional problem shifts is given three times through choice of the indicator. In that way sectoral shifts of problems can be assessed 16 times but the chosen indicator does not provide such information 21 times. Thirty-six of the identified goals form part of a target system, while six do not belong to a comprehensive set of targets. Sectors are addressed by 21 of the goals, while 27 address the whole economy. Overall, this criterion does not deliver sound results regarding the consistency and the vertical or horizontal integration within the target system. A specification in the form of milestones or interim targets is only carried out in 16 cases, four times partially, and is totally absent in 22 cases.

The majority of the identified goals refer to all raw materials or mineral resources. Although mass metals and critical or rare metals are associated with much higher environmental impacts than non-metallic minerals, they are in practice not addressed by reduction or efficiency goals (Finland plans an increase of extraction in order to combat European import dependency of critical metals). However, they are in part integrated in recycling targets (e.g., EU waste directive).

Finally, the specific "types of objective" of the resource that were addressed in this paper will be summarized and briefly evaluated with regard to their current application:

- *Qualitative increase of resource efficiency/productivity*: present in almost all sustainability strategies and programs;

- *Absolute increase of resource efficiency/productivity*, e.g., the resource productivity target of 3,700 EUR/ton in Japan;
- *Proportional increase of resource efficiency/productivity*, e.g., a resource efficiency increase +50% [factor 2] in Austria and Germany until 2020, factor 4 until 2030 in Italy, +15% in China until 2015;
- *Proportional reduction of consumption*, e.g., by 80% until 2020 (in comparison to 2007) in Hungary and Italy, although without further reporting duties;
- *Qualitative reduction of consumption*, e.g., EU Raw Materials Initiative;
- *Absolute consumption or extraction limits*, e.g., a maximum of 12 million tons gravel in Sweden, 20 million tons oil shale in Estonia;
- *Recovery quotas*, e.g., 60% of the phosphate from waste water in Sweden;
- *Minimum recycling quotas*, e.g., 70% of the construction minerals (EU waste directive), 90% in Belgium, 50% of the metals from household and domestic wastes in the EU;
- *Minimum input quotas*, e.g., 25% of the construction materials in UK "from responsible sourcing";
- *3R-Strategies*, e.g., Circular Economy Law in China, Japan.

The details of the classification and evaluation can be found in Table A1 (Appendix).

5. Simulation and Modeling

Simulation of potential lines of development of resource use and resource productivity with integrating data on material flows for Europe in a macroeconomic framework only started a few years ago. There are two major strands of those exercises. The first type comprises methods where measures or instruments are being simulated and their effects on material demand and resource use are compared to a baseline or business-as-usual scenario. The second type of modeling simulates target values by making assumptions regarding potential resource/material input reductions (without considering particular measures or instruments) and then reflects the impacts on certain economic variables (such as GDP, employment, government revenues, *etc.*).

One of the first studies that carried out policy simulations for total material requirements was provided in 2005 [58,59], using the economic environmental model PANTA RHEI. The MOSUS project accomplished a simulation of European environmental policies, including a material policy, with data for global material extraction with the model GINFORS [60,61]. In a German project on Material Efficiency and Resource Conservation (MaRess) the model PANTA RHEI simulated a policy mix for Germany indicating that an absolute decoupling between economic growth and total material requirement is possible [62]. The impacts of an environmental tax reform on economic development and material and energy consumption were studied for Europe [63]. Direct material consumption and global material extraction was simulated with the model E3ME for Europe and globally with GINFORS in the PETRE project [64].

A recent type 1 approach was applied in the project MacMod simulating a targeted policy mix (recycling ratios, taxation and information instruments) which results in TMR (total material requirement) reduction of 8.1% in 2030 compared to a projected 2.5%–11% TMR increase in the baseline scenarios without policy measures [65]. A set of type 2 scenarios assuming an increase of the resource productivity from 1% to 3% per annum (in total: 15% to 50% between 2014 and 2030) discovers that an "*absolute material decoupling takes place in the scenarios where RP [resource productivity] targets are 2% p.a. and above*" (while a 1.7% GDP growth rate for Europe is assumed) [66]. Ongoing research within the FP7 framework, *inter alia* in the project POLFREE (Policy options for a Resource Efficient Economy), 2012–2016, further investigate both types—impacts on the economic development when reducing the material input and impacts of instruments on the material requirement [67].

The simulations suggest that scenario cases can show a distinct improvement of resource productivity or efficiency provided a specific policy mix is implemented for this purpose. However, the modeling also shows that even positive and directional results are partly far away from action plans and strategies formulating targets such as factor 4 or 10 or projections calling for reductions or resource use up to 80% [18,19]. The present modeling confirms the skeptics as to efficiency targets and provides evidence that a relative decoupling is not necessarily associated with absolute declines of materials and resource use. The challenges remain large.

6. Concluding Remarks

Resource policies and resource targets aim at more sustainable resource management. Thereby, both quantitative approaches and qualitative approaches are employed. The long-term perspective of a resource policy is the model of an economy embedded in natural bio-geochemical cycles with a minimal resource consumption that ideally does not develop at the expense of other regions and future generations [40,68]. However, the present spectrum of resource policy goals presents a scattered mosaic of selective and single measures and individual goals at the national level that are hardly capable to yield substantial progress. There is no coherent effort for lowering resource consumption, let alone a consensus on the issue of whether that is desirable at all. While governments tend to increasingly address the resource conservation and resource efficiency issue qualitatively, they remain by and large incoherent. Specific reduction targets for different raw materials and/or sectors exist only partially. When formulated against the background of a globally increasing resource consumption, they often stop here and do not disclose any rebound effects and international burden shifts arising from their focus on efficiency goals instead of absolute reduction targets [48,68–70].

This may be due to the fact that the current scientific state of knowledge does not provide sufficient basis for the deduction of targets and roadmaps from neither the scarcity of raw materials in supply nor the boundaries of the capacity of ecosystems. While the latter can be defined in many cases, their causal relation to (raw) material consumption is not clear enough as to derive specific goals for single raw materials therefrom [71].

Heated debates revolve around the questions of whether quantitative targets and target systems can be sufficiently consistent at all, whether they are useful within the political process of an open society that faces so many potential conflicts of interest and a plurality of targets, and how, assuming that the knowledge will remain incomplete, relevant targets can be formulated scientifically robust [71,72]. Targets provide orientation and guidance and thus contribute to a prioritization of goals and measures in a society [9], potentially acting as a powerful instrument of environmental policy. The opposite standpoint regards a target-based approach as suboptimal, since—depending on the target and the derived policy mix—it may trigger unintended side effects. This objection is indeed of interest for the resource use context, where interdependencies are still not fully understood or under control [20].

However, against the background of limited resources, regionally and globally restricted capacities of ecosystems, overexploitation of resources, a globally unequal distribution of resource consumption, and further inter- and intra-generational aspects of distribution, immediate and directional action is much needed. As long as the knowledge base about absolute boundaries and complex interdependencies between raw materials, substances, and side effects is as incomplete as it is, normative considerations and decisions must remain an essential element of the process towards resource efficiency. A vision of a resource-efficient European economy inevitably has to take into account aspects of sufficiency and translate them into quantitative, tangible targets. At the same time, a number of scenario calculations show that reductions of material inputs do not necessarily go along with negative effects on economic variables and that policy mixes can lead to absolute reductions in resource requirements. These savings are, however, far from factor 4 or factor 10 goals.

Targets and objectives contribute to long-term orientation. In a multi-level political-administrative system, objectives can be set at all levels and for all areas of responsibility—at the global, regional, state, or municipal level, at the company or organization level, for sectors, for specific (environmental) policy areas or, ultimately, for single resources or raw materials. The development or formulation of objectives for resource use is not only challenging, but can even become a policy objective itself, for instance by constituting an element within a policy mix of different measures and initiatives or forming a step of the agenda setting. From a policy perspective, policy formulation is a political process, including all the different stages in a policy cycle. From an economic perspective, resource goals serve society and the economy by overcoming orientation and information deficits. From a consumer perspective, they can initiate or prepare for a change in behavior.

The EU and individual pioneering countries such as Japan could take a leading role in pushing for more extensive and ambitious resource goals and might encourage other countries to follow. Promising institutional and programmatic improvements have been implemented on a national and European level and should be fostered and disseminated in order to substantially contribute to stronger macroeconomic effects.

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Author Contributions

Bettina Bahn-Walkowiak did the main research and writing; Sören Steger contributed to the classifications system, the modeling section, and the discussion of targets.

Conflicts of Interest

The authors declare no conflict of interest.

Appendix

Table A1. International, European, and national examples of raw material targets evaluated according to eight criteria.

Target	Raw material group	Region	Name of the approach	Target year	Base year	Target perspective	Governance level	(a) quantitative *vs.* qualitative	(b) absolute reduction *vs.* efficiency	(c) shift of problems	(d) indicator(s)	(e) part of a target system	(f) specification: macro economy	(f) specification: sectoral targets	(f) specification: interim targets	(g) implementation/ reporting duties	(h) validity
International																	
Increase of Resource Efficiency by 15%	All Materials	China	12th National Five Year Plan for National Economic and Social Development	2015	2011	short-term	national	quantitative	relative	partly	GDP/ A(adjusted) DMC	yes	yes	n/a	no	partly	yes
3R—Reduce, Reuse, Recycle	All Materials	China	Circular Economy Promotion Law (CEPL)	n/a	n/a	short-term	sectoral	qualitative	relative	no	no	yes	no	yes	no	yes	yes
Doubling of green investments in clean technology, Recycling and renewable Energies ($468 bn)	/	China	12th Five-Year Plan for National Economic and Social Development (2011–2015)	2011	2015	short-term	sectoral	qualitative	relative	no	n/a	yes	yes	n/a	no	yes	yes
Resource Productivity Target 3,700 EUR/t (6,700 EUR/t without Stones and Earths) (+50%)	All Materials	Japan	FP Sound Material-Cycle Society (2008)	2015	2000	short-term	national	quantitative	relative	partly	GDP/DMI	yes	yes	no	yes	yes	yes

Table A1. *Cont.*

Target	Raw material group	Region	Name of the approach	Target year	Base year	Target perspective	Governance level	(a) quantitative *vs.* qualitative	(b) absolute reduction *vs.* efficiency	(c) shift of problems	(d) indicator(s)	(e) part of a target system	(f) specification: macro economy	(f) specification: sectoral targets	(f) specification: interim targets	(g) implementation/ reporting duties	(h) validity
Efficient Use of Resources	Minerals, Metals	Japan	Law on the Promotion of Effective Utilization of Resources (2000)	2000	n/a	short-term	sectoral	qualitative	relative	partly	MFA	yes	no	yes	yes	yes	yes
Waste Limit 23 m/t (−60%)	Waste	Japan	SMCS (2008)	2015	2000	short-term	national	quantitative	absolute	no	t	yes	yes	no	yes	yes	yes
Recovering Quota 14%–15% (40%–50% Increase)	All Materials	Japan	SMCS (2008)	2015	2000	short-term	national	quantitative	relative	partly	DMI	yes	yes	no	yes	yes	yes
Minimum Recycling Quota 95%	Constructi on Minerals	Japan	Construction Materials Recycling Law (2002)	2010	2002	short-term	sectoral	quantitative	relative	no	%	yes	no	yes	no	yes	yes
Recycling + Substitution	Critical Metals	Japan	Rare Metals Strategy (2009)	n/a	n/a	n/a	national	qualitative	n/a	n/a	none	no	yes	no	no	no	yes
Efficient Use of Resources	All Materials	South Korea	Act on the Promotion of Saving and Recycling of Resources (2007)	2013	2009	short-term	national	qualitative	relative	no	none	no	yes	no	no	no	yes
Green Recovery Program (83,6 Bn. USD = 4% des BIP)	Mainly Energy	South Korea	Green New Deal (2009–2013)	2013	2009	short-term	national	qualitative	n/a	n/a.	%	n/a	yes	n/a	n/a	k.A.	yes

Table A1. *Cont.*

Target	Raw material group	Region	Name of the approach	Target year	Base year	Target perspective	Governance level	(a) quantitative *vs.* qualitative	(b) absolute reduction *vs.* efficiency	(c) shift of problems	(d) indicator(s)	(e) part of a target system	(f) specification: macro economy	(f) specification: sectoral targets	(f) specification: interim targets	(g) implementation/ reporting duties	(h) validity
Sustainable Use of Resources	38 Materials, Products, and Services	USA	Sustainable Materials Management (2009)	2020	2009	short-term	sectoral	qualitative	relative	partly	MFA, IO, LCA	no	no	yes	no	no	yes
Increase of the Recycling Quota	(critical) Metals (Energy Sector)	USA	Critical Materials Strategy (2011)	n/a	n/a	n/a	national	qualitative	relative	no	none	yes	no	no	no	yes	yes
Europe																	
Increase of resource efficiency	Minerals, Metals	Europe	EU Roadmap (2011)	2020	2011	short-term	international, EU	qualitative	relative	partly	GDP/DMC	yes	yes	yes	yes	partly	yes
Increase of resource productivity and consumption reduction	Minerals, Metals, critical metals	Europe	Raw Materials Initiative (2008/2011)	n/a	n/a	n/a	international, EU	qualitative	relative	no	n.d.	yes	yes	no	no	yes	yes
Recycling Quota 100%	abiotic (Minerals) (Phosphate)	Europe	EP resolution on a resource-efficient Europe (2012)	2020	2012	short-term	international, EU	quantitative	relative	no	%	yes	yes	no	no	no	yes
Minimum Recycling Quota 70%	Construction Minerals	Europe	Waste Framework Directive (2008)	2020	2010	short-term	international, EU	quantitative	relative	no	%	yes	yes	yes	no	yes	yes
Minimum Recycling Quota 50%	Metallic waste from households	Europe	Waste Framework Directive (2008)	2020	2010	short-term	international, EU	quantitative	relative	no	%	yes	yes	yes	yes	yes	yes

Table A1. *Cont.*

Target	Raw material group	Region	Name of the approach	Target year	Base year	Target perspective	Governance level	(a) quantitative *vs.* qualitative	(b) absolute reduction *vs.* efficiency	(c) shift of problems	(d) indicator(s)	(e) part of a target system	(f) specification: macro economy	(f) specification: sectoral targets	(f) specification: interim targets	(g) implementation/ reporting duties	(h) validity
National																	
Increase of Resource Productivity by Factor 4	All Materials	Austria	NSTRAT (2002)	2008–2012	1990–1997	short-term	national	quantitative	relative	partly	MFA/NAMEA	yes	yes	yes	yes	yes	yes
Increase of Resource Productivity by Factor 4 to 10	All Materials	Austria	REAP (2012)	2050	2008	long-term	national	quantitative	relative	partly	GDP/DMC	yes	yes	no	yes	yes	yes
Increase of Resource efficiency by 50%; Reduction of Consumption by 20%	All Materials	Austria	REAP (2012)	2020	2008	short-term	national	quantitative	relative	partly	GDP/DMC	yes	yes	no	yes	yes	yes
Minimum Recycling Quota 90%	c&d waste	Belgium (Brussels)	Waste Prevention and Management Plan	2020	2010	short-term	sectoral	quantitative	relative	partly	%	yes	no	yes	no	no	yes
Consumption reduction	abiotic (Sand, gravel, tones *etc.*)	Denmark	Tax on raw materials	n/a	n/a	n/a	sectoral	quantitative	relative	no	t/yr	no	no	yes	partly	partly	yes
Consumption reduction	Minerals	Estonia	Mineral resources extraction charge	n/a	n/a	n/a	sectoral	quantitative	relative	no	t/yr	no	no	yes	partly	partly	yes
Limit of consumption 20 Mt Oil Shale/year	Oil Shale	Estonia	National Development Plan (2008-2015)	2015	2008	short-term	national	quantitative	absolute	no	t/yr	yes	yes	no	yes	yes	yes

Table A1. *Cont.*

Target	Raw material group	Region	Name of the approach	Target year	Base year	Target perspective	Governance level	(a) quantitative *vs.* qualitative	(b) absolute reduction *vs.* efficiency	(c) shift of problems	(d) indicator(s)	(e) part of a target system	(f) specification: macro economy	(f) specification: sectoral targets	(f) specification: interim targets	(g) implementation/ reporting duties	(h) validity
Increase of efficiency + Substitution	Construction Minerals	Estonia	National Development Plan for the Use of Construction Minerals 2011–2020	2020	2011	short-term	sectoral	qualitative	relative	no	n/a	yes	no	yes	no	yes	yes
Recovering Quota 60%	c&d waste	Estonia	National Development Plan (2011–2020)	2020	2011	short-term	sectoral	quantitative	relative	no	%	yes	no	yes	yes	yes	yes
Intelligent use of resources	All Materials	Finland	National Resources Strategy (2009)	n/a	2009	long-term	national	qualitative	relative	no	none	yes	yes	no	no	yes	yes
Increase of extraction up to 70 Mt (2008–2020)	Minerals, Metals, critical Metals	Finland	Minerals Strategy (2010)	2020	2011	long-term	sectoral	quantitative	absolute	no	t/y	yes	no	yes	no	no	yes
Increase of resource efficiency	abiotic resources & material use	Germany	Resource efficiency program (ProgRess) (2012)	2020	2012	short-term	national	qualitative	relative	partly	GDP/DMI + DMC cap + TMC + RME	yes	yes	yes	yes	yes	yes

Table A1. *Cont.*

Target	Raw material group	Region	Name of the approach	Target year	Base year	Target perspective	Governance level	(a) quantitative *vs.* qualitative	(b) absolute reduction *vs.* efficiency	(c) shift of problems	(d) indicator(s)	(e) part of a target system	(f) specification			(g) implementation/ reporting duties	(h) validity
													macro economy	sectoral targets	interim targets		
Increase of resource productivity by factor 2	Resource Productivity (abiotic resources)	Germany	Sustainability Strategy (2002)	2020	1994	middle-term	national	quantitative	relative	partly	GDP real EUR / DMI abiot (t)	yes	yes	no	no	yes	yes
Consumption Reduction	Construction Minerals	United Kingdom	Aggregates levy	n/a	n/a	n/a	sectoral	quantitative	relative	partly	DMC/GVA	yes	no	yes	partly	partly	yes
Smart Consumption	All Materials	United Kingdom	SD Strategy (2005, 2010)	2010	1990	middle-term	national	qualitative	relative	partly	DMC/GDP	yes	yes	no	no	partly	yes
Minimum Input 25% responsible sourcing (cert. quarries)	Construction Minerals	United Kingdom	Sustainable Construction Strategy (2008)	2012	2008	short-term	sectoral	quantitative	relative	no	%	yes	no	yes	yes	yes	yes
Reduction of Material Intensity to 80%	All Materials	Hungary	National Environmental Technology Innovation Strategy (NETIS) (2011)	2020	2007	short-term	national	quantitative	relative	partly	DMC/GDP	yes	yes	yes	no	yes	yes
Reduction of Consumption by 25%	All Materials	Italy	SD Strategy (2002)	2010	n/a	short-term	national	quantitative	relative	yes	TMR in t	yes	yes	no	no	n/a	yes
Reduction of Consumption by 75%	All Materials	Italy	SD Strategy (2002)	2030	n/a	middle-term	national	quantitative	relative	yes	TMR in t	yes	yes	no	no	n/a	yes

Table A1. *Cont.*

Target	Raw material group	Region	Name of the approach	Target year	Base year	Target perspective	Governance level	(a) quantitative *vs.* qualitative	(b) absolute reduction *vs.* efficiency	(c) shift of problems	(d) indicator(s)	(e) part of a target system	(f) specification: macro economy	(f) specification: sectoral targets	(f) specification: interim targets	(g) implementation/ reporting duties	(h) validity
Reduction of Consumption by 90%	All Materials	Italy	SD Strategy (2002)	2050	n/a	long-term	national	quantitative	relative	yes	TMR in t	yes	yes	no	no	n/a	yes
(Possible) increase of Resource Productivity by 3%–4%/year	All Materials	Romania	National SD Strategy (2008)	2013	2008	short-term	national	quantitative	relative	no	n/a	yes	yes	yes	yes	no	yes
Increase of Resource Efficiency	Minerals	Slovenia	National Mineral Resource Management Program (2009)	n/a	n/a	n/a	sectoral	qualitative	relative	n/a	n/a	n/a	no	yes	n/a	n/a	yes
Limit of Consumption 12 Mt/Year	abiotic (Minerals) (Gravel)	Sweden	Taxation of Gravel	2010	n/a	short-term	sectoral	quantitative	absolute	no	t/yr	no	no	yes	partly	partly	yes
Minimum Recycling Quota (60% from Sewage)	abiotic (Minerals) (Phosphate)	Sweden	Interim Target	2015	n/a	short-term	national	quantitative	relative	no	%	yes	n/a	n/a	yes	no	yes
Reduction of Consumption to "Footprint One"	All Materials	Switzerland	Cleantech Masterplan (2011)	n/a	2011	n/a	national	quantitative	absolute	yes	Footprint	yes	yes	no	no	no	yes
Regional																	
Stable Level of Consumption	All Materials	Spain (Basque Country)	Environmental Strategy (2002–2020)	2006	1998	short-term	regional	quantitative	absolute	partly	GDP/DMC (€/Kg) (TMR)	yes	no	no	yes	no	no

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