Małgorzata Burchard-Dziubińska
University of Lodz

PRODUCTION FOR A GREEN ECONOMY

1. Introduction

In all published reports and strategies dedicated to a greener future, the sector of production goods and services plays a crucial role. Current patterns of production have direct negative impacts on the environment and natural resources worldwide. Pollution and even poisoning of air, soil and water are in many cases the undesirable consequences of previous production systems. The need for changes in this field have been theoretically well-recognized and defined, however the question still remains valid whether we are ready to pick up the gauntlet in practice and make a decisive turn in the direction of more environmentally-friendly production patterns. In order to achieve the objectives of sustainable development and put the green economy into practice, conventional approaches to the production must be re-oriented towards the promotion of renewable, cleaner and more efficient technologies aimed at the conservation of all natural resources. This requires a new approach to the design of products and their production, and requires the inclusion of post–industrial and post-consumer residues into permanent circulation and the development of eco-innovative management patterns.

2. Starting point for the development of green production patterns

Existing patterns of production (and of consumption) have led directly to the deep ecological imbalance that will have such drastic social and economic consequences in the near or not-too-distant future. To avoid these negative effects and put society and the economy on the path of long-term sustainable development, radical changes in production patterns are needed. The problems identified are usually considered to susceptible to resolution through the use of new technologies and resource-efficient, cleaner production.

The suggested changes generally concern extensive investment in resource-efficiency and renewability. These are of course important, but also inadequate to the scale of changes necessary given the time we have. All patterns based on the old philosophy of production in the 'brown economy' are well known as "business as usual". Basic differences between the brown and green economy are listed in Table 1.

Table 1. Basic differences between the brown and green economy

Green Economy	Brown Economy
Decoupling economic growth from the consumption of raw materials	Unlimited economic growth
Resource-efficient production, cleaner production	Resource-intensive production
The dominance of renewable energy resources	Fossil fuels as a primary energy source
High energy efficiency	Low energy efficiency
Protection of biodiversity	Thoughtless approach to biodiversity
Sustainable consumption	Over-consumption
Corporate social responsibility	Business as usual
Intergenerational end to interregional justice	Acceptance of social inequality
Building of social trust	Lack of public trust

Source: own elaboration.

The problem which still remains unresolved is the scale of production. This is due to the simultaneous impact of two factors: demography, and the use of quantitative measures of developmental success, according to which the more we produce, the better for us and the whole economy. The growing human population generates growing consumer demand, which of course is connected with the increased demand on raw materials and energy. Demographic change will probably be the factor that most impacts the development of individual countries and regions in the twenty-first century. If the population, currently estimated at 7 billion, continues to grow and if the projections of demographers are correct, in the middle of this century humanity is going to reach 9.3 billion.[1] While in developed countries the population is likely to drop, or at least slow down in terms

[1] *UN Population Division, World population in 2300*, 2003, http://www.un.org/esa/population/publications /longrange2/longrange2.htm

of the growth rate, in other parts of the world there is going to be a real population explosion. A consequence of population growth is an increase in demand for food and other goods and services. The rising consumer aspirations of societies in the developing countries are an important cause of increasing pressure on the natural environment. This is reflected in the growing consumption of primary resources and the ever more noticeable in some regions deficit of key resources such as water and arable land area, as well as in the constant deterioration of the natural environment on a global scale. Despite local successes achieved in environmental protection, generally on the global level the increase in emissions continues. This applies to air, water and soil, which inevitably entails health risks and problems in food production.

The second factor – the use of quantitative measures of development – stimulates permanent growth in the amount of produced goods and services, which is reflected in GDP growth, which continues to be the most popular index of economic activity. In the Europe 2020 strategy improved resource efficiency is a key for achieving both economic and environmental objectives.[2] However, the resource-efficiency gains attained so far have not been sufficient to change the trend in the absolute consumption of natural resources, which continues to increase both in Europe and globally.[3] The rate of annual increase in material productivity in the EU over the past few years was 3.2% (GPD in purchasing power parity). Europe is among the world's regions with the highest material consumption levels (around 16 tonnes per capita), but absolute levels of consumption also grew by around 8%. An absolute reduction can only be realized if the annual growth rates of material productivity are higher than the economic growth rate.[4]

The next problem are "hybrid monsters" as an output of our production systems. The term "hybrid monsters" is used to describe products which are mixtures of materials – both technical and biological – neither of which can be salvaged after their current lives. Nowadays over 67 million different substances are known, each of which has its eco-toxicological potential. For example, the average television is made up of 4,360 chemicals.[5] Some of them are toxic, but others are valuable materials for industry. They are wasted when a television ends up in a landfill. Some chemicals released into the environment can enter into interactions with others, a process that is in many cases out of control because of the continuous

[2] *Europe2020 A European strategy for smart, sustainable and inclusive growth*, http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020% 20-%20EN%20version.pdf.

[3] *The Eco-Innovation Challenge, Pathways to a resource efficient Europe, Annual Report eco-innovation observatory p. VII*, http://www.eco-innovation.eu/media/ECO_report_2011.pdf [download 20.10.2014].

[4] *Ibidem*, p. 89.

[5] M. Braungart, W. McDonough, *Cradle to cradle. Re-making the way we make things*, Vintage Books, London 2009, p. 110.

movement and mixing of the materials in the environment. Other materials are durable waste.

Moreover, each product has its own ecological rucksack. In accordance with the research conducted in the Wuppertal Institute, ecological rucksack is the total quantity (in kg) of the natural material that is disturbed in its natural setting, and thus considered as the total input in order to generate a product – counted from the cradle to the point when the product is ready for use – minus the weight (in kg) of the product itself. All materials used in the production of goods are listed by weight and multiplied by rucksack factors, and then summed to include all materials.

$$MI = SUM (Mi \cdot Ri)$$

Here, MI is material intensity (the ecological rucksack), Mi is the weight of the material given in kilograms and Ri is the rucksack factor. The following examples demonstrate how "heavy" are our rucksacks of some materials: plastic – 5 kg, paper – 15 kg, aluminum – 85 kg, copper – 500 kg, gold – 550.000 kg[6] and of energy conversion: atomic energy – 271 kg resources pro 1 MWh, gas – 283 kg/MWh, oil 306 kg/MWh, coal – 722 kg/MWh, brown coal 1,134 kg/MWh.[7] An electric current produced from brown coal is the most expensive fossil fuel at all in terms of its ecological price.

Over 90% of raw materials and energy mobilized for the production of consumer goods is consumed long before the stage of the finished product. As an example one may cite waste in the mining industry, the heat loss in power plants, barren soil in mechanized agriculture, waste wood and metals processing, grain in animal husbandry, water used in the finishing of metals and, fuel for transportation. The more one reduces resource consumption, the more eco-efficient is the economy. This is why such high hopes are associated with the development of new technologies and the use of innovative products, which will drastically reduce the consumption of energy and raw materials.

3. Preferred changes in production patterns

In the discussion about the transformation of production for a green economy three methods of operation are preferred. These are: the growing importance of renewable resources, material efficiency, and waste minimization.

Renewable resources are replenished naturally, which means that the stock of these resources can remain unchanged or can even increase over time, but only

[6] F. Schmidt-Bleek, *Grüne Lügen*, Ludwig Verlag 2014, p. 56–57.

[7] *Ibidem*, p. 62–63.

under the condition that they are not over-exploited. These may become non-renewable resources if they are used faster than nature can replace them. In order to maintain the sustainability of renewable resources, the harvest rate must not be higher than natural growth rate. This means that each resource can be harvested no greater than at the maximum sustainable yield (MSY),[8] i.e. the maximum yield that can be harvested from renewable resource stock without reducing the size of the stock.

In the discussion about production patterns for a green economy, the material efficiency approach is strongly emphasized. The expected progress can be achieved by more efficient use of resources and energy, which is of course a welcome change from the business' point of view. Reducing resource use creates a significant business opportunity to reduce costs. This is particularly relevant at a time of increasing prices of natural resources. According to the Eurobarometer survey, 75% of businesses such as manufacturing, construction, agriculture, and water and food services reported an increase in the cost of materials in the past five years.[9] Nine out of ten surveyed companies expect material prices to increase in the future. The changes in the use of materials can be focused on:

– production – by replacement of additive material and operating material and by new production methods,
– production periphery – by warehousing and consignment and packaging,
– product – by re-design, new material, less material, less material variety and by standardization, modularization, and typification,
– personnel – by raising the awareness, training, and motivation of employees.

This means, that more efficient material use is achievable thanks to its integration with quality management systems, which use a material flows analysis, life-cycle assessment and material input per service unit to compare and identify the "best" end-of-life options. These and other management supporting systems enable the assessment of every impact associated with all life stages of a product – from raw material extraction through to production, selling and application, and up to disposal or re-use – and this assessment can help to minimize the environmental costs of production.

In accordance with the incentive addressed to entrepreneurs by the German Federal Ministry of Economics and Technology and known as the German Material Efficiency (in particular with respect to SMEs in the manufacturing industry), it is known that improving material efficiency can be done at a profit. "Nearly half of the 700 companies achieve material efficiency improvements with investment costs under 10,000 Euros and 20% of companies for around 50,000. In these cases, around 200,000 Euros on average have been saved per company through

[8] T. Żylicz, *Ekonomia środowiska i zasobów naturalnych* [*Economics of environment and natural resources*], Polskie Wydawnictwo Ekonomiczne, Warszawa 2004, p. 85.

[9] Eurobarometer survey: How green are European SMEs?, European Commission MEMO Brussels, 17 December 2013, http://europa.eu/rapid/press-release_MEMO-13-1152_en.htm

material efficiency gains, which means that the material efficiency measures had a leverage effect factor of 20. This is the equivalent of around 3,300 Euro per employee and increases the yearly sales-to-profit margin by about 2.4%. In relation to their turnover, small companies have the highest relative material cost-savings potential."[10] This interest in lowering costs by reducing the consumption of raw materials may also be beneficial for the environment, provided that the absolute use of natural resources will decrease simultaneously.

One promising way to increase resource efficiency and make progress in the greening of the economy is through the development of eco-innovations and eco-industries. "Eco-innovation is any innovation that reduces the use of natural resources and decreases the release of harmful substances across the whole life-cycle." The understanding of eco-innovation has broadened from a traditional understanding of innovating to reduce environmental impacts towards innovating to minimize the use of natural resources in the design, production, use, re-use and recycling of products and materials.[11] The perception of eco-innovation cannot be limited only to producing "green products". Technological innovation alone is not sufficient to enable the transition into a green economy. Equally important are systemic innovations in the way services are delivered and organizations are run. Some researchers even expect revolutionary change, with a strong return to renewables, (especially in relation to energy production), improvement of resource efficiency, together with the guarantee that these efficiency gains are not offset by growth in the total consumption of natural resources, and with changes in management both in terms of resource management and production processes cycles.[12] Another option is the development of biotechnologies. In accordance with Art. 2 of the UN Convention on Biological Diversity,[13] biotechnology is "any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products or processes for specific use." In other words, it is the use of living systems and organisms to develop or make useful products. An example of such activity is the German government's *National Research Strategy BioEconomy 2030,* which represents a "striving towards a natural cycle oriented, bio-based economy that is in accordance with technology and ecology."[14]

---

[10] Demea (2010), *Die betriebs- und volkswirtschaftliche Bedeutung der Materialeffizienz und bisherige Erfahrungen mit dem Impulsprogramm Materialeffizienz der Bundesregierung* [*The economic relevance of resource efficiency and experiences of the government so far*], Workshop der FES, 8 July 2010. Berlin, [in:] *The Eco-Innovation Challenge*…, p. 94.

[11] *The Eco-Innovation Challenge, Pathways to a resource efficient Europe, Annual Report eco-innovation observatory p. VIII*, http://www.eco-innovation.eu/media/ECO_report_2011.pdf [download 20.10.2014].

[12] *Ibidem*.

[13] *UN Convention on Biological Diversity 1992, Art. 2*, https://www.cbd.int/doc/legal/cbd-en.pdf [download 20.09.2014].

[14] *National Research Strategy BioEconomy 2030. Our Route towards a biobased economy, Bundesministerium für Bildung und Forschung 2010*, http://www.bmbf.de/pub/National_ Research_Strategy_BioEconomy_2030.pdf.

In this strategy five main courses of action are formulated for further development towards a knowledge-based, internationally competitive bioeconomy. These are:

– global food security,
– sustainable agricultural production,
– healthy and safe foods,
– the industrial application of renewable resources,
– the development of biomass-based energy carriers.[15]

In the USA a *National Bioeconomy Blueprint* was adopted in 2012. It follows on the 2009 report by the US National Research Council, *A New Biology for the 21st Century*, and highlights the potential of technological innovation for health and food in the future. The *National Bioeconomy Blueprint* describes five strategic objectives for a bioeconomy with the potential to generate economic growth and address society's needs. These are:

– support for R&D investments that will provide the foundation for the future U.S. bioeconomy,

– facilitate the transition of bioinventions from research lab to market, including an increased focus on translational and regulatory sciences,

– develop and reform regulations to reduce barriers, increase the speed and predictability of regulatory processes, and reduce costs while protecting human and environmental health,

– update training programs and align academic institution incentives with student training for national workforce needs,

– identify and support opportunities for the development of public-private partnerships and pro-competitive collaborations – where competitors pool resources, knowledge, and expertise to learn from their successes and failures.[16]

In 2010 US income from various biotechnologies (excluding the agricultural sector) was already estimated at as much as USD 100 billion, and its further expansion is expected.

The last issue is waste minimization. This refers to strategies aimed at preventing the generation of waste. On the production side, these strategies are focusing on optimizing resource and energy use and lowering toxicity levels during manufacture. Strategies that are considered to minimize waste and thus improve resource efficiency, either in or even before the manufacturing process, include for example, product design, cleaner production, re-use of scrap material, improved quality control, waste exchanges, *etc*.[17]

---

[15] *Ibidem*, p. 2.

[16] The *National Bioeconomy Blueprint, April 2012*, p. 3–5, http://www.whitehouse.gov/sites/default/files/microsites/ostp/national_bioeconomy_blueprint_april_2012.pdf.

[17] *Waste Minimization, United Nations Environmental Programme Global Partnership on Waste Management*, Web. 3 Jan. 2013, http://www.unep.org/gpwm/FocalAreas/WasteMinimization/tabid/56460/ Default.aspx

A hierarchical approach to materials management includes source reduction, recycling, energy recovery, treatment, and finally, disposal. For example, compacting, neutralizing, diluting, and incinerating are not typically considered waste minimization practices.

4. Critique of the preferred changes of production patterns

Undoubtedly the shift towards renewable resources, savings in the use of materials, and waste minimization is a meaningful and desirable change. It can contribute to the greening of the economy, but it still may not be enough to stop the growth of the global ecological crisis in the long term.[18]

A more decisive shift towards renewable resources may in practice be difficult to achieve due to the already visible overexploitation of many of these resources. Unlimited access applies only to a very few of them like sun, wind and wave energy. The control of use of natural resources in order to maximize the benefit that resource provides should simultaneously prevent the overexploitation or degradation of the resource base. Proper resource management is needed to ensure that the resource harvest and extraction are both efficient and sustainable. The already-observed problems in many places of the world, e.g. deforestation, water, crop, and land shortages, may extend to other types of resources due to the increasing demand for them.

The next issue to consider is the so-called rebound effects that prevent the continuation of production and consumption within ecological constraints. Unfortunately, previous experiences show a reverse trend. Any savings in the use of materials and energy are immediately captured and offset by new applications, so the scale of production continues to expand. According to a report published in December 2011 for the German government, "there is very little analysis of the impact of increasing the efficiency of resource consumption at the level of the entire economy." The authors are of the opinion that "when it comes to the strategy of decoupling the GDP from resource use, the most that can be noted is that while the consumption of certain raw materials increased less rapidly than GDP (relative decoupling), the number of cases in which there was an absolute reduction of resource consumption (absolute independence) is close to zero."[19] The environmen-

[18] B. Unmüßig, W. Sachs, u. T. Fatheuer, (2012), *Critique of the Green Economy Toward Social and Environmental Equity*, Vol. 22, Heinrich Böll Foundation.

[19] R. Madlener, u. B. Alcott, (2011), *Herausforderungen für eine technisch-ökonomische Entkoppelung von Naturverbrauch und Wirtschaftswachstum unter besonderer Berücksichtigung der Systematisierung von Rebound-Effekten und Problemverschiebungen* [*Challenges for a technical-economic decoupling of resource use and economic growth with special emphasis on systematization of rebound effects and problem shifts*], Enquete-Kommission „Wachstum, Wohlstand,

tal benefits of the achieved material savings or productivity growth are nullified by the shift to new applications. This applies in particular situations, which are defined as beneficial for all players, that promise environmental benefits concurrently with economic gains. They have a kind of "built-in" rebound effect due to higher financial profits.

Another reason for the difficulties in implementing a green economy is that the global economic demand for natural resources increases with the overcoming of poverty and the entrance onto the path of development in many previously poor regions. Generally, the use of old production techniques negates the chances of development in more environmentally-friendly way. The duplication of already-known production patterns in less developed countries reinforces the negative environmental effect, which does not help these countries to reach a green economy, and in the end will only deepen the global ecological crisis.

The conclusion is that more efficient use of resources should go hand in hand with more modest goals. Without such a link any increase in efficiency is not enough in itself to bring about a positive change in the total volume of natural resources used, and thus reduce the pressure on the environment.

An important issue is also chemicals' management and environmentally sound waste management. This is connected with strengthening the efforts towards a more robust, coherent, effective and efficient international regime for substances, (in particular toxic substances) throughout their lifecycle. Without such a contribution to the management of production processes it would be difficult to be successful in the development of a green economy.

5. From "cradle to grave" to "cradle to cradle"

The development of a green economy needs new patterns of design, production and management based on the approach that each element used in production should be seen as a part of the matter-energy life cycle in the world, where the concept "waste" would be replaced by the concept of "nutrient". In this case a nutrient is a substance that provides nourishment essential for growth and the maintenance of the life of our economy. The idea of management of a product's life cycle "from cradle to grave" is assessed as not sufficient to avoid the problem of cluttering of the environment by the residues of production and consumption processes. In pre-industrial culture most products would safely biodegrade once they were thrown away, buried or burned. The exceptions were metals: as highly valuable these were not usually thrown away, but melted down and reused. In times of scarcity,

Lebensqualität" des Deutschen Bundestages, Berlin 12 Dezember 2011. Kommissionsnmaterialien M-17(26)13.

the recognition of the value of technical materials was of high importance. People were careful about reusing things and waste materials to "feed" industrial needs. But the development of industrialization changed our approach to things and materials. The cheapening of production and implementation of new synthetic materials resulted in a shift towards the use of primary resources instead of the development of infrastructures for collecting, transporting, cleaning and processing things for reuse. The repairing of broken devices was replaced by their conversion to the new. Products of advanced industrialization are, in many cases, not suitable for reuse, but rather only for costly utilization. In places where resources are hard to get, people still creatively reuse materials to make new products. Our ability to be creative should be further applied to the life cycle approach.

When we look at the process of production and consumption in terms of life cycle, we can distinguish between two kinds of metabolisms: the biological metabolism and the technical one, each with different kinds of nutrients.

A biological nutrient is a material or product that is designed to return to the biological cycle. It can be consumed by microorganisms and return to the material/energy streams as a element useful for the next production cycles.[20]

A technical nutrient is a material or product that is designed to go back into the technical cycle, into the industrial metabolism from which it came.[21]

A number of products are already being designed as biological or technical nutrients. But unfortunately some materials do not fit to any of these metabolism systems because they contain materials that are hazardous and toxic. They need special technologies of detoxification (which in some cases still do not exist) or the development of production without them. It is important that companies remove toxic substances from production cycles and further from the waste stream. The poisoning of the environment by toxic materials, and finally by toxic waste, is an irresponsible and short-sighted action. It has nothing to do with intergenerational justice. The transition to a green economy should be connected with an increasing mimicking of natural systems in order to create a more dynamic system of production, consumption and reuse. The trend in material reuse should be extended across the entire material stock, recycling if it leads to higher environmental and economic benefits.

6. Conclusions

In a green economy, growth in income and employment should be driven by investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services.

[20] M. Braungard, W. McDonough, *op. cit.*, p. 105.

[21] *Ibidem*, p. 109.

Almost all the protagonists of the green economy advocate for intensive investments into resource efficiency and renewables. None of them consider the "business-as-usual" scenario to be an option. This assertion is repeated over and over in the large amount of publications and studies concerning the idea of a green economy. Undoubtedly these are desirable trends, but the effects may not be sufficient from the point of view of reducing pressure on the environment and at the same time improving its condition. Problems which remain unresolved are the scale of production itself and the significant presence of toxic substances. Reliance on the further development of renewables and resource efficiency will enable, at most, achieving only a 'greening' of the current economy. The true green economy needs changes in the philosophy of design, production, distribution and consumption of goods and services.

Thus the desirable direction of change is to strive for the compatibility of production with the natural environment; in other words, the exploitation of nature without destroying it. If humans are truly going to prosper, it is necessary to learn to imitate nature's highly effective cradle-to-cradle system of nutrient flow and metabolism, in which the very concept of waste does not exist. To eliminate waste, both in the material and conceptual sense, means to design things and production systems which, from the very beginning, are based on the assumption that instead of waste we need to have valuable nutrients for the next production cycles. However, neither the increase in the efficiency of product development or harmonization with nature is enough if they are not linked to the strategy of moderation /restraint. The most difficult question is: How much is enough? This is clearly at the core of the very concept of a green economy, as well as the development strategies published by various countries and international organizations designed to lead to its implementation.

Appropriate management techniques aimed at the implementation of production patterns for a green economy should stimulate companies which previously invested in end-of-life design to explore investment in a cradle-to-cradle system, where the end-of-life products constitute a feedstock for further production.

References

Braungart M., W. McDonough, (2009), *Cradle to cradle. Re-making the way we make things*, Vintage Books, London, p. 110.

Burchard-Dziubińska M., (2013), *Zielona gospodarka jako nowy obszar zainteresowań ekonomii* [*Green economy as a new area of interest of economics*], IX Kongres Ekonomistów Polskich, PTE, Warszawa 2013.

Demea (2010), *Die betriebs- und volkswirtschaftliche Bedeutung der Materialeffizienz und bisherige Erfahrungen mit dem Impulsprogramm Materialeffizienz der Bundesregierung* [*The economic relevance of resource efficiency and experiences of the government so far*], Workshop der FES, 8 July 2010, Berlin, [in:] *The Eco-Innovation Challenge, Pathways to a resource efficient Eu-*

rope, Annual Report eco-innovation, http://www.eco-innovation.eu/media/ECO_report_2011, p. 94, pdf [download 20.10.2014].

Europe 2020, A European strategy for smart, sustainable and inclusive growth, http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%20 2020%20-%20EN%20version.pdf.

Madlener R., Alcott B., (2011), *Herausforderungen für eine technisch-ökonomische Entkoppelung von Naturverbrauch und Wirtschaftswachstum unter besonderer Berücksichtigung der Systematisierung von Rebound-Effekten und Problemverschiebungen* [Challenges for a technical-economic decoupling of resource use and economic growth with special emphasis on systematization of rebound effects and problem shifts], Enquete-Kommission „Wachstum, Wohlstand, Lebensqualität" des Deutschen Bundestages, Berlin 12 Dezember 2011, Kommissionsnmaterialien M-17(26)13.

National Research Strategy BioEconomy 2030. Our Route towards a biobased economy, Bundesministerium für Bildung und Forschung 2010, http://www.bmbf.de/pub/Natinal _Research_Strategy_BioEconomy_2030.pdf.

Observatory p. VIII, http://www.eco-innovation.eu/media/ECO_report_2011.pdf [download 20.10.2014].

Schmidt-Bleek F., (2014), *Grüne Lügen*, Ludwig Verlag, p. 56–57.

The Eco-Innovation Challenge, Pathways to a resource efficient Europe, Annual Report eco-innovation, http://www.eco-innovation.eu/media/ECO_report_2011.pdf [download 20.10.2014].

The National Bioeconomy Blueprint, (2012), April, p. 3–5, http://www.whitehouse.gov/sites/default/files/microsites/ostp/national_bioeconomy_blueprint_april_2012.pdf.

UN Convention on Biological Diversity 1992, Art. 2, https://www.cbd.int/doc/legal/cbd-en.pdf [download 20.09.2014].

Unmüßig B., W. Sachs, u. T. Fatheuer, (2012), *Critique of the Green Economy Toward Social and Environmental Equity*, Vol. 22, Heinrich Böll Foundation.

Waste Minimization, (2013), United Nations Environmental Programme, Global Partnership on Waste Management, Web. 3 Jan. 2013, http://www.unep.org/gpwm/FocalAreas/Waste Minimization/tabid/56460/Default.aspx

Żylicz T., (2004), *Ekonomia środowiska i zasobów naturalnych* [*Economics of environment and natural resources*], Polskie Wydawnictwo Ekonomiczne, Warszawa.

ABSTRACT

In the chapter are discussed new approaches of production development in order to achieve the objectives of sustainable development and put the green economy into practice. Conventional approaches to the production must be re-oriented towards the promotion of renewable, cleaner and more efficient technologies aimed at the conservation of all natural resources. This requires a new approach to the design of products and their production, and requires the inclusion of post-industrial and post-consumer residues into permanent circulation and the development of eco-innovative management patterns. In the implementation of such solutions the "cradle to cradle" approach could be useful.

Key words: production, green economy, cradle to cradle, biological metabolism, technical metabolism.

Cite: Burchard-Dziubińska M., (2015), *Production for a green economy*, [in:] Burchard-Dziubińska M. (ed.), *Towards a green economy. From ideas to practice*, Wydawnictwo Uniwersytetu Łódzkiego, Łódź, p. 67–78.