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# Redesigning public governance of the Danish built environment from relative to absolute metrics

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**Abstract.** Planet Earth is imbalanced due to human consumption, growth in population and exponential reaction chains in Nature. New theories of sustainable development are challenging status quo. Examples of these theories are 1) Circular Economy, 2) Absolute Sustainability and 3) Doughnut Economy. These models for sustainable development challenge the built environment in Denmark where governance currently focuses on realising relative reductions in impact. Where each building permit is given based on compliance with a theoretical energy frame which defines the maximum annual permitted energy consumption per m<sup>2</sup>. There is however no limit to the number of m<sup>2</sup> built each year. This essentially means that more and more m<sup>2</sup> are built each year and the building industry is nowhere near realising the necessary reductions in environmental impact. Furthermore, the energy frame is a theoretical framework that neglects to consider human behaviour and comfort of building users. If compliance with the Paris agreement is to be within reach there is thus an urgent need to redesign governance of the built environment. This paper presents a short review of the theories behind Circular Economy, Absolute Sustainability and Doughnut Economy, as well as, a review of how building permits are currently given in Denmark. Based on these reviews an idea for how to redesign public governance of the built environment is presented. The idea focuses on the practicalities of 1) how to move from relative to absolute metrics and 2) how to redesign the way the building permits are given. The paper concludes with a discussion of how this affects processes and stakeholders involved in the built environment and conditions that ensure practical implementation of the idea.

**Keywords** Carbon accounting, Carbon neutrality, Governance and regulation, Doughnut Economy, Absolute Sustainability.

## 1. Introduction

Planet Earth is burning and the icecaps are melting. The effects of climate change are more visible than ever with wildfires in the Amazonian Rainforest and bush fires in Australia in Autumn 2019, some of which are still burning in January 2020. In Denmark visible effects of climate change are increased intensity of storm floods and increase in periods with extreme drought (e.g. the summer 2018), increased



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rainfall (e.g. annual precipitation 2019) as well as increased frequency of 100 year occurrences of storm floods [1].

On June 5<sup>th</sup>, 2019 the national election for Danish Parliament resulted in a change in government. The period leading up to the election showed a major rhetorical switch in focus where climate change for the first time was a deciding factor for the people when deciding who to vote for. On December 6<sup>th</sup> 2019 a new Climate Law was passed and supported by most parties in parliament which in abstract terms states that Denmark must reduce its carbon emissions by 70% in 2030 compared to 1990 levels [2]. In 2011 the Danish Government set out to ensure that Denmark becomes free of fossil energy sources by 2050 [3] and on December 13<sup>th</sup>, 2019 the EU Commission excluding Poland committed to working towards a carbon neutral continent by 2050. A path towards carbon neutrality is described in A Clean Planet for All [4]. Considering the large impact of buildings on European and Danish CO<sub>2</sub> emissions, reducing these emissions is a critical step towards reaching the Danish and European goals of carbon neutrality [4 p.8 and 12]. When it comes to buildings, optimisation occurs on multiple levels; 1) building operation, 2) energy supply and 3) building materials. Regulation thus effect different stakeholders: building designers and contractors, energy suppliers and building users which requires application of different levers and incentive structures.

### *1.1. Current and previous Danish regulation of environmental impact from the built environment*

Energy-efficiency and carbon emissions from the Danish built environment is regulated through energy frames and voluntary low-energy schemes. This energy frame describes a maximum permitted kWh energy requirement per m<sup>2</sup>. The calculated kWh requirement is multiplied by emission factors for heating and electricity respectively to convert the calculated kWh to primary energy. Buildings requiring cooling, extended use, increased lighting and ventilation are allowed a supplement to the energy frame which increases the frame, thus increasing the permitted energy consumption [5]. Voluntary low-energy schemes that promote relative (percentage) reductions against the energy frame have been used in the building regulation in versions from 1985[6], 2006[7], 2010[8], 2015[9] and 2018[5]. Until 2018 the energy frame only focused on regulating new buildings whilst building renovations were regulated through maximum permitted transmission coefficients (U-values) and energy-efficiency of ventilation systems. From 2018 and onwards energy frames were introduced for building renovation. The energy frames have enabled a significant reduction of the energy consumption of new Danish buildings.

Carbon emissions from energy production have mainly been reduced through carbon tariffs and incentive schemes enforced between 1996 and 2018 which led to a significant increase in the production of renewable energy. Energy plants, industries and indirectly consumers had to pay an energy tax which was then spent as subsidies for carbon reductions with consumers and power plants [10].

Building owners are currently not regulated once the building is completed and handed over to its daily users. The incentives to reduce energy consumption and carbon emissions is thus only regulated by market forces i.e. consumer demands.

Despite past successes with regulation of the built environment, achieving carbon reduction is limited. This is because 1) energy reductions are measured against a theoretical frame with simplified settings for user behaviour (e.g. room temperatures of 20°C and internal heat gains from appliances and users), 2) low energy buildings promote relative reductions against the energy frame and 3) the quantity of m<sup>2</sup> built is not currently regulated. This results in a situation where 1) the energy frames are not representative of the actual energy consumption of buildings and 2) the energy savings from replacing existing buildings with new and more efficient buildings are partly evened out because of an increase in the number of m<sup>2</sup> built and in operation. This paper will present an approach for how to change this with inspiration from circular economy, doughnut economy and absolute sustainability.

### *1.2. Building permits anno 2020*

Municipalities are the governing bodies of building permits. Permits are given based on compliance with local plans and documents indicating compliance with the Danish Building Regulation and current standards. Compliance is no longer audited by Municipalities. As of January 1<sup>st</sup>, 2020, fire and structure

documentation is reviewed by certified engineering consultants or a certified 3<sup>rd</sup> party [19]. Whilst the building regulations ensure energy-efficiency of new buildings and major refurbishments there is no limit to how many m<sup>2</sup> are constructed each year and the effect of the energy-efficiency is thus levelled out by increased building activity.

## 2. Method

This paper contains a review of current methodologies that aim to support behaviour in sync with planetary boundaries. The review is based on practical experiences with lifecycle assessments on real life building projects in combination with a review of literature available about the different methodologies. Based on the analysed methodical approaches, the paper presents an idea for how to improve decision-making processes in the built environment, so they support an approach in which buildings are designed, constructed, operated and maintained in a way that ensures a low absolute impact within the planetary boundaries of the built environment.

## 3. Review of methodologies relevant to absolute sustainability

Three methodologies are reviewed for inspiration on absolute metrics; Circular Economy, Doughnut Economy and Absolute Sustainability. These were selected because they all challenge conventional thinking about sustainable building design towards more absolute and finite models and because they have not yet become a natural part of how buildings are designed.

### 3.1. Circular economy

The concept of circular economy can be dated back to the 1960s where several different theorists starting with Kenneth Boulding who in 1966 described the earth as a closed and circular system with limited capacity and promoted that economy and environment was interdependent [11]. The first to successfully introduce circular economy into the built environment was the architect William McDonough and the chemist Michael Braungart who introduced Cradle to Cradle to the design community in 2002. Cradle to Cradle was coined in response to the reductionist rhetoric used in relation to sustainable development. The Cradle to Cradle design paradigm defined two circular resource systems; the natural and the technical system. The natural system consists of biological materials that are renewable and biodegradable when treated correctly throughout their lifecycle whilst the technical cycle consists of non-renewable resources of high technical value that must be recycled without reducing the material's technical qualities [12].

In 2010 the Ellen MacArthur Foundation was founded and the political focus on circular economy increased. In 2018 the technical committee for the first ISO standard for circular economy was established. The due date for the ISO standard is 2022. To this day circular economy is still an abstract concept for most companies and building practitioners with only few completed circular buildings in Denmark by 3XN Architects [13], Vandkunsten Architects [14] and Lendager Architects [15]. These buildings primarily focus on the technical sphere of the cradle to cradle design paradigm through recycling or upcycling materials and designing buildings for disassembly and reuse.

### 3.2. Doughnut Economy

The doughnut economy was developed by Kate Raworth in response to the linear and consumeristic approach of linear economy she experienced as an economist. Doughnut Economy combines theories of planetary boundaries with a circular economic model.

The doughnut defines a healthy space in which humans can operate within the planetary boundaries. "Humanity's 21st century challenge is to meet the needs of all within the means of the planet. In other words, to ensure that no one falls short on life's essentials (from food and housing to healthcare and political voice), while ensuring that collectively we do not overshoot our pressure on Earth's life-supporting systems, on which we fundamentally depend – such as a stable climate, fertile soils, and a protective ozone layer. The Doughnut of social and planetary boundaries is a playfully

serious approach to framing that challenge, and it acts as a compass for human progress this century.”[16, 17].

Whilst circular economy primarily focuses on the business case for circularity, Doughnut Economy includes both social and planetary boundaries that define an ecological ceiling and a social foundation based on indicators relating to interdependencies between environmental impact and liveability (Table 1). So far there are no reports of Danish building design projects using this approach. It is however very relevant when targeting an absolute like zero carbon or visualising the impact of a building project or business.

Table 1 Indicators in Doughnut Economy (2017) [16]

Ecological ceiling / planetary boundaries	Climate change, Ozone layer depletion, Ocean acidification, Chemical pollution, Nitrogen and phosphorus loading, Freshwater withdrawals, Land conversion, Biodiversity loss, Air pollution.
Social Foundation	Energy, Water, Food, Health, Income & Work, Peace and justice, Political voice, Social equity, Housing, Networks.

### 3.3. Absolute sustainability

The approach *Absolute Sustainability* was developed at Aarhus University and the Technical University of Denmark and presented to the public in 2015[18 p.88]. The approach aims to provide a framework for assessing a building’s sustainable performance in an absolute context by comparing the building’s environmental impact to environmental carrying capacities; “A building is (...) sustainable if its annual environmental burden is less than the share of the environmental carrying capacity of the earth available to the building type”[18 p. l: 82-87]. Carrying capacity is defined for 11 impact categories relating to environmental impact. Person equivalents are used to convert these 11 impact categories into one normalised Carrying Capacity (CC) score and if this score is <1 the building is considered ‘absolute sustainable’[18]. The approach has been used to evaluate the sustainability of a handful of Danish buildings that claim to provide sustainable solutions. A CC impact score was calculated for a standard Danish house and *Upcycle House* by Lendager Architects. Both buildings have the same expected annual energy consumption of 37.8 kWh/m<sup>2</sup>. Both buildings supersede the Carrying Capacity where the standard house utilised 365-689% of the available Carrying Capacity and *Upcycle house* utilised 126-237% of the Carrying Capacity [18 p. 94]. This demonstrates how important it is to consider absolute metrics in the evaluation of life cycle assessment results.

### 3.4. Comparison of approaches

There are significant overlaps between the three reviewed methodologies – especially when it comes to Doughnut Economy and Absolute Sustainability regarding environmental sustainability and planetary boundaries. Doughnut Economy is however the only methodology to insure a social foundation. The Doughnut Economy is thus the broadest of the three approaches in which the calculation methodology from Absolute Sustainability can be used to calculate the carrying capacity of each of the planetary boundary indicators in the Doughnut Economy.

When comparing the focus areas of the different approaches to the broad range of focus areas for sustainable built environment it becomes apparent that many indicators used in e.g. certification systems are not represented in these models (Figure 1). The X-axis of Figure 1 lists a number of focus areas found in certification systems and design paradigms for circular building and regenerative buildings. The illustration underlines the complexity and challenges associated with transforming absolute impact categories into design principles. ‘Full integration’ indicates that the methodology covers all relevant measures currently applied for the focus area whilst ‘Partial integration’ indicates that the methodology only covers some of these measures.

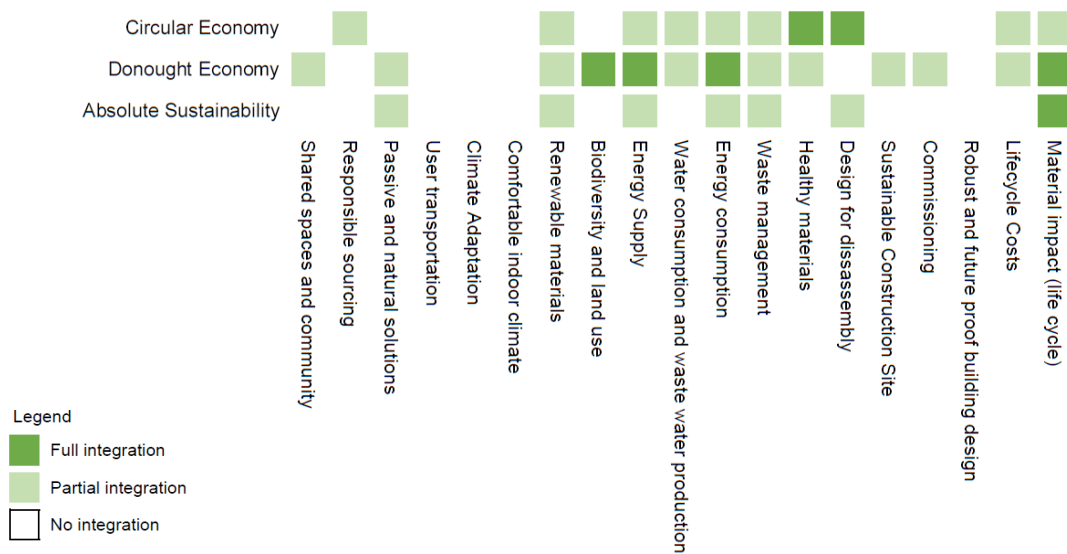


Figure 1 Correlation between methodologies and political frameworks and design principles for regenerative building design

#### 4. Redesigning public governance of the Danish built environment from relative to absolute metrics

When redesigning public governance of the built environment the following issues emerge; 1) Which metrics to regulate and 2) How to regulate these metrics in an absolute context.

##### 4.1. Regulating metrics

Considering the increase in extreme weather events from global warming and the acceleration of the sixth mass extinction [23,24] some metrics are becoming more important than ever. Since the Brundtland report in 1987 sustainable building design has tried to balance social, environmental and economic sustainability as areas of equal importance. For the purpose of this paper the understanding of metrics for environmental, social and economic sustainability is as listed in table 2.

Today environmental sustainability has become the precondition for ensuring future social and economic sustainability of societies. The personal and societal costs of ignoring planetary boundaries to ensure a high living standard or financial growth have proven too high to ignore [20]. The most important metrics in this respect is environmental impact i.e. performance against planetary boundaries.

Whilst environmental metrics must be measured against a global framework, social and financial sustainability is easier to regulate regionally or locally through municipal regulation in combination with market drivers (e.g. user and investor demands). This is especially true in Denmark where the living standard is much higher than what is necessary to ensure a social foundation and the building regulation enables users to lead healthy lives within their buildings.

This paper will thus explore how to design a national governance approach towards absolute metrics for environmental impact from the built environment. The Doughnut Economy offers a relevant framework for evaluating and visualising performance against planetary boundaries and Absolute Sustainability provides a methodology for assessment of Life Cycle Impact Assessments (LCIA) - a methodology for how to calculate and normalise environmental impact from materials used for building and energy consumed in buildings. The DGNB system [21] offers a methodology to evaluate water consumption and waste water production as well as Human and animal toxicity. BREEAM [22] provides a methodology to evaluate impact from land use and biodiversity.

Table 2 Metrics for environmental, social and economic sustainability

Environmental Sustainability <sup>1</sup>	Social Sustainability	Economic Sustainability
<ul style="list-style-type: none"> <li>• Carbon footprint [Ratio between calculated CO<sub>2</sub> eq. and planetary boundary &lt;1]</li> <li>• Ozone Depletion Potential [Ratio between calculated R11 eq. and planetary boundary &lt;1]</li> <li>• Photo Chemical Ozone creation potential [Ratio between calculated C<sub>2</sub>H<sub>4</sub> eq. and planetary boundary &lt;1]</li> <li>• Acidification Potential [Ratio between calculated SO<sub>2</sub> eq. eq. and planetary boundary &lt;1]</li> <li>• Eutrophication Potential [Ratio between calculated PO<sub>4</sub> eq. and planetary boundary &lt;1]</li> <li>• Biodiversity [Species/m<sup>2</sup>] before and after construction and from material production (factor &gt;1),</li> <li>• Habitat area before and after construction (factor &gt;1)</li> <li>• Habitat connectivity (yes/no)</li> <li>• Land use [ratio between m<sup>2</sup> of reused land and m<sup>2</sup> converted virgin or rural land &lt;0,10]</li> <li>• Drinking water consumption [m<sup>3</sup>/year]</li> <li>• Wastewater production [m<sup>3</sup>/year]</li> <li>• Human and Animal Toxicity [compliance with EU's CLP]</li> </ul>	<ul style="list-style-type: none"> <li>• Ensuring user health [air quality, thermal comfort, visual comfort and acoustic comfort]</li> <li>• Personal impact on occupied space [flexibility and geometry of spaces]</li> <li>• Prevention of loneliness [assessment of quality of space functionality and building flow]</li> </ul>	<ul style="list-style-type: none"> <li>• Lifecyclecosts [Dkr./m<sup>2</sup>]</li> <li>• Robust and adaptable solutions [Durability of surface materials, Building geometry, Structural and technical principles]</li> <li>• Location [Access to transportation networks, Utility supply, Access to amenities, Access to work, Risk of flooding]</li> </ul>

#### 4.2. Regulating absolute planetary resources in the built environment.

To ensure evaluation against an absolute national target it is necessary to include Life Cycle Assessments (LCA), Water and Biodiversity calculations when processing applications for building permits. Animal and human toxicity should be prohibited, and compliance should be documented once the construction is completed as part of the as-built documentation for environmental impact of the building project. Without the as-built documentation the building is not approved for habitation.

Each municipality is allotted a part of the annual budget of planetary resources. The budget depends on the number of inhabitants and the natural resources in the area contributing to carbon capture and biodiversity. If a Municipality wishes to increase their annual budget for planetary resources, they must establish new natural resources or reduce the impact of building operations within the municipality through incentive schemes for building owners in the municipality or municipal investment in renewable energy and water supply. Another way to increase the municipal budget is to trade with other municipalities.

Before a building permit is given, the regulating authority ensures that the planetary resources required for the building is available within the annual municipal budget. Once the building permit is given the draw on planetary resources is registered in a national database that records spending across all municipalities and reviews this on a monthly, quarterly and annual basis. Once the entire budget of planetary resources for the year is used, building permits are only given to projects that have a neutral impact on planetary resources.

## 5. Discussion

The suggested methodology will impact all stakeholders within the built environment. It requires a knowledge upgrade within municipal bodies, as well as, research institutions, consulting architects and engineers when it comes to environmental impact of the built environment.

### 5.1. Stakeholder education

For consulting architects and engineers this transition will be relatively easy judging by the fact that between 480 and 600 architects and engineers have completed the DGNB-DK consultant education. Most of these would be able to complete LCA and water calculations with very little effort. The learning

<sup>1</sup> Evaluation of environmental impact should include impact from building materials, energy consumption, water consumption and user transportation.

curve will be steeper when it comes to calculating biodiversity and documenting compliance with regulation of animal and human toxicity with which only a few consulting architects and engineers have practical experience. The building industry has already demonstrated potential solutions when it comes to three out of four environmental indicators with large current overshoot i.e. climate change, biodiversity loss and land conversion. Examples of solutions are utilisation of biomaterials for construction, green urban areas with green corridors and preservation of onsite habitats. The last indicator, nitrogen and phosphorus loading, is mostly impacted by the farming industry, household gardening and building materials. The building sector also provides a part of the solution for this indicator; urban farming without use of pesticides, toxin free gardening and building material innovation.

The learning curve with municipal building authorities will be steep because the new approach requires that reviewers of building permit applications know how to review Life Cycle Assessments, water calculations, biodiversity calculations as well as documentation for compliance with regulation of animal and human toxicity. Alternatively, this could be reviewed by the Danish Building Research Establishment and Green Building Council Denmark.

### 5.2. *Impact on building activity and jobs*

When introducing new regulation to the built environment politicians are often worried about how this will affect building activities and job creation. Lobbyist organisations tend to use loss of jobs against politicians who wish to enforce regulation. When the financial crisis hit the Danish building industry hard in 2008 there was a temporary loss of jobs. It did however prove to be a great lever when it came to motivating contractors to engage with innovation in the building industry. Before the financial crisis there was little interest in anything that changed business as usual. During the financial crisis contractors were willing to adapt to change because they saw this as a way of securing work in a competitive market.

Whilst some corporations still hope for regulation through voluntary incentive schemes, there is an increase in the number of Danish companies calling for the government to introduce regulation of the built environment. Many companies have set their bar high aiming for carbon neutrality within the next 10-20 years.

## 6. Conclusion

This paper presents an idea of establishing a national budget for planetary resources that is distributed across Danish municipalities who remain the regulating authority of the built environment. It also suggests which environmental indicators and units to use to measure impact. The approach is ambitious and requires quite a lot of effort from the building industry. It is however a necessary first step towards a world where the building industry is designed in symbiosis with Earth instead of at the expense of continuous overshooting. The approach is inspired by methodologies used for budgeting and financial statements in private businesses where investments are made within the annual budget and spending is measured continuously with monthly, quarterly and annual reports. The suggested approach will impact all stakeholders in the value chain – especially construction clients, consulting architects and engineers and provide much needed drivers to change behaviours in the built environment.

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