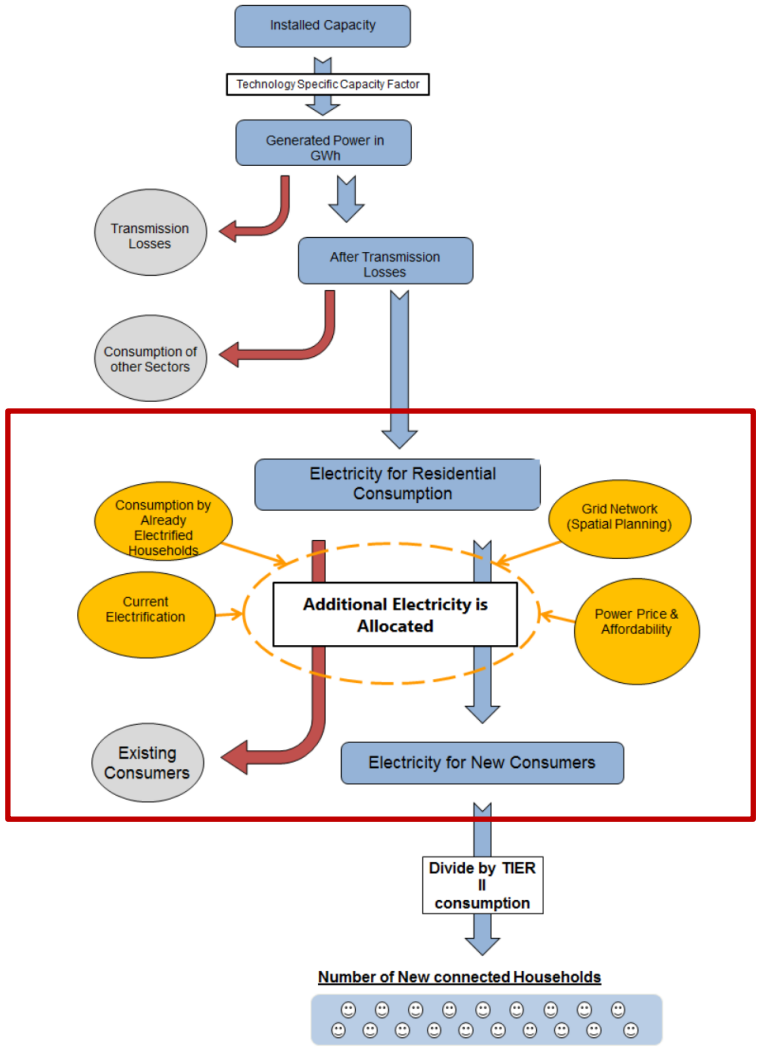
Allocating Energy to the Residential Sector

Between New an Current Users



A Working Paper by b.linked to Introduce Its Algorithm

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Content

Inferred Access to Energy – Allocation Factor

Introduction

In 2015 the United Nations spearheaded the 17 Sustainable Development Goals (SDGs) as a follow-up on the Millennium Goals. Number seven targets to give people affordable access to clean energy.[1] For the 193 governments that are involved in this process the estimation of the impact of their projects regarding this topic is crucial. Yet, it is almost impossible to directly measure the effect of on-grid electricity generating projects. Thus, it is necessary to create an algorithm that determines a reliable approximation already at the time of commitments of funds ("ex-ante").

First, only a share of the energy generated by a project is going to the residential sector. Here again only a fraction is used for the creation of new electricity connections while the remaining part is consumed by already connected households. The main topic which is covered by this note, centres around the question how much of this energy is allocated to potentially new consumers. One solution is provided by the World Bank.[2] The factor calculation is based on the current levels of electrification and electricity consumption by electrified people in the country.

[1] http://www.un.org/sustainabledevelopment/energy/ http://www.un-energy.org/ – Furthermore, energy is an important input factor for achieving the other SDGs.

[2] https://openknowledge.worldbank.org/bitstream/handle/10986/17370/853760BRI0ADD00for0collection0title.pdf – The method in described on page 4.

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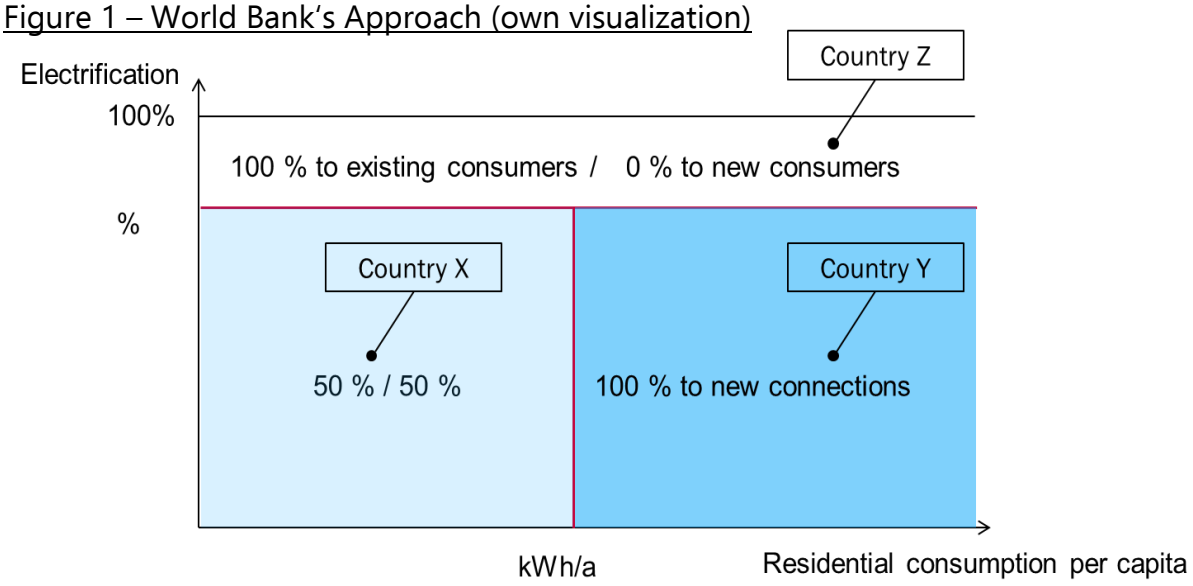
Figure 1 – World Bank's Approach (own visualization)



The World Banks approach is separating all countries into three categories:

- *0% → Country Z*
- *50% → Country X*
- *100% → Country Y*

This option provides an answer that is comprehensive as well as applicable. However, there are two major concerns: Firstly, most relevant countries have low levels of electrification and electricity consumption so the overwhelming majority is getting the 50% factor without any distinctions. Secondly, the factor for a country that is located close to the set boarder can change suddenly quit extremely.[3]

Therefore, an expansion of the World Bank's approach has been developed. It aims to provide a solution for a more diversified and dynamic calculation. This essay serves to give the reader an understanding of both the concept and

[3] This refers for example to South Africa which has a high level of electricity consumption by electrified people but isn't nearly entirely electrified. Depending on the chosen base year in South Africa either 0% or 100% of the share of newly generated energy for the residential sector will be used for new connections.

the potential implementation of this method.

General Concept of the b.linked Approach

As the *b.linked Approach* is just an expansion of the World Bank's original approach the general concept is equivalent. The countries factor is calculated by using its current rates of electrification and electricity consumption by connected users. Based on the outlined problems in the previous section the *b.linked Approach* is focussing mainly on clear distinction of the countries with low levels of both.[4] The fundamental idea is: Until a certain level of electrification is reached and everyone is consuming a satisfying amount of electricity, newly generated energy is allocated to both new connections and already connected consumers. If both rates grow proportionally, the ratio will be held constant. However, the share that goes to new consumers is increasing with the level of energy consumed by already connected users and is decreasing when the rate of electrification in the country is already high.

Mathematical Implementation

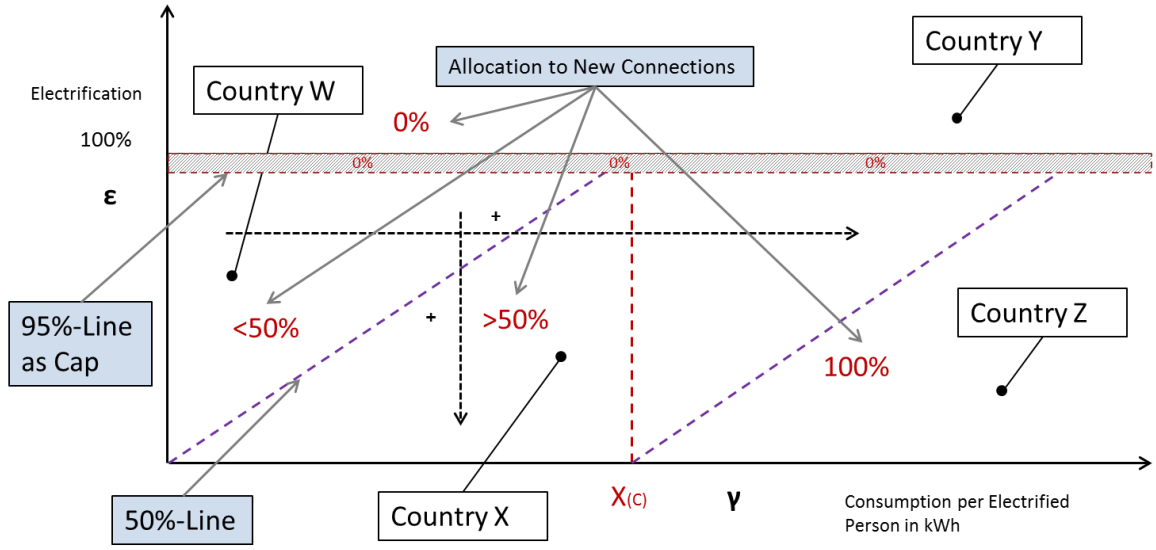
We will assume that 50% of the new energy to the residential sector is allocated to new consumers if both levels are growing proportionally. Let ε be the level of current electrification (in %) and γ the level of electricity consumed by already connected consumers (in kWh). Additionally we set $\mathrm{X(C)}$ as satisfying consumption level (in kWh). The assumed maximum level in our case is 95%. For countries above this rate the additional amount of electrification is assumed to be zero.[5] The resulting formula is the following:

$$Formula\colon \quad for\ \varepsilon < 95\%$$
$$Factor = 50\% - \varepsilon[\%] * 50\% + \frac{\gamma}{\mathrm{X(C)}} * 50\%$$

[4] Refer to figure one.

[5] The method will be mainly applied on developing countries. One can assume that a low to middle income country that is between 95 and 100% electrified will focus on increasing the electricity consumption of the already electrified people. Furthermore, it is likely that a share of the population stays in areas that aren't connected to the grid.

Figure 2 – b.linked Approach (own visualization)



$$\text{Formula: for } \varepsilon < 95\% \text{ Factor} = 50\% - \varepsilon[\%] * 50\% + \frac{\gamma}{X(C)} * 50\%$$

The New Method is creating a dynamic change of the country's factor depending on the exact proportion of the levels of current electrification and electricity consumption per electrified households. This would result into the following assumed allocation for the four example countries pictured above:

- *Less than 50% → Country W*
- *More than 50% → Country X*
- *0% → Country Y*
- *100% → Country Z*

As one can see, the factor remains constant if both levels are growing proportionally and is decreasing due to a disproportionally high level of electrification or a disproportionally low level of consumption by already connected consumers. [6] The resulting factor calculation is illustrated in figure two.

Moreover, another similarity of the *b.linked Approach* to the World Bank's is that at a sufficiently high level of electricity consumption by already

[6] When implementing the calculation, it is mandatory to cap the factor at 100%. Otherwise the factor for countries with very low levels of electrification and high consumption will exceed this value.

connected users, 100% of the new energy is distributed to new connections. To further align the *b.linked Approach* with the World Bank's approach, which assumes a 50%-allocation of new energy for the countries with low levels of both indicators[7], one might set α on 50%. Hence, the calculation results into a 50%-allocation for the countries that have a proportional growth of both factors[8].

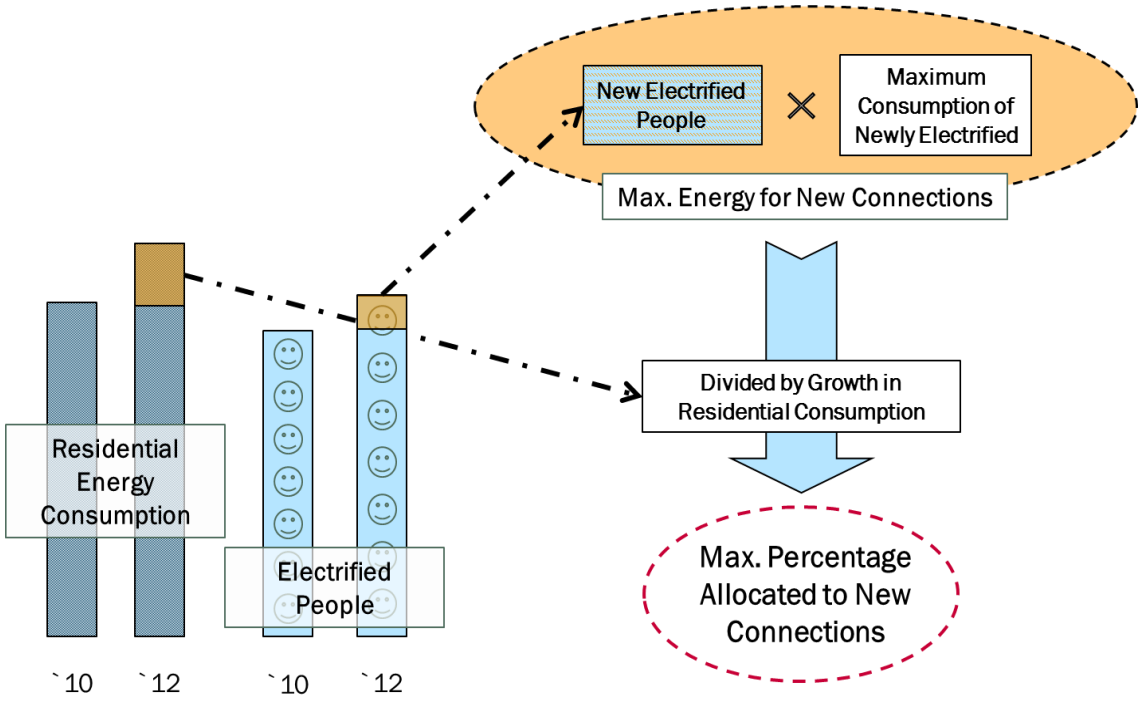
[7] These countries are located in the bottom-left area of figure one and two.

[8] These countries are located along the left purple line in figure two. Depending on the chosen level of satisfying consumption, Togo or the Democratic Republic of Congo would fall into this category. *[Please refer to Chapter Sources]*

Factor Plausibility Check

The factor presents the distribution of energy for the residential sector to already connected consumers and new electricity connections. To have an approximate validation one can look at the historic allocation. Therefore, the increase in energy consumption by the residential sector is compared to the newly connected people during a specific time period. It is assumed that a newly connected household has only a certain amount of energy availably for consumption. Multiplying this with the number of new connections derives the maximum amount of energy that could have been used for electrification growth. Finally, the result of the calculation is compared to this maximum share and reduced to it if necessary. One might consider capping it only if it exceeds a certain tolerance margin above the historic portion.

Figure 3 – Factor Plausibility Check



In the figure above the years 2010 und 2012 are used as an example.

Sources

Calculations

The number, referred to in this essay, are calculated using an own excel tool, based on the described algorithms. Neither b.linked, nor its employees guarantee their accuracy. The input data is extracted form the following sources:

- Sustainable Energy for all (SE4ALL) database from World Bank, Global Electrification database
- OECD iLibrary
- World Development Indicators

Reading

- World Bank: "Measuring the Results of World Bank Lending in the Energy Sector";
  https://openknowledge.worldbank.org/bitstream/handle/10986/17370/853760BRI0ADD00for0collection0title.pdf;
  [12 June 2017].
- United Nations: "Affordable and Clean Energy: Why it Matters";
  http://www.un.org/sustainabledevelopment/energy/;
  [12 June 2017].