Net-zero energy housing virtual Article 6 pilot

Net-zero energy buildings in Cartagena, Colombia

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Introduction

Article 6 of the Paris Agreement provides the framework for a new generation of carbon markets in a context where all countries are supposed to formulate and implement ambitious Nationally Determined Contributions (NDC) towards a temperature target and ratchet their contribution on a regular basis. Under this new regime, carbon market mitigation activities must account for, encourage, enable and - most importantly - not be a disincentive for increased domestic climate action. With the final rules for Article 6 a topic of ongoing negotiation in the UNFCCC, virtual pilots can help contribute to the discussion regarding rulemaking for Article 6 and inform new approaches to cooperation.

NewClimate has identified the construction of net-zero energy buildings (NZEBs) in Colombia as a promising emission reduction option for a virtual Article 6 pilot. Large improvements in the energy efficiency of buildings combined with decentralised energy generation as with NZEBs are important measures to decarbonise the building sector so as to reach overall global temperature targets. An NZEB housing development would very likely be both additional and inaccessible in Colombia. First, NZEBs and their components are uncommon to non-existent in Colombia and more widely Latin America. Local architects, construction companies, financial intermediaries, and house buyers are not familiar with them. Domestic regulations do not currently foster efficient building design and practices, nor efficient appliances; the Colombian residential solar PV market is immature compared to other Latin American countries; and notably there are no significant existing distributors for mechanical ventilation with dehumidification systems in the local market. These, combined with significantly increased upfront costs of NZEBs compared to current practices constitute a barrier to the large-scale uptake of NZEBs, as illustrated in Figure 1.

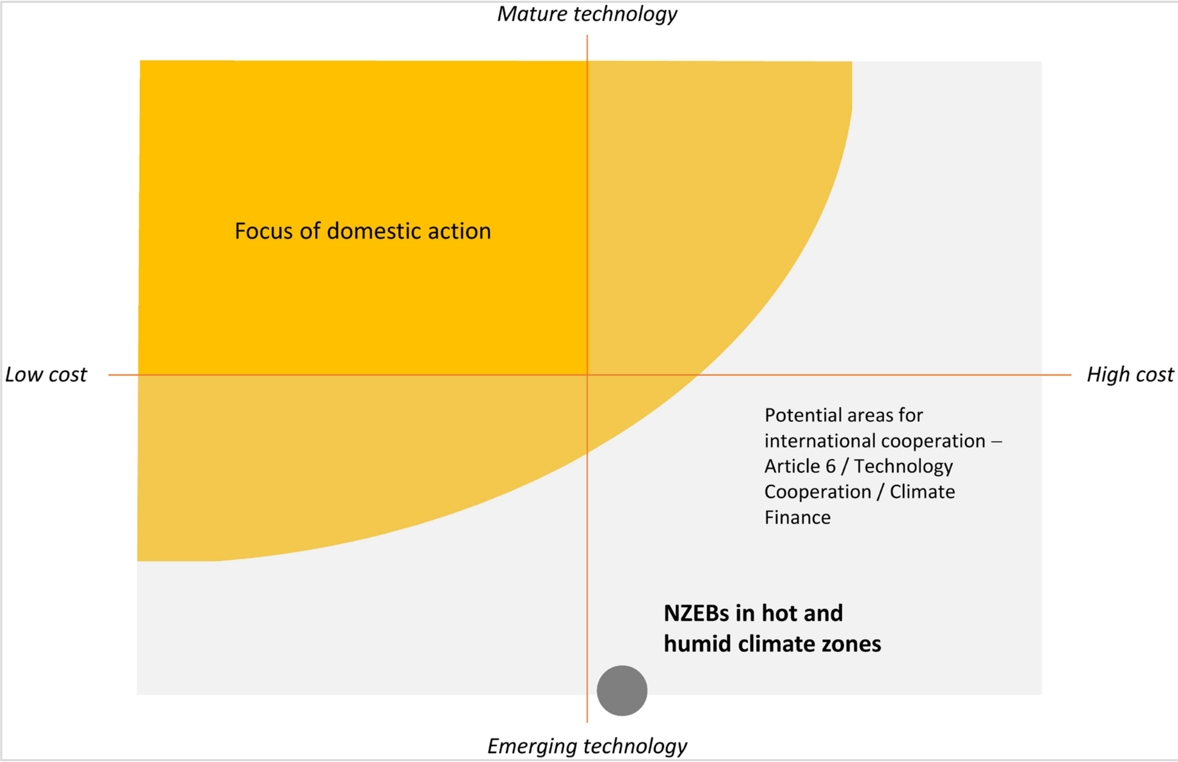

Figure 1: NZEBs in Colombia are classified as high-cost, emerging technology quadrant and are therefore inaccessible to the country as well as a potential area for international cooperation.

Context

Buildings represent a fifth of the total energy use in Colombia. Residential buildings alone emitted about 4.4% of the country's 2014 total emissions, excluding the agriculture, land-use and forestry sectors. Emissions from the sector are expected to increase by up to 3.3% per year in the next two decades, reaching 17 $MtCO_2e$ in 2040. The sector is included in the Colombian NDC and is expected to contribute to the overall target of a 20% reduction in economy wide greenhouse gas (GHG) emissions by 2030 compared to the business as usual (BAU) scenario.

There are various plans for incremental energy efficiency improvements in Colombian building codes, but implementation has been a challenge – especially with regard to updating and enforcement – and there is no plan for a medium to long-term decarbonisation of the sector.

Introducing NZEBs to Colombia has the potential to improve construction practices, reduce energy consumption, realise monetary savings both for residents and the Colombian government, increase energy access and security, improve personal health and comfort, as well as reduce emissions. For our virtual pilot study, we take the Puerto Madero housing project as a case study. Puerto Madero is a planned real estate development built to Passive House standard in Cartagena. Located in the hot and humid climate zone on the Caribbean coast, buildings in Cartagena use large amounts of electricity for air conditioning. However, building practices are not significantly different in the hot and humid zones compared to other climate zones in Colombia. Air conditioning is generally installed by residents, rather than planned and installed by construction companies from the outset.

Pilot implementation

NZEBs are highly energy efficient buildings that meet their energy needs through onsite renewable energy generation. NZEBs consume no natural gas and generate their own electricity onsite for instance through solar PV. NZEBs are grid connected and can use electricity from the grid on cloudy days or at night but feed an equivalent amount of electricity into the grid within a certain period - in our case on a monthly basis.

Based on the typical energy use profile of the Colombian housing sector, a literature review of technological options for NZEBs and the actual Puerto Madero case study, we identified a number of measures necessary to reach NZEB status in Cartagena. These are outlined in Table 1.

Table 1: Design features of a baseline building, the planned passive house measures, and an NZEB

	Design features baseline building (Sustainable Construction Guide compliant)	Design features of planned Puerto Maduro Passive House Project	Design features NZEB
Building orientation	No optimisation of building orientation and shading system	Optimised building orientation and shading system	
Shading System	No shading or sun protection	Window shading	
Wall insulation and air tightness	No insulation of walls or roof, no extra air sealing	Building envelope insulation and air sealing	
Window efficiency	Single glazed aluminium windows	Double pane energy efficient windows	
Ventilation and humidity control	No mechanical ventilation and dehumidification system	Dedicated Outdoor Air System (DOAS) that includes automatic ventilation with heat exchanger with a dehumidification function	
Lighting	Some CFL, though increasingly commonly LED	LED lighting	
Air conditioning	Average large capacity air conditioning units	Efficient smaller air-conditioner (A/C) units – passive measures enable a reduction in necessary system size	
Clothes dryers	Vented clothes dryers	Non-vented heat pump condensing clothes dryers	
Cooking	Natural gas-based cooking	Switching from natural gas to electric coil stove top for cooking	Switching from natural gas to efficient induction electric cooking
Energy sources	Grid supplied electricity	Grid supplied electricity	Grid connection and solar PV
	Grid supplied natural gas	Elimination of natural gas use	

Based on our case study in Cartagena, an NZEB comes at approximately a 15% price premium compared to standard buildings. The financial attractiveness of an NZEBs for housing buyers is heavily dependent on their income level and the socio-economic grouping that determines their eligibility for electricity and gas subsidies. While given current mortgage interest rates, a NZEB is likely to have a positive net present value over a 20-year period for all socio-economic groupings, the high upfront costs mean that for shorter time horizons, for example the first five to ten years, the additional cost makes the investment unattractive.

Regardless of income level and socio-economic grouping, the price premium of an NZEB comes at a significant financial risk with regard to the upfront investment. If NZEBs become more common, however, supply chains would develop, economies of scale could be found, and costs are expected to decrease. Depending on the business model chosen, an Article 6 based pilot would encounter various challenges on an individual project basis, notably in terms of costs for robust baseline assessment but would likely make more sense if implemented on a (sub-)sectoral level rather than a collection of individual one-off projects. If developed further, such a pilot should only last for a limited time to support ambitious early adopters. Indeed, energy subsidies that households receive from the government are a disincentive to invest in efficiency and would benefit from reform.

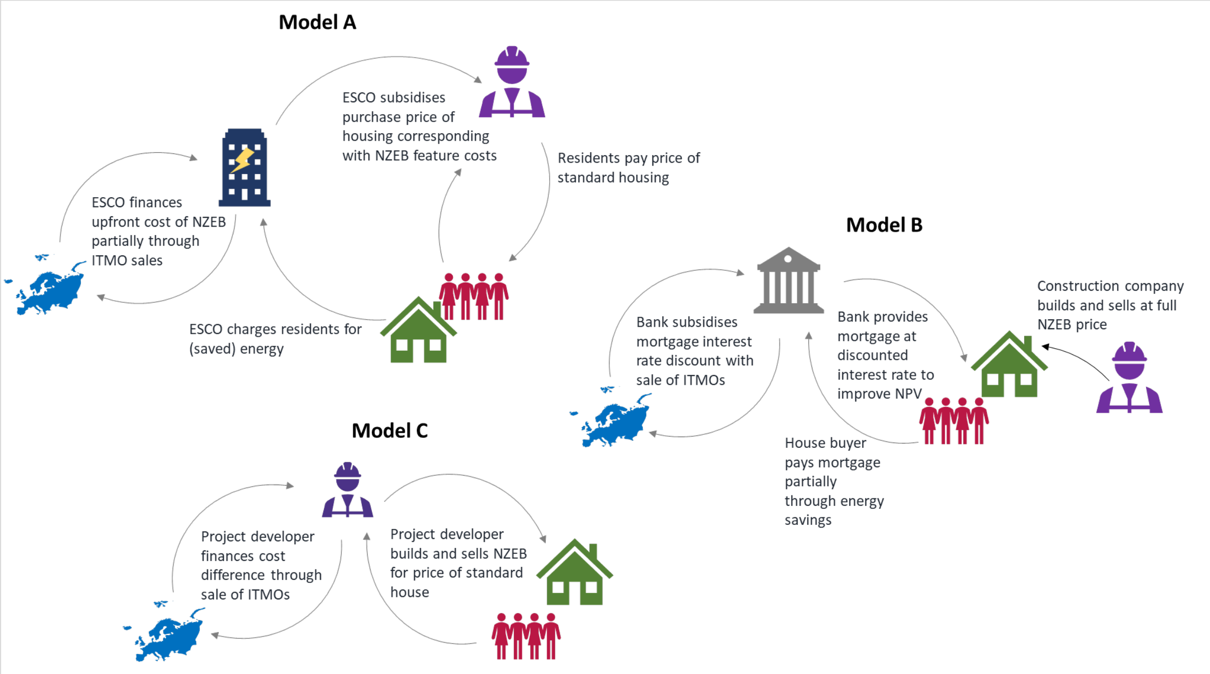

Figure 2: Potential business model for implementation of renewable heating in Mongolia

Possible business models for the development of NZEBs in Colombia include an Energy Service Company (ESCO) business model ("Model A"), a bank subsidised interest model ("Model B"), or a real estate developer focussed business model ("Model C") − (see Figure 2). Model A, the ESCO business model is likely to be the most feasible: A housing construction company would build NZEBs and sell them to residents at prices close to the price of standard buildings. The ESCO would pay the housing construction company the price difference between a standard building and an NZEB upfront. The ESCO would recoup this investment over a number of years with monthly fees paid by residents in an NZEB, combined with the sale of ITMOs. These fees would come at a slight reduction to utility costs for residents of a standard building so as to provide an incentive for residents to choose the NZEB housing.

Article 6 provides that the international transfer of emissions, and other cooperative actions, should promote sustainable development. In addition to SDG 13 on climate action, the construction of NZEBs in Colombia would contribute to a number of other SDGs: SDG 1 (No poverty), SDG 3 (Good health and well-being), SDG 7 (Affordable and clean energy), SDG 8 (Decent work and economic growth), SDG 11 (Sustainable cities and communities), and SDG 12 (Responsible consumption and production).

Encouraging NZEB construction has the potential to support the transformation of the Colombian building sector. If realised, an NZEB pilot would seek to leverage experience from other countries where NZEBs have been developed for the social housing sector in order to build capacity among architects, construction companies, finance institutions, and house buyers in Colombia.

Potential impact

Based on our case study, we make the rough estimation of what additional construction costs and emission reductions could be. We find that a building of 48 housing units similar to those in the Puerto Madero real estate development that is upgraded to net-zero energy basis could reduce emissions by approximately 58 tCO_2 per year, compared to standard newly built houses.

There are however multiple uncertainties that make accurately estimating the potential future impact of an intervention to support NZEBs in Colombia is extremely challenging. First, energy use in buildings depends on a large number of factors including the building envelope design, energy efficiency of appliances, number of occupants, and occupant behaviour. It is further challenging to know with certainty what kind of buildings will be built without the intervention. A robust estimate would require further sampling of recently built housing, as well as various assumptions including expectations for future Colombian policy planning in the residential sector and an estimate of future emissions associated with electricity generation.

A prominent example of uncertain future policy developments for the Colombian building sector is the 2018 National Economic and Social Policy Council (CONPES) strategy for sustainable buildings. This strategy defines a roadmap for the building sector by setting the goal for all 'new buildings' to comply with 'sustainability criteria' by 2030 (National Department of Planning, 2018). Improved energy performance targets are expected to be part of the criteria. However, it remains unclear how ambitious these will be and functional examples of net-zero energy concepts in Colombia are missing.

The electricity grid emission factor is also an important assumption in determining the number of emissions a NEZB would reduce. Thanks to Colombia's relatively large hydroelectric resource capacity, the emissions intensity of electricity in the country is relatively low. In 2015, hydropower represented 65% of the total electricity production, gas 19%, and coal 12% (IEA, 2016a). However, changing El Niño–Southern Oscillation patterns and associated droughts are likely to reduce future hydropower potential (Dennis, 2015), or at least make it less predictable. The future of Colombia's energy grid is currently uncertain. The country has large coal resources, and the government has existing plans to construct a number of coal-fired power plants with a total capacity of 1,575 MW (Evans, 2019). At the same time, although Colombia lags behind regional neighbours in renewable electricity investment (Flavin *et al.*, 2014; WWF, 2014), it is also accelerating the development of renewable energy. In addition to hydropower, the country enjoys abundant wind, solar, and geothermal resources (Procolombia, 2015) and the region of la Guajira in particular has large potential for wind power development in the country (Norton Rose Fulbright, 2017; Vergara, Deeb, Toba, Cramton, & Leino, 2010).

Disclaimer

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