endowment would not have been afforded in the context of target driven approaches practiced by development agencies and governments, and this has been the most significant contributing factor to the success of the initiative. A patient process has allowed time for learning so that technology development and social embedding evolve simultaneously. People have watched and seen what makes sense for them, and Skyloos are self-replicating because of the process not the organisation.

The initiative was also able to take advantage of landlords' demand for new sanitation solutions in response to the problems they were experiencing and anticipating. CCODE and the MHPF work with and support those who recognise the impending obsolescence of pit latrines but do not have access to the knowledge, technology or finance to change their circumstances.

CCODE has had to assume multiple roles in addition to their primary goal of mobilising a social process around informal settlement upgrading. CCODE had to develop its own technical capacity and learn about ecosan from scratch before they could begin translating their new knowledge into local action. Without knowledge partners, the process of technology development was unnecessarily encumbered and as a result a number of substandard products were built during the early stages.[112]

The demand for Skyloos is now at a point where additional sources of capital finance. If the scale of demand were to be seriously entertained a partnership with government is required. The social process established around sanitation will benefit the CCODE/MHPF initiative during the initial engagement with government, where the heightened bargaining power of the poor will ensure that the terms of engagement are fair.

The implementation of ecosan technology as a solution to a human problem in Lilongwe shows how human needs can be met using practical, ecologically sensitive approaches. The CCODE and MHPF approach illustrates that the process of understanding what works for a specific context is critical in determining whether the technology will be accepted and demanded by users. Contextual learning has been critical to the success of project, and the ability to learn from mistakes has shaped this response into something which is beginning to self replicate.

15. Aerial cable-cars in Medellin, Colombia: social inclusion and reduced emissions

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In 2004, Medellín, Colombia's second largest city, implemented the world's first modern urban aerial cable-car public transport system. As a relatively cheap, clean and highly visible response to urban transport problems, it has attracted widespread attention from city authorities throughout Latin America, Europe and Asia. The audacious application of proven ski-lift technology to densely populated and hilly low-income informal settlements was subsequently followed by major neighbourhood upgrading comprising new social housing, schools and other social infrastructure, as well as support

to micro-enterprises. The combination of these two sets of interventions has helped upgrade and integrate into the city's fabric large areas marked for years by severe poverty and violence.

The addition of aerial cable-cars (known locally as *Metrocables*) to the public transport infrastructure in this city of three million inhabitants was an imaginative leap. The first system was built in the poor and inaccessible north-eastern *comunas* (districts). This area is marked by a difficult, steeply sloping terrain broken by deep smaller valleys carved by the numerous streams running down the hillside to the Medellín River. Developed through informal settlements and land invasions in the 1950s and 1960s, by the end of the 20th century it was the most densely urbanised part of the city, with over 400 dwellings per hectare. Minimal road infrastructure made access difficult, although the area was relatively well served by conventional buses and limited numbers of taxis.

The first line was made possible through the combined technical foresight of the city's publicly owned *Metro de Medellín* (Medellín Metro Company) and the political will of a newly elected mayor. It arose from the desire to promote social development in a deprived area, and increase passenger numbers for an underutilised overground mass-transit metro system.

Metrocable Line K with the Parque España library in the background (Source: author, Julio Davila 2010)

Three aerial cable-car lines are in operation (with three more planned), two of which are urban public transport systems (Line K inaugurated in 2004 and Line J in 2008) and a third (Line L) introduced in 2010 to connect with Line K as a tourist route to a nature reserve on the edge of the city. While the first line has been highly successful and runs at full capacity (approximately

30,000 passengers per day), the impact of the second cable-car line suggests that, to be economically and socially significant, cable-car systems require specific minimum conditions in terms of urban morphology and population density, as well as careful integration with the existing mass public transit network.[113]

Cable-car systems are relatively cheap and quick to construct, as little land needs to be publicly acquired and the technology is well-tested. Medellín's cable-car systems are a public sector project, financed jointly by the municipality and the *Metro de Medellín*. Low construction costs make public sector capital borrowing feasible; in Medellín's case all three lines were financed through capital investment budgets. The cost of the first line was close to US$24 million and the second US$47 million, with costs per km comparing favourably with BRT and rail systems. However, due to technical limitations, aerial cable-cars are generally not considered to be mass-transit systems as they cannot transport significantly more than 3,000 passengers per hour.[114]

In 2004, following a change in municipal administration, the area around the first cable-car line became a prototype for social interventions in some of the poorest sectors of the city. This followed a policy of integrating the cable-car systems into the urban fabric through urban upgrading, in a strategy combining mobility, environment, housing and public space, and the goal of creating new dynamic centres in previously economically depressed areas. Municipal interventions across the city also involved increasing and upgrading the stock of social infrastructure such as schools and public libraries, including the construction of distinctive buildings designed by well-known national and international architects. The Parque España Library is one such set of buildings, located close to the first cable car line, and has become a distinctive landmark for the city in a neighbourhood where fear of violence would have kept outside visitors from venturing in.[115] Another distinctive feature of the urban interventions is that the use of local manual labour was made a feature of all public work contracts, while the introduction of participatory budgeting has allowed local communities to collectively decide on the use of some 5% of the municipal budget allocated to these areas for investment.

Although the original drive for implementing the first aerial cable-car hinged on social and mobility considerations rather than environmental ones, potential environmental impacts were considered in the planning stages.[116] Since 2003, the *Metro de Medellín* has sought to formally measure and evaluate the environmental contributions of this intervention through the use of internationally-accepted criteria. Under the aegis of the Clean Development Mechanism (CDM) framework, in 2003 the *Metro de Medellín* prepared a Project Design Document (PDD), which was examined by the CDM Executive Board in 2005.[117] The PDD proposed a baseline and a methodology to monitor the reduction in greenhouse gas emissions arising from the implementation of aerial cable-cars around the world. The proposed methodology was submitted to the United Nations Framework Convention on Climate Change in 2007[118] and validated in 2009.[119]

Baseline emissions were defined as those that would have resulted from the use of other modes of transport to cover the required origin and destination distances. In the case of Medellín, the modes available were minibuses, taxis and jeeps using fossil fuels such as gasoline and diesel.[120] According to this baseline, the replacement of the fossil fuel operating vehicles by a system of hydroelectric-powered aerial cable-cars was projected to contribute to a reduction of up to 121,029 in total

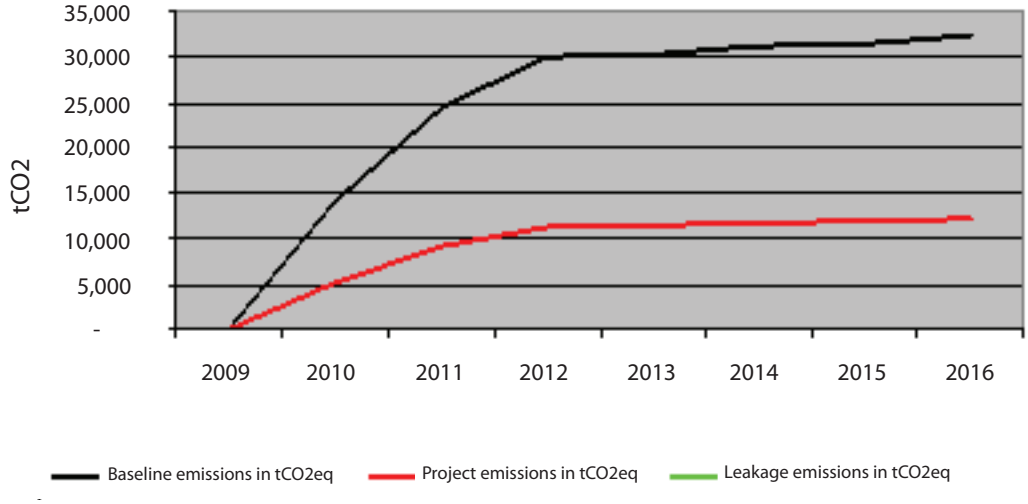
CO_2 emissions between 2010 and 2016). The calculations contemplated the existing three lines and three additional lines projected to begin operations in 2011. In addition, the CDM report states that volumes of trans-boundary air pollutants (mainly carbon monoxide and sulphur dioxide) drop as baseline modes of transport are replaced with a system relying on electricity, generated in Colombia predominantly through the use of renewable resources.[121]

Figure 1: Medellín: Projected emission reductions from six aerial cable-cars

	2009	2010	2011	2012	2013	2014	2015	2016	Total
Baseline emissions in tCO_{2eq}	-	14,005	24,434	30,103	30,382	31,189	31,458	32,311	193,881
Project emissions in tCO_{2eq}	-	5,135	9,083	11,208	11,450	11,724	11,980	12,274	72,853
Emissions reduction in tCO_{2eq}	-	8,870	15,350	18,895	18,932	19,465	19,478	20,038	121,029

Source: Grütter, J. (2009) Cable Cars Metro Medellín, Colombia: Clean Development Mechanism Project Design Document Form (CDM-SSC-PDD), Version 1.3. Unpublished document.

Figure 2: Comparative emissions: Baseline, project emissions and leakage



Source: Grütter, J. (2009) Cable Cars Metro Medellín, Colombia: Clean Development Mechanism Project Design Document Form (CDM-SSC-PDD), Version 1.3. Unpublished document.

Although measurement of the social and economic consequences of the Metrocables is fraught with difficulties, from an environmental and social perspective the impact of the aerial cable-cars can be said to be largely positive on balance. The system has helped to improve the quality of life of the urban poor by making it easier for them to access the opportunities of the city, by enhancing the visibility of the socially stigmatised areas in which they live, and by improving air quality. The first cable car and the associated urban upgrading interventions around the station have given the area higher visibility to outsiders and a sense of social and political inclusion among local residents. Coupled with substantially increased commercial activities around the stations, as well as greater police presence and changes in the nature of the illegal drug business,[122] this has helped to reduce levels of violence and crime in the neighbourhoods surrounding the aerial cable cars.