Reducing Residential Air-Conditioning (AC) Use in the Tropics: Systems Dynamics Scenarios of Climate Sensitive Buildings in Malaysia[1]

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Coping with Heat in the Tropics

The risks of heat to health—especially in light of climate change—is evident in the hot-and-humid tropics. Use of AC as a cooling strategy is rapidly increasing in the tropics. This exacerbates temperatures rise through urban heat island effects in the short-term and climate change impacts in the long term. Residential demand is high in these areas due to growing populations. Climate sensitive buildings (CSB) that reduce the temperature gap between indoor and outdoor temperatures may be a way to reduce AC use and mitigate health risks from heat.

Residential AC use in Malaysia is heavily weighted toward evening-use even though most residences are occupied during the day and night-time temperatures are much cooler.[2] This suggests that residential AC use is strongly driven by issues of sleep quality.

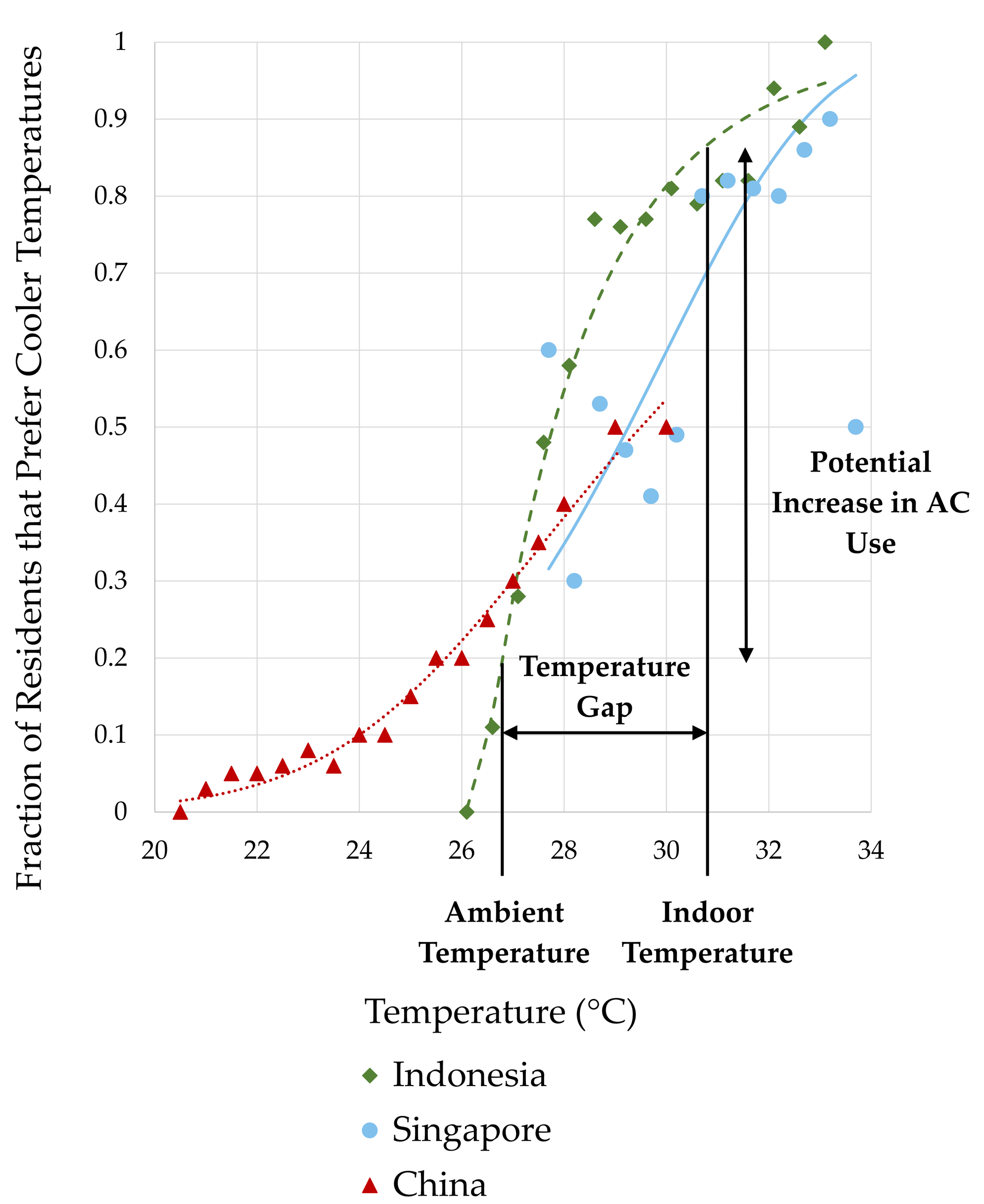

Figure 1: Fraction of residents preferring cooler temperatures for a range of ambient temperatures in Singapore, Indonesia, and Central Southern China,[3-5] and an illustration of building effects on AC use.

Outdoor night-time temperatures in the tropics are often within thermal preference ranges. However, conventional building design and resident behaviours result in indoor temperatures that are several degrees warmer.

Systems Dynamics Model and Scenarios

Data surrounding the cost of residential CSB and societal willingness-to-pay (WTP) is scarce. A systems dynamics model was used to explore possible CSB adoption scenarios based on Malaysian demographics and expected housing demand. Available data on green building uptake was used as a proxy for CSB. Reductions in cost through experience, subsidy interventions, and future climate change impacts were considered in scenario development.

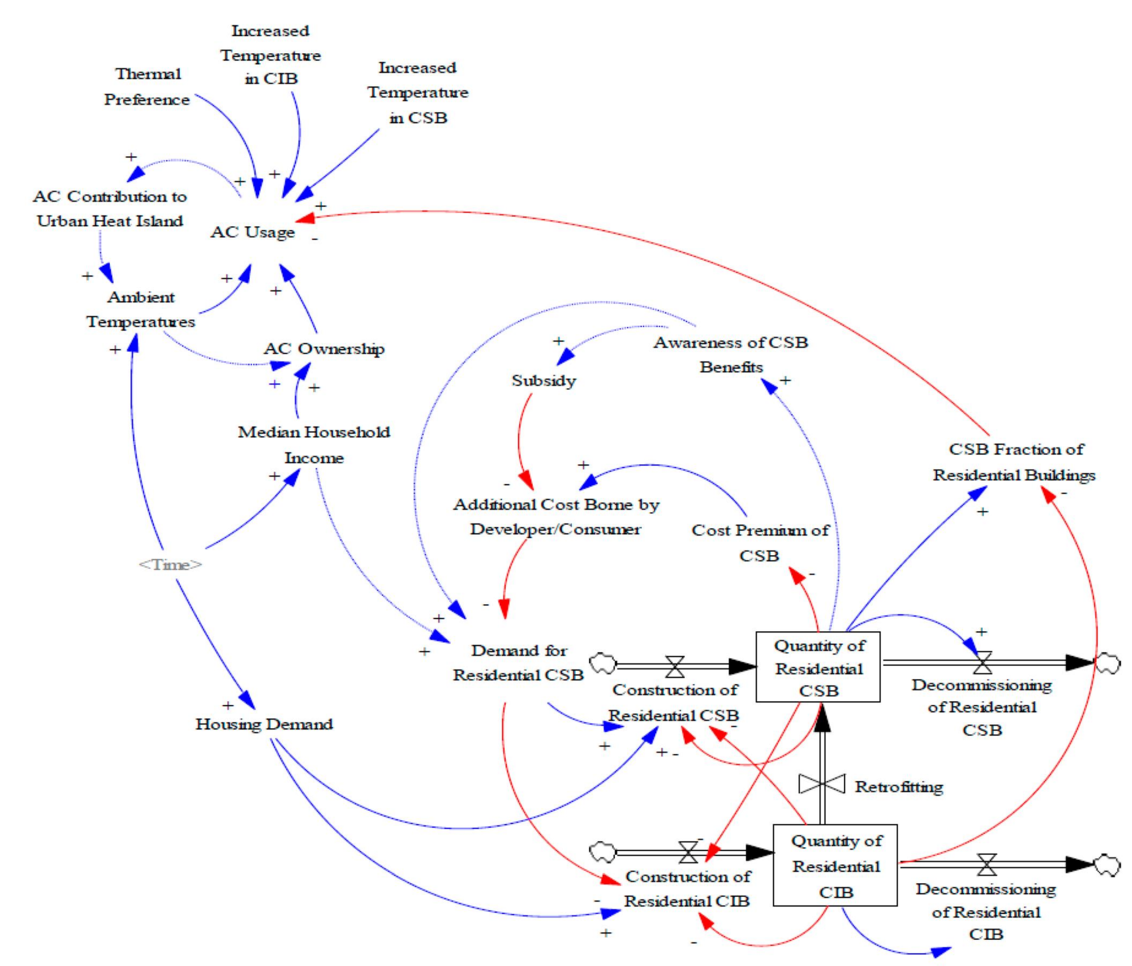

Figure 2: Conceptual model for exploring CSB uptake. Solid arrows were included in the systems dynamics model while dotted arrows represent potentially important relationships beyond the scope of this analysis.

Subsidies and WTP Effects

The effectiveness of subsidies as an intervention to increase CSB uptake is highly dependent on consumer WTP. At reasonable ranges of WTP, subsidies may be superfluous, necessary, or ineffectual. Questions of social equity are also important, as very high subsidy levels may be needed to achieve high uptake of CSB. Subsidies at lower levels are likely to disproportionately benefit higher-income households, increasing inequitable outcomes.

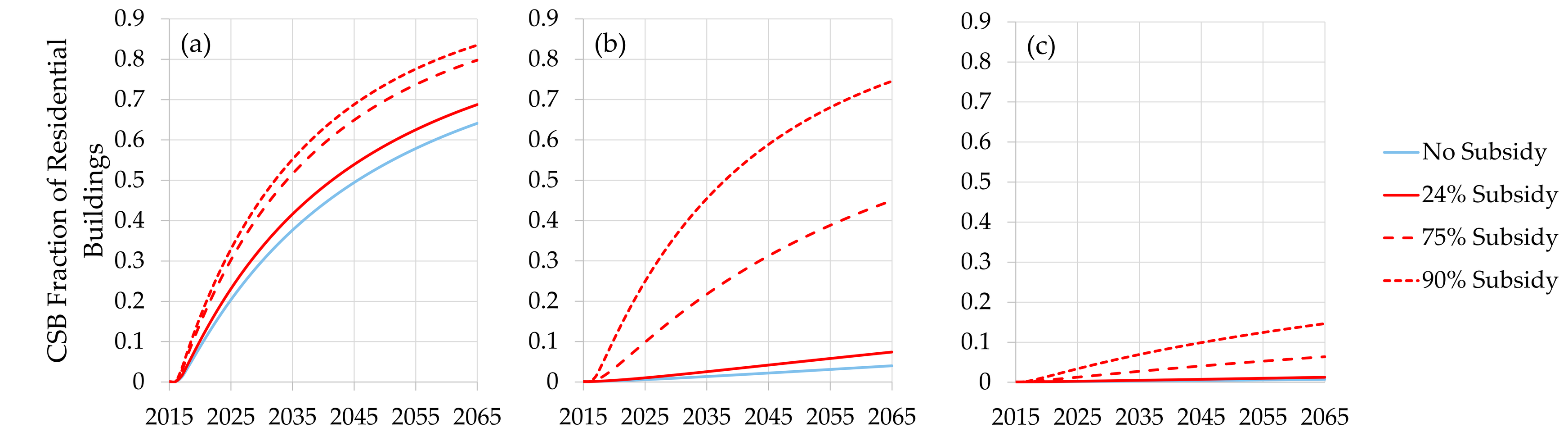

Figure 3: Subsidy effects on climate-sensitive building fraction of Malaysian residential stock for (a) High, (b) Medium, (c) Low consumer WTP.

Climate Change Considerations

The rapidly increasing number of households alone—doubling between 2015 and 2065—will result in a large increase in AC use. Even at very high adoption levels, CSB alone will only mitigate this increase, not reverse it. Climate change impacts[6] are also expected to accelerate AC use. Rising temperatures will cause ambient night-time temperatures to exceed residents' thermal preferences more and more frequently, undermining the capacity of CSB to provide adequate thermal comfort. Under these circumstances, CSB will nevertheless be important for mitigating health risks from heat.

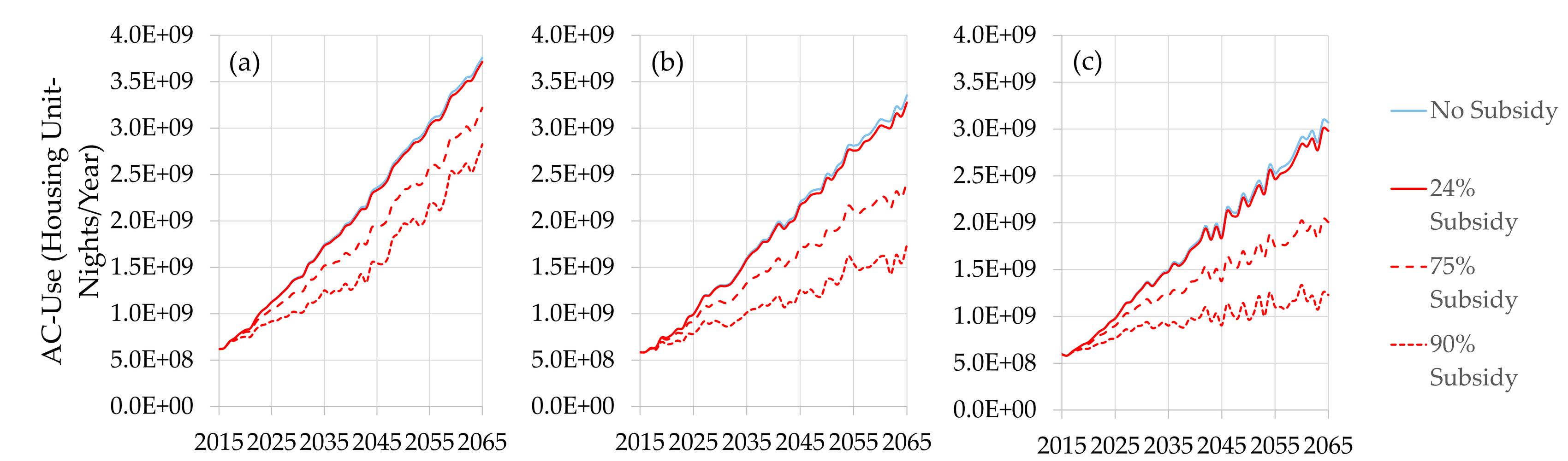

Figure 4: Subsidy effects on Malaysian residential night-time air-conditioning usage under various climate change scenarios: (a) A1FI, (b) A1B, (c) B1. Short-term fluctuations in AC use are due to year-to-year climate variances.

References

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