Considerations of Global Equity and Burden-Sharing in Community-Scale Climate Action Planning

Peter Erickson, Chelsea Chandler, and Michael Lazarus, SEI

December, 2010

Stockholm Environment Institute
Working Paper WP-US-1008

Abstract

Cities around the world have been leaders in efforts to reduce greenhouse gas emissions, and many have adopted pledges to cut emissions 80% from 1990 levels by 2050. However, while the goal of 80% below 1990 levels by 2050 may be considered very *ambitious* in terms of the required policies, technologies and actions to achieve it, it may no longer represent an *adequate* target in terms of confronting the risks of climate change. Furthermore, when applied at a community scale, such goals do not consider the UNFCCC principle of "common but differentiated responsibility" that places greater burden on developed countries to finance and deliver emission reductions. In setting emissions goals, we suggest that communities consider "burden-sharing" approaches that consider historic responsibility and capacity to pay for emissions reductions. To demonstrate the feasibility of such approaches, we apply one burden-sharing framework – the Greenhouse Development Rights – to the City of Seattle, which indicates that to fulfill a global mitigation obligation the community would need to go carbon "negative" before 2020 and progressively more so thereafter. Communities can serve as laboratories for testing replicable models for widespread (e.g., national) adoption. We recommend that further research and pilots explore the mechanics of establishing equity-based community climate goals and the associated financing mechanisms.

For more information about this document,
Contact pete.erickson@sei-us.org.

Stockholm Environment Institute - US
11 Curtis Avenue
Somerville, MA 02144-1224, USA
www.sei-us.org and www.sei.se

Acknowledgements

This report was prepared with funding from the Swedish International Development Cooperation Agency via SEI's Core project funding. We thank Tom Athanasiou, Paul Baer, and our SEI colleagues Sivan Kartha, Eric Kemp-Benedict, and Anja Kollmuss for helpful review of early drafts of this paper.

Introduction and Background

Many cities have been leaders in efforts to reduce greenhouse gas emissions. For example, in much of the last decade (2000-10), when national U.S. leadership on climate was severely lacking, actions by states and cities built momentum for climate policy and action at regional and national levels. Around the world, hundreds of cities have adopted aggressive pledges to cut emissions. Many of those pledges have been in line with a global target of 80% reduction in greenhouse gases (compared to 1990 levels) by 2050.

Cities that have so far been leaders in the effort to address climate change are now pondering "what next", especially given the slow pace of action at the national (e.g., US) and international (e.g., UNFCCC) levels. For example, the City of Seattle, a city that has long been a leader in climate action and where this paper's authors are based, is considering a more ambitious goal.[1] In early 2010, the Seattle City Council announced an intention to explore making the city "carbon neutral", and the City is planning to update its climate action plan in 2011.

Indeed, the state of knowledge and discourse has advanced somewhat since Seattle and other communities committed to goals of "80% by 2050." Scientists and politicians alike have helped articulate a growing consensus that the earth's mean temperature should not exceed 2 degrees C above the pre-industrial level if the earth is to maintain a safe operating space for humanity.[2] More recently, many scientists have suggested that a safe operating space might require staying within a 1.5 degrees C increase, and many climate-vulnerable nations have endorsed such a goal. To attain such goals, scientists and civil society are calling for atmospheric carbon dioxide (CO_2) levels to be ultimately stabilized at 350 parts per million (ppm).[3] Attaining this level would require a dramatic and rapid reduction in global greenhouse gas emissions. The IPCC Fourth Assessment report suggested that even a 450ppm CO_2 equivalent trajectory (roughly 400 ppm CO_2 alone), which would have a less than 50% probability of achieving a 2 degree C target would require reductions from developed countries on the order of 80-95% from 1990 levels by 2050.[4] Therefore, while the goal of 80% below 1990 levels by 2050 may be considered very *ambitious* in terms of the required policies, technologies and actions to achieve it, it may no longer represent an *adequate* target in terms of confronting the risks of climate change.

Additional scientific assessments have further refined what future global emissions pathways could limit warming to 2 degrees C over pre-industrial levels with reasonable confidence. For example, the following figure, taken from the German Advisory Council on Global Change, charts out different possible global CO_2 emissions pathways that could limit warming to 2 degrees C. Note that the longer

[1] The City of Seattle has long pioneered efforts to address climate change, from the City-owned electric utility's commitment to net zero emissions to the City's official goal to reduce greenhouse gas emissions 80% below 1990 levels by 2050. In 2005, Seattle mayor Greg Nickels launched the U.S. Mayor's Climate Protection initiative to convince other cities to adopt Kyoto protocol targets at the city scale. Over 1,000 mayors around the country have now signed the pledge, with many also including a goal to reduce emissions in their communities by 80% below 1990 levels by 2050.

[2] For an assessment of the "reasons for concern" associated with warming of 2 degrees, see Smith et al (2009), http://www.pnas.org.ezproxy.library.tufts.edu/content/106/11/4133.abstract. The 2 degree target was also noted by signers of the Copenhagen Accord.

[3] For a summary of the reasons for a 350 ppm target, see Rockstrom et al (2009).

[4] See Box 13.7, page 776, of the IPCC Fourth Assessment Working Group III Report (Metz et al. 2007). . http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter13.pdf

global action is delayed and emissions continue to rise, the faster and deeper the ultimate pathway must be – perhaps to zero globally. [5]

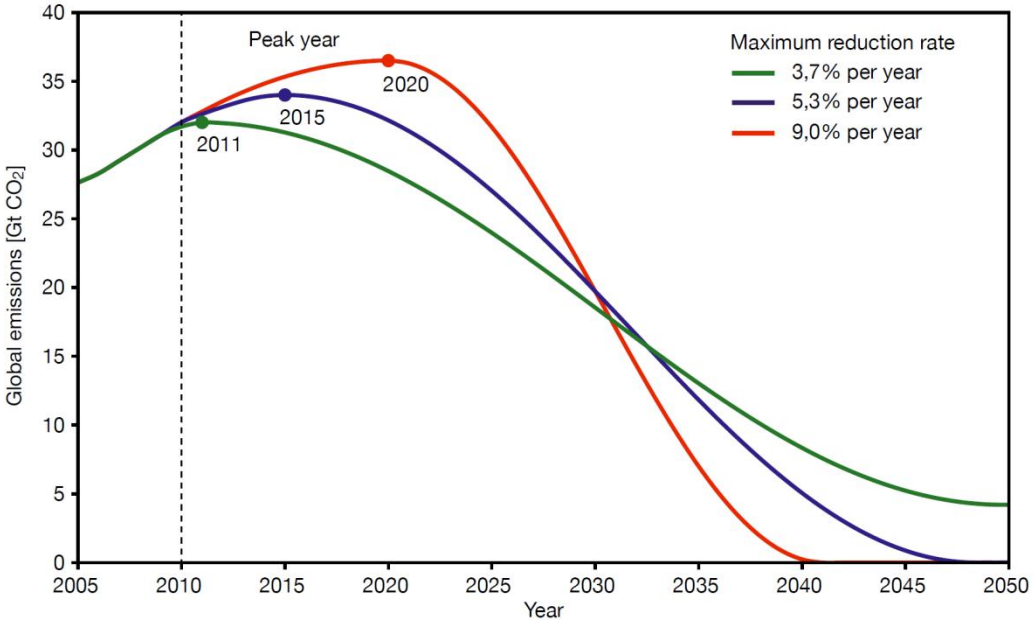

Figure 1. Examples of Alternative Global Emissions Pathways to Meet 2° C "Guardrail" (WBGU 2009)[6]

While Figure 1 illustrates *global* emissions pathways for achieving a 2 degree target, it does not speak to "common but differentiated responsibilities", a guiding principle of the UNFCCC that places greater burden on developed countries to finance and deliver emission reductions. From a pragmatic as well as moral perspective, the emissions pathway for wealthier regions would need to be even more ambitious than the global pathway shown above. The United States, with a per capita emissions rate that is more than three times higher than China and more than ten times higher than India, for example, would be obliged to curb its emissions more rapidly than these countries, which are still trying to extend basic energy services to hundreds of millions of their underserved population.

"Burden sharing" approaches assert that, to be consistent with the "common but differentiated responsibilities" principles of the UNFCCC, relatively prosperous countries have obligations not only to adopt their own ambitious emissions reduction goals, but also to provide financial and technological support to countries or communities with significantly less historical contribution to global emissions and limited capacity to pay for reduction actions (UNFCCC 2009; Baer et al. 2008; WBGU 2009; Chakravarty et al. 2009). The same logic can also be applied to communities. After all, countries are made up of hundreds or thousands of communities, emissions reductions goals will inevitably play out

[5]The goal of limiting warming to 2 degrees Celsius was also recognized at the Major Economies Forum in July 2009. Note also that a country's reductions, and the financial responsibility for those reductions, need not be the same. For example, some discussions have focused on payments or other form of financing from developed countries to developed countries to support "nationally appropriate mitigation actions" in those countries.

[6] These scenarios were constructed to limit global CO2 emissions to 750 Gt between 2010 and 2050, a level that is believed to yield a 67% chance of averting warming of 2 degrees over pre-industrial levels.

at the community scale, and (as noted above), communities are increasingly adopting and planning for achievement of greenhouse gas emission reduction targets. Yet little research has explored how to apply burden-sharing approaches at the sub-national (including community) scale. In our view, sub-national regions remain (as they have been in the last decade) important laboratories for climate policy development, especially because these regions continue to push the frontier by adopting ever more-ambitious emissions goals. Including elements of burden-sharing in these regions' goals could help set the stage for broader discussions of equity and create replicable models for national adoption. Therefore, in this paper, we describe the potential application of a burden-sharing framework to the community scale, using the City of Seattle as an example. We selected Seattle as a case study for this research given the City's long track record of leadership on climate action, the existing planning process underway in the city, and our SEI office location in Seattle.

Burden-Sharing at a Community Scale

Several cities around the world have pursued "carbon neutral", or similarly ambitious climate action plans. For example, Copenhagen, Denmark has announced a goal of reducing its net community GHG emissions to zero by 2025, and Melbourne, Australia has pledged to meet the same goal by 2020. Both cities are held up as among the most ambitious community climate goals globally.[7]

Neither city, however, specifically addresses how their community goals relate to a global plan of action involving "common but differentiated responsibility" or a burden-sharing approach. In our review of community climate action planning efforts (see Appendix A for a summary), we identified only one example of a burden-sharing approach at a community level: the efforts of the London Sustainable Development Commission and its partners (Bioregional and the London Sustainable Development Commission 2009).[8] The London study used a "contraction and convergence" approach (Bows et al. 2006) to define an emissions reduction trajectory for the City of London out through 2050. Contraction-and-convergence approaches assume countries gradually reduce from historic or "grandfathered" emissions levels down to an equal, global per-capita level . Because equal per-capita approaches assume by definition that each country has the same per-capita right to emissions, these approaches do not consider the fact that some countries have already contributed much more emissions (per capita) to the atmosphere or that some countries have higher relative incomes and thus capacity to implement solutions. In other words, contraction and convergence approaches consider neither historic responsibility nor relative incomes in calculating an emissions reduction responsibility.

In this paper, we use a different approach to calculate global obligations for reducing emissions: the Greenhouse Development Rights (GDR). Unlike per-capita approaches (including the widely publicized "One Billion High Emitters" of Chakravarty et al 2009, as well as *contraction and convergence*), the GDR framework takes into account a region's historic emissions contribution and relative capacity to pay for a global solution. Where per-capita approaches equally distribute the already scarce remaining allowable *emissions*, the GDR framework distributes the *emissions mitigation* by accounting for relative wealth and historical emissions among regions. In doing so, the GDR development framework leaves room for economic growth in poor regions.

The GDR framework works by identifying a "development threshold" – "a level of welfare below which people are not expected to share the costs of a climate transition" of $7,500 per year, and determines each country's contribution to solving the global climate problem as being proportion to its

[7] Both cities plan to use offsets to meet their goals.
[8] For a summary of our review of other "carbon neutral" community efforts, please see the Appendix.

income above that threshold ("capacity") and its historic emissions since 1990 ("responsibility").[9] For example, the United States has (approximately) one-third of the global capacity and one-third of global responsibility, and its obligation would correspondingly be to undertake one-third of the required global mitigation. Under such an approach, a country's obligation for undertaking mitigation and contributing to a global solution can actually exceed the country's domestic emissions – an outcome not possible in approaches based on equal per-capita allocations such as contraction-and-convergence.

Approach

We used the Greenhouse Development Rights (GDR) framework to conduct a mitigation trajectory for Seattle that would take into account global responsibility.

The GDR framework relies on assessments of *responsibility* (R), a measure of historic emissions (by residents above the development threshold), and *capacity* (C), a measure of income above the development threshold. For any given region, both responsibility and capacity are expressed as percent of the global responsibility or capacity. The two terms are then combined as a simple weighted sum to form a Responsibility and Capacity Indicator (RCI).[10] Accordingly, each region's RCI represents the share of global mitigation required. Baer et al. (2008) calculate an RCI and emissions scenario for countries of the world through 2030 based on the mitigation required to meet a 2-degree target. We simply apply their same method to the City of Seattle, and extend it to 2050 to align with the timeline of Seattle's climate action planning.[11]

In particular, our methodology was as follows:

1. Start with the City of Seattle's official GHG inventory, which includes emissions for 1990, 2005, and 2008 (City of Seattle 2009). The City's inventory includes all emissions released within the Seattle community, plus emissions released to generate electricity consumed in the community and a proportional share of emissions from air travel at the region's airport.[12]
2. Calculate Seattle's responsibility, capacity, and resulting RCI index using the equations and assumptions in Kemp-Benedict (Kemp-Benedict 2010) and the Second Edition of the GDR Book (Baer et al. 2008). Key Seattle-specific data sources other than the City's GHG inventory (Step 1) included income forecasts for the Seattle area per Conway (2006), income distribution data from

[9] Although EcoEquity and SEI developed the GDR framework for countries, we apply it here to the City of Seattle to demonstrate the applicability and utility of GDRs at a community scale. We use the same equations defined in Baer et al (2008) and the supporting documentation Kemp-Benedict (2010).

[10] Following Baer et al (2008), we assign equal weight (0.5) to each.

[11] We used Baer et al (2008) as our template, coupled with the supporting methodology appendix (Kemp-Benedict 2010). We supplemented these documents with conversations with the authors of those documents, especially Eric Kemp-Benedict.

[12] Once could argue that an even more equitable application of GDRs would be to measure emissions on a consumption (footprint) basis, which would include the embodied emissions in goods and services imported into a region. In fact, since the *Second Edition* of the GDR book, the GDR authors have been exploring a consumption basis. However, given that we rely on the published and well-documented *Second Edition* and that a full consumption-based inventory for Seattle does not (yet) exist, we use the City's existing, hybrid inventory.

the US Census Bureau's American Community Survey for 2008[13], and population forecasts by the Puget Sound Regional Council (PSRC 2006).

3. Calculate Seattle's mitigation obligation as Seattle's RCI (Step 2) multiplied by the global required mitigation (emergency 2 degree path) per Baer et al. (Baer et al. 2008).
4. Project future reference case for Seattle's emissions. In particular, we assumed that, in the absence of a comprehensive climate policy, Seattle's emissions would hold constant between now and 2050. This assumption is informed by modeling we conducted to support the City of Seattle's climate action planning (Lazarus, Chandler, and Erickson 2010), which showed that expected trends were likely to hold emissions relatively constant.[14]
5. Calculate GDR allocation to Seattle as difference between Seattle's reference case (Step 4) and its share of the global mitigation requirement (Step 3)
6. Chart results, showing the reference and allocation calculations (Steps 4 and 5) as well as Seattle's existing official reduction goal of 7% by 2012 and 80% by 2050 compared to 1990 levels

The spreadsheet used to conduct the calculations is available upon request from the authors.

Results

Figure 2 below depicts three scenarios for Seattle's future greenhouse gas emissions. The reference case scenario assumes Seattle's emissions hold constant at the current level (as described above) and the blue line represents Seattle's existing official goal of an 80% reduction by 2050. The yellow line shows Seattle's "global obligation" under the GDR framework, based on the historical emissions of Seattle and the relative income (and income distribution) of Seattle residents relative to the global average. As the figure indicates, Seattle's relative wealth and historic emissions suggest that to contribute equitably to global emissions mitigation consistent with a 2-degree target may require the city to accept an obligation far greater than its own emissions, implying a pathway that takes Seattle carbon "neutral" before 2020, and progressively more carbon "negative" thereafter. Similar findings would likely hold for most U.S. cities, though the particular trajectories of future emissions and global obligation would vary.[15]

[13] http://factfinder.census.gov/servlet/ADPTable?_bm=y&-geo_id=16000US5363000&-qr_name=ACS_2008_1YR_G00_DP4&-context=adp&-ds_name=&-tree_id=308&-_lang=en&-redoLog=false&-format=

[14] This reference case assumes improvement in energy intensities consistent with the U.S. Department of Energy's Annual Energy Outlook 2010 (US EIA 2010).

[15] Because Seattle relies predominantly on low-carbon hydropower for its electricity, the community's baseline emissions are likely lower (on a per-capita basis) than a comparable community, and so the "global obligation" trajectory may cross into "negative" territory sooner than cities that do not use such low-carbon electricity.

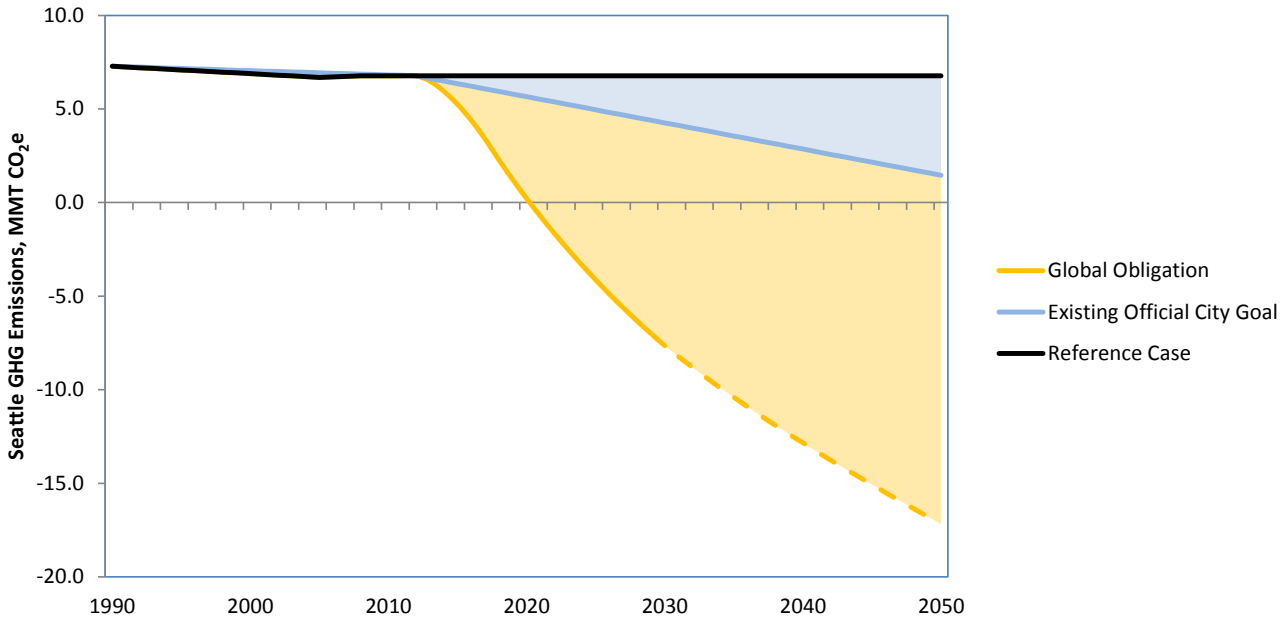

Figure 2. Seattle's GHG Emissions Mitigation Obligation Based on the Greenhouse Development Rights Framework

What does it mean to go "carbon negative"? Practically speaking, we don't intend Figure 2 to imply that prosperous, industrialized cities like Seattle should reduce emissions far below zero through activities that sequester greenhouse gases, such as forestry or carbon capture and sequestration. Instead, we suggest that such cities' roles in a global climate response are to reduce their own emissions dramatically, while simultaneously investing to enable a low-GHG transition to occur elsewhere. This enabling support will be needed in world regions that have much more limited capacity and responsibility to invest in climate change mitigation, but which nonetheless may face even greater urgency to provide low-carbon energy and infrastructure. Indeed, absent such investment, much of the growth in global GHG emissions in the coming two decades is likely to occur as developing country cities expand to accommodate nearly 2 billion new residents.

Discussion

Garnering the resources and support to finance and implement deep reductions remains a major challenge of our time. This is especially true with respect to emission reductions in developing countries, given competing needs including energy access, clean water, food sufficiency, and health care. Among the financing options that have emerged in the international negotiations are purchases of offsets and direct transfer of public funds or resources (Project Catalyst 2009).

Either of these approaches could also apply, in theory, at the community level. Communities could purchase greenhouse gas offsets through an international market in an amount equal to the difference between the community's own emissions and its full global obligation trajectory as depicted (for example) in Figure 2. Or, communities could be to provide other forms of direct financial or technology support outside a market-based mechanism. Each of these options is discussed below.

Use of Offsets in Fulfilling Communities' Global Abatement Obligations

Carbon or greenhouse gas offsets provide a means for entities to finance GHG emission reductions or removals elsewhere as a substitute for making reductions themselves. A greenhouse gas offset represents one ton of greenhouse gas emissions avoided, sequestered, or reduced by a source, country, or sector not subject to a binding emissions reduction limit.[16] For example, under the Kyoto Protocol, countries established the Clean Development Mechanism, under which industrialized ("Annex 1") country parties could finance emission reduction projects in developing countries as a substitute for some fraction of the domestic greenhouse gas reductions required under the Protocol.[17] Offset programs have also been developed to serve companies and individuals interested in voluntarily offsetting their emissions, outside of a comprehensive emissions reduction program.

Communities could use greenhouse gas offsets to make up the difference between their own emissions and their global obligations (as assessed, for example, in Figure 2). More specifically, since the intent of burden-sharing approaches (and the GDR framework in particular) is to support low-GHG transitions in poor areas with low historic emissions, we suggest that communities could target their offset purchases to countries meeting these criteria. For example, communities could purchase offsets from areas with correspondingly low global obligations in the same framework (e.g., Greenhouse Development Rights) used to quantify the community's (proportionally larger) obligation.[18]

Offsets are not without risks, however. For example, research has shown that one ton of offset credit may not result in one ton of actual emissions reduction or removal, as some projects may not be "additional" to what would have happened otherwise (Schneider 2009a). Nevertheless, carefully designed programs (and offset protocols) can indeed result in realization of the stated benefits (Erickson, Lazarus, and Kelly 2010). Communities can help ensure the quality of their purchased offsets by using supplemental quality criteria, such as excluding offsets from environmentally questionable project types (such as large hydro and certain industrial gases) and requiring that offset projects (even those generated by regulatory programs, such as the Clean Development Mechanism) meet a rigorous third-party standard to ensure social and environmental co-benefits (e.g., the Gold Standard). Other mechanisms, such as purchasing more offsets than what the emission reduction goals require, often called "discounting" (Schneider 2009b) could also be employed to ensure that each ton of offset credit purchased represents a ton (or more) of real emissions benefit.

Alternatives to Offsets—Direct Technology or Financial Support

Offsets are not the only means of supporting greenhouse gas abatement in developing countries. Communities could instead pursue direct financing or technology transfer. In the international climate negotiations, countries have so-far agreed to two different types of financing for mitigation in developing countries, representing long-term and short-term needs. In the longer term, under the Cancun Accords, developed country parties committed to "mobilizing jointly USD 100 billion per year by 2020 to address the needs of developing countries," with a focus on the most vulnerable countries (UNFCCC 2010). These funds – termed the Green Climate Fund – are to come from a variety of sources, including public and private entities, and be managed under the auspices of the United

[16] GHG offsets are created by the application of quantification, verification, and enforcement criteria that assess whether the project is resulting in "additional" greenhouse gas reductions that would not otherwise have happened in the absence of the offset market.

[17] For a summary of existing offset programs, protocols, and standards, see Kollmuss et al (2010)

[18] The question of how to account for emission-reductions made by sub-national actors within a national comprehensive climate policy is interesting. For some possible approaches, see Bianco and Litz (2010).

Nations. In the shorter term, industrialized countries have committed (in the Copenhagen Accord, and again in the Cancun Accords) "fast-start finance" resources "approaching $30 billion" for years 2010 to 2012 to support climate efforts in developing countries, with a focus on the most vulnerable countries. Fast-start funds are now administered largely through conservation organizations in the developing countries, such as forest funds in the Amazon and Congo or renewable energy funds in Africa and southeast Asia (Ballesteros et al. 2010).

Communities could contribute to similar efforts or develop more specific partnerships with community-scale efforts in "sister cities" (including the possibility of city-to-city cap-and-trade programs, per World Bank 2010) or other areas to either provide finance or to provide low-carbon technology.[19] In the absence of formal offset protocols, however, a key challenge would be calibrating the scale of support accurately to community's global obligation.

Assembling the Community-Scale Program

Mechanisms such as those discussed above can allow cities to pursue and meet aggressive, burden-sharing-based emissions abatement goals through relationships with partners in developing countries. Given the slow progress in national and international climate negotiations, proactive efforts by communities to explore and test such alternative partnerships could help test methods and build support for future broader-scale climate action.

A necessary prerequisite, of course, is how a community would realistically build support for, and put in place, such a goal, given limitations in political and community support and financial resources. We expect that, while equity may be an important driver for some communities and associated stakeholders, concerns are more likely to focus (at least at first) on local-scale equity issues such as affordable housing and environmental justice. We view discussions of local and global equity as complementary: both involve assessing the relative impacts of climate changes and responsibilities for action, and we envision conversations that start with local-level concerns could eventually be broadened to include global dimensions.[20]

Enacting a financing mechanism to support fulfillment of the global obligation may be even more challenging, given limited political appetite for new taxes and substantial other demands on existing (or any new) revenue. At a cost of $20/ton CO_2e, for example, the cost of meeting Seattle's obligation in 2020 would approach $100 million.[21] This translates to $150 per resident annually – a figure that may be near the upper end of what residents – even in Seattle – have supported in ballot initiatives for social or environmental equity concerns.[22] Still, $150 is less than one-half of one percent of the projected median per-capita income in Seattle in 2020. When viewed from that context, the cost of meeting a community's global obligation for addressing climate change may well be manageable. Furthermore, in the international negotiations, countries have advanced proposals for leveraging

[19] One example of a similar effort is the decades-old sister-city partnership between Zurich, Switzerland and Kunming, China, in which Zurich planners helped Kunming conduct a "Public Transport Master Plan", with funding from the Swiss Central Government. The cities have continued to collaborate on low-carbon infrastructure.

[20] In fact, if sufficient data are available, it may also be possible to calculate burden-sharing (e.g., GDR) approaches for sub-segments of the population even within communities in industrialized cities. For example, our estimates for the City of Seattle suggest that 12% of Seattle's population would be below the development threshold and therefore have no obligation for addressing climate change.

[21] $20/ton in 2020 is within the range of estimates of carbon prices under recently considered U.S. climate legislation (US EPA 2009; US EIA 2009; US EPA 2008)

[22] For example, in 2009 Seattle voters approved a housing levy to support affordable housing that costs the average Seattle *household* $65 per year.

financing to spur additional mitigation and lower overall per-ton mitigation costs. Under these proposals, developing countries would commit to making additional reductions over and above the mitigation associated with the purchased offsets, such that one ton of offset purchased could equal more than one ton of actual emissions mitigation, perhaps meaning that not as many offsets would need to be purchased and costs could be reduced.[23]

Recommendations

Communities in industrialized countries around the world – even those that have committed to aggressive emissions-reduction goals such as carbon neutrality, have yet to consider burden-sharing approaches in their goal-setting and climate action planning. Yet research suggests that taking "common but differentiated responsibility" seriously requires relatively prosperous countries (and communities therein) to go further and substantially support low-carbon transitions in developing countries (Baer et al. 2008). Further research is needed to explore how sub-national geographies – including communities – could use burden-sharing approaches and create replicable models for widespread (i.e., national) adoption.

In particular we recommend that leading communities, and associated researchers:

- **Introduce equity and burden-sharing considerations into local climate action planning processes.** Since burden-sharing concepts are likely to be unfamiliar to many stakeholders, communities may wish to introduce concepts gradually to build support and interest, while pursing partnerships with social justice and globally focused organizations. Some communities may even wish to conduct focus groups, surveys, or other social research to understand interests and motivations in the community and to test and assess alternative methods for introducing burden-sharing concepts. Based on initial experiences, we recommend that communities document and disseminate best practices for discussing global equity in community scale climate action.
- **Pilot methods for establishing support of GHG reductions in developing countries, including consideration of offset programs or other developed-to-developing-country community partnerships** to directly support low-GHG development in developing countries and communities. Since few communities globally have attempted to apply burden-sharing approaches or finance GHG reductions beyond national borders, new and innovative approaches should be explored. . Such approaches might include working with standards for offsets with strong local benefits (e.g., Gold Standard), developing specific projects with "sister cities", or pioneering new subnational arrangements, such as the State or California is exploring to reduce deforestation in Brazil and Indonesia.
- **Research and pilot financing mechanisms,** perhaps starting with voluntary initiatives, wherein residents or businesses pledge to substantially reduce their own emissions (consistent with an ambitious in-community goal such as 80% or more by 2050) and also fulfill a proportional share of the community's global obligation through purchase of offsets (or equivalent instruments). Additional research could study the feasibility of broad-based financing mechanisms such as voter-approved property tax levies or other taxes or fees to support low-carbon investments locally and in poor communities in developing countries.

[23] For example, in the concept of no-lose sectoral crediting, developing countries would only be able to sell offset credits if they met a particular emissions trajectory that was lower than business-as-usual (Ward et al. 2008). The concept of "supported NAMAs" is similar.

- **Establish official goals in community planning documents (climate action plans, comprehensive plans) to fulfill global obligations by a certain year (e.g., 2020).** Community climate action plans are often given extra weight by the adoption of comprehensive plans with official GHG-reduction goals that can drive city policy. Inclusion of burden-sharing concepts (and, where feasible, quantitative goals) can help give extra weight to these efforts.

This paper has demonstrated the feasibility of applying burden-sharing approaches at the community level, including a quantitative assessment of a fair global mitigation obligation for one city (Seattle) using a particular framework (the Greenhouse Development Rights). Our hope is that this paper helps lay groundwork for further assessments and explorations of global equity in sub-national climate action planning.

References

Baer, Paul, Tom Athanasiou, Sivan Kartha, and Eric Kemp-Benedict. 2008. *The Greenhouse Development Rights Framework: The right to development in a climate constrained world: Revised second edition*.

Ballesteros, Athena, Clifford Polycarp, Kirsten Stasio, Emily Chessin, Xing Fu-Bertaux, and Kaija Hurlburt. 2010. Summary of Developed Country 'Fast-Start' Climate Finance Pledges. November 29.

Bianco, Nicholas, Franz Litz, Madeline Gottleib, and Thomas Damassa. 2010. Reducing Greenhouse Gas Emissions in the United States Using Existing Federal Authorities and State Action.

Bioregional and the London Sustainable Development Commission. 2009. Capital consumption: the transition to sustainable consumption and production in London. November. http://www.bioregional.com.

Bows, A, S Mander, R Starkey, M Bleda, and K Anderson. 2006. Living within a carbon budget. *Manchester, Tyndall Centre for Climate Change Research*.

Chakravarty, Shoibal, Ananth Chikkatur, Heleen de Coninck, Stephen Pacala, Robert Socolow, and Massimo Tavoni. 2009. Sharing global CO2 emission reductions among one billion high emitters. *Proceedings of the National Academy of Sciences* 106, no. 29 (July 21): 11884 -11888. doi:10.1073/pnas.0905232106.

City of Seattle. 2009. *2008 Seattle Community Greenhouse Gas Inventory*. Office of Sustainability and Environment.

Conway, Dick. 2006. *Puget Sound Economic and Demographic Forecast: Detailed Forecasts and Methodology*. Dick Conway & Associates for the Puget Sound Regional Council, February.

Erickson, Peter, Michael Lazarus, and Alexia Kelly. 2010. The Importance of Program Design for Potential U.S. Domestic Greenhouse Gas Offset Supply. *Climate Policy*.

Kemp-Benedict, Eric. 2010. *Calculations for the Greenhouse Development Rights Calculator*. Stockholm Environment Institute Working Paper. March 14.

Kollmuss, Anja, Michael Lazarus, Carrie Lee, Maurice Lefranc, and Clifford Polycarp. 2010. *Handbook of Carbon Offset Programs: Trading Systems, Funds, Protocols and Standards*. Earthscan/James & James.

Lazarus, Michael, Chelsea Chandler, and Peter Erickson. 2010. *Draft Carbon Neutral Seattle Baseline and Scenario Analysis*. SEI-US for the City of Seattle Office of Sustainability and Environment, December.

Metz, B, OR Davidson, PR Bosch, R Dave, and LA Meyer. 2007. Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. *Cambridge University Press, Cambridge, UK and New York, NY. Retrieved June* 26: 2007.

Project Catalyst. 2009. *Scaling up Climate Finance: Finance briefing paper*. ClimateWorks and European Climate Foundation, September.

PSRC. 2006. Population, Households, and Employment Forecast. Puget Sound Regional Council. http://www.psrc.org/data/forecasts/saf/.

Rockström, J, W Steffen, K Noone, Å Persson, FS Chapin, EF Lambin, TM Lenton, M Scheffer, C Folke, and HJ Schellnhuber. 2009. A safe operating space for humanity. *Nature* 461, no. 7263: 472-475.

Schneider, Lambert. 2009a. Assessing the additionality of CDM projects: practical experiences and lessons learned. *Climate Policy* 9, no. 3: 242-254.

———. 2009b. A Clean Development Mechanism with global atmospheric benefits for a post-2012 climate regime. *International Environmental Agreements: Politics, Law and Economics* 9, no. 2 (May 1): 95-111. doi:10.1007/s10784-009-9095-9.

Smith, Joel B., Stephen H. Schneider, Michael Oppenheimer, Gary W. Yohe, William Hare, Michael D. Mastrandrea, Anand Patwardhan, et al. 2009. Assessing dangerous climate change through an update of the Intergovernmental Panel on Climate Change (IPCC) "reasons for concern". *Proceedings of the National Academy of Sciences* 106, no. 11 (March 17): 4133-4137. doi:10.1073/pnas.0812355106.

UNFCCC. 2009. Copenhagen Accord. December 18. http://unfccc.int/files/meetings/cop_15/application/pdf/cop15_cph_auv.pdf.

———. 2010. Draft decision -/CP.16: Outcome of the work of the Ad Hoc Working Group on long-term Cooperative Action under the Convention (Advanced Unedited Version). December. http://unfccc.int.

US EIA. 2009. *Energy Market and Economic Impacts of H.R. 2454,the American Clean Energy and Security Act of 2009*. U.S. Energy Information Administration.

———. 2010. *Annual Energy Outlook 2010*. U.S. Energy Information Administration, May 11. http://www.eia.doe.gov/oiaf/archive/aeo10/index.html.

US EPA. 2008. EPA Analysis of the Lieberman-Warner Climate Security Act of 2008: S. 2191 in 110th Congress. March 14.

———. 2009. *EPA Analysis of the American Clean Energy and Security Act of 2009; H.R. 2454 in the 111th Congress*.

Ward, Murray, Charlotte Streck, Harald Winkler, Martina Jung, Markus Hagemann, Niklas Hohne, and Robert O'Sullivan. 2008. *The Role of Sector No-Lose Targets in Scaling Up Finance for Climate Change Mitigation Activities in*

Developing Countries. EcoFys/GTripleC. file://C:\Users\Victoria Clark\Documents\Zotero\References for Upload\EndNote_Library_Pete\My EndNote Library.Data\PDF\08Ward-etal-2008_sector_no_lose_targets-2716615945/08Ward-etal-2008_sector_no_lose_targets.pdf.

WBGU. 2009. Solving the climate dilemma: The budget approach. German Advisory Council on Global Change. http://www.wbgu.de/wbgu_sn2009_en.pdf.

World Bank. 2010. Tokyo's Emissions Trading System: A Case Study. *Directions in Urban Development*, June.

Appendix: Summary of Community-scale Carbon Neutrality and Other Similarly Ambitious Goals

Even though carbon neutrality is a relatively new concept that lacks a universally accepted definition, various cities in the United States and across the world have begun to craft visions of what carbon neutrality might look like, and have developed plans for achieving this goal. While many companies and organizations have committed to achieving carbon neutrality (Seattle's public electric utility being a notable local example), this section focuses exclusively on communities.

While not an exhaustive list, Table 1 summarizes some of the most ambitious and best-articulated carbon neutral, and similarly ambitious, goals and plans to date. This summary compares terminology, scope (e.g., city limits, whether embodied or consumption emissions are included), use of offsets, and specific measures planned to meet carbon neutral or mitigation goals.

The first section covers existing cities explicitly seeking to achieve "carbon neutrality" or a similar term to reflect "net zero" emissions at some point in time. While many communities are flying the carbon neutral flag, in our review, we found only two, Copenhagen and Melbourne, that have committed to achieving net zero emissions for a comprehensive scope (all city emission). Other communities have limited the scope of carbon neutrality to a handful of emissions sources, generally those over which they can exert significant control: municipal operations (Austin, Vancouver), new buildings (Vancouver), and new electricity sources (Austin). Växjö, a town of 55,000 in a biomass-resource rich region of Sweden, has set a fossil-fuel (CO_2) free goal for 2030, and reduced its per capita emissions by a third largely from switching to waste biomass for district heating. Other communities aspire to become carbon neutral but are not included in this discussion because they lack concrete goals and sufficient analysis to inform practically the discussion of carbon neutrality goals.

The second part of the table describes a couple of path-breaking efforts in developing countries to design a carbon neutral community from scratch. Masdar City, a research and technology-intensive community located just outside Abu Dhabi, aims to be a zero-carbon, zero-waste, zero-car area, highly reliant on solar and other renewable energy sources. Dongtan, a suburb of Shanghai, was envisioned as an "eco-city" incorporating green transport, renewable energy sources, and wetland protection, though these plans have been postponed indefinitely.

Finally, the third part of the table covers additional plans and initiatives relevant to this project: ambitious municipal plans and goals of major communities that aim to be exemplars (Chicago, NYC, and London), visioning studies that chart a carbon neutral course for an entire nation (Zero Carbon Britain), and initiatives that aim to set ambitious targets for municipalities (Climate Positive). While the Zero Carbon Britain study provides the best example of a detailed analysis of how a carbon neutral goal can be achieved through deep reduction actions, some municipalities have conducted relatively extensive emission reduction / scenario analyses that were used to inform plans and targets (e.g. Melbourne and NYC).

The London study is particularly notable; it defines a long-term consumption-based emissions goal, and provides an analysis of how this year 2050 goal could be achieved through city-level actions. Should the carbon neutrality goal for Seattle encompass consumption perspective, this study provides a concrete example of how scenario analysis could be conducted.

It is perhaps not surprising that nearly all plans that aim for "neutrality" rely on offsets to meet their stated goals; some emission sources are very difficult or costly to reduce, and offsets can be easily

invoked to compensate for remaining unabated emissions. In fact, both communities that have set carbon neutrality goals for a broad scope of emissions, Copenhagen and Melbourne, rely quite heavily on offsets. In its plan, Copenhagen achieves approximately half of its emission reductions by 2025 through offsets, while Melbourne relies on offsets an even larger fraction of emissions reductions by 2020, its target year for neutrality. (In comparison, the Zero Carbon Britain study aims to use offsets for only about 10% of emission reductions in 2030; and in their case, entirely from sequestration within Britain itself). In general, these plans leave offsets very loosely defined (in contrast to their more specific definition and requirements in the context of emission trading systems). Offsets, as referred to in various plans, can include the purchase of emission credit or allowance instruments (e.g. tradable offset credits), direct sequestration activities (within or outside jurisdiction), or investment in emission reducing activities outside the jurisdiction.

Table 1. Examples of Carbon Neutral Plans

Community	Goal Statement	Goal Scope	Goal Definition	Offsets Allowed?	Supporting Analysis?
City plans					
Copenhagen, Denmark[24]	"carbon neutral" by 2025	Full community emissions (geographic)	- Reduce CO2 emissions by 20% between 2005 and 2015	Yes, expected source of ≈ half of reductions in 2025	Sectoral/ scenario analysis (LEAP-based)
Austin, TX[25]	"carbon-neutral"	Municipal operations; new electricity sources	- City facilities and operations carbon-neutral by 2020. Utility Plan - Expand efficiency and renewable energy programs; cap CO2 emissions from existing power plants; all new electricity generation carbon-neutral.	Yes, loosely	Limited
Melbourne, Australia[26]	"zero net emissions" by 2020	Full community emissions (geographic)	- Commercial sector: 25% below 2020 BAU - Residential sector: 20% below 2020 BAU - Passenger transport: 10% below 2020 BAU -Energy supply: 18% below 2020 BAU	Yes, expected source for majority of reductions	Sectoral/ scenario analysis
Vancouver, B.C., Canada[27]	"carbon neutral"	Municipal operations; new buildings	- Municipal operations: carbon neutral by 2012 - Community emissions: 6% below 1990 by 2012, 33% by 2020, 80% by 2050 - All new buildings are carbon neutral by 2030	Yes, in corporate plan	Limited
Växjö, Sweden[28]	"fossil fuel-free"	Full community	- Halve per-capita emissions by 2010 (from 1993); reduce by 70% by 2025. - Fossil-fuel-free by 2030.	N/A	Limited
Rizhao, China[29]	"carbon neutral"	Full community	– Specific goals for reduction of energy intensity (per unit GDP), but definition of carbon neutrality not clear.	N/A	Limited
New cities: designing carbon neutrality from scratch					
Masdar City, U.A.Emirates[30]	"carbon-neutral"	Full community	-Carbon neutral; zero-waste	Yes, aim to limit to 1%	Limited
Dongtan, China[31]	"eco-city"	Full community	- 64% reduction in energy demand; no emissions from energy for power/heat; project postponed indefinitely	N/A	Limited
Other notable climate plans and initiatives					
Chicago, IL[32]	"climate action plan"	Full community	- 80% below 1990 GHG emissions by 2050, with an initial goal of a 25% reduction below 1990 by 2020	N/A	Sectoral analysis
New York, NY[33]	"PlaNYC"	Full community	- Reduce global warming emissions by more than 30% by 2030	N/A	Sectoral/ scenario analysis
London, UK[34] (not an official plan)	"capital consumption"	Full community (consumption-based)	- Reduce consumption-based emissions 70% by 2030 and 90% by 2050.	N/A	Sectoral/ scenario analysis

[24] http://kk.dk/sitecore/content/Subsites/CityOfCopenhagen/SubsiteFrontpage/CitizenInformation/~/media/558FF07CE64041AE85437BB71D9EDF49.ashx

[25] http://www.ci.austin.tx.us/acpp/downloads/acpplan_overview.pdf; http://www.ci.austin.tx.us/acpp/downloads/acpp_res021507.pdf; http://www.ci.austin.tx.us/acpp/downloads/report2009.pdf

[26] http://www.melbourne.vic.gov.au/Environment/WhatCouncilisDoing/Documents/zero_net_emissions_2020.pdf

[27] http://vancouver.ca/sustainability/climate_protection.htm; http://vancouver.ca/sustainability/documents/CommunityClimateChangeActionPlan2005coverandreport.pdf; http://vancouver.ca/sustainability/documents/Progress2007.pdf; http://vancouver.ca/sustainability/documents/corp_climatechangeAP-1.pdf

[28] http://postcarboncities.net/europes-greenest-city-even-its-power-plant-smells-more-sauna http://www.unep.org/ClimateNeutral/Default.aspx?tabid=208

[29] http://www.scientificamerican.com/article.cfm?id=sunrise-on-chinas-first-carbo-neutral-city;http://www.unep.org/ClimateNeutral/Default.aspx?tabid=205; http://www.renewablepowernews.com/archives/546

[30] http://www.masdarcity.ae/; http://www.npr.org/templates/story/story.php?storyId=90042092

[31] http://www.c40cities.org/docs/casestudies/buildings/dongtan_carbon.pdf; http://www.arup.com/_assets/_download/8CFDEE1A-CC3E-EA1A-25FD80B2315B50FD.pdf; http://www.sustainablecityblog.com/2010/01/dongtan-delayed-but-not-dead/

[32] http://www.chicagoclimateaction.org/filebin/pdf/finalreport/CCAPREPORTFINALv2.pdf

[33] http://www.nyc.gov/html/planyc2030/downloads/pdf/report_climate_change.pdf; http://www.nyc.gov/html/planyc2030/downloads/pdf/progress_2008_climate_change.pdf

[34] http://www.bioregional.com/files/publications/capital-consumption.pdf

Community	Goal Statement	Goal Scope	Goal Definition	Offsets Allowed?	Supporting Analysis?
Zero Carbon Britain[35] (not an official plan)	"zero carbon" by 2030	National (considers embodied energy)	- Vision study rather than adopted plan - Zero carbon by 2030	Yes, for 10% residual emissions	Scenario analysis (REAP-based)
Clinton Climate Initiative Climate Positive Program[36]	"climate positive"	17 communities	- Strive to reduce the amount of on-site CO2 emissions to below zero.	Yes, necessarily	Limited

[35] http://www.zerocarbonbritain.com/

[36] http://www.clintonfoundation.org/what-we-do/clinton-climate-initiative/our-approach/cities/climate-positive