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Moving Toward Collective Impact in Climate Change Literacy: The Climate Literacy and Energy Awareness Network (CLEAN)

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ABSTRACT

In recent years, various climate change education efforts have been launched, including federally (National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration, National Science Foundation, etc.) and privately funded projects. In addition, climate literacy and energy literacy frameworks have been developed and deployed, and both have been reviewed and endorsed by the U.S. Global Change Research Program. This paper describes a community-based effort to promote climate and energy literacy: the CLEAN Network (originally the Climate Literacy Network). We describe results from a member survey about the importance of the network to the members' professional lives and review the development and position of the network within the larger community of climate and energy literacy stakeholders. The CLEAN Network was first formed in 2008 to support climate literacy efforts, largely through voluntary efforts. It serves as a champion and rudimentary and unfunded backbone support organization, enabling first steps toward establishing the elements necessary for successful collective impact in achieving climate literacy. Among the elements that have been described to be essential for a collective impact, the CLEAN Network most effectively provides continuous communication for the broad community of climate literacy stakeholders. The network enables its professionally diverse members to learn of one another's needs and to begin identifying mutually reinforcing activities that will address the common agenda and shared system of measures (two other key elements of collective impact) once they are established. The CLEAN Network serves as a small champion group that continues to seek input from the larger climate literacy stakeholder community on how a backbone support organization might support and extend their efforts. The next steps in a collective impact approach to climate and energy literacy include defining and forming a backbone support organization to facilitate the development of a shared agenda and a shared system of measures, which has the support of all stakeholders, that is sufficiently funded and can help mobilize funding to scale what works in climate and energy literacy. Such an organization would have collective impact that is commensurate to the challenges and opportunities climate change present to the nation. [DOI: 10.5408/13-057.1]

Key words: climate literacy, climate change, collective impact, impact of climate change, community, climate literacy essential principles, climate education, energy education, energy literacy, shared measures, backbone organization, common agenda, climate literacy activities, virtual community, community building

INTRODUCTION

Unlike most societal problems of the past, climate change is impacting and will impact a cross section of society, varying by region and community, timescales on which impacts become significant, and expertise and resources available for adaptation. Furthermore, the scale of the reductions in greenhouse gas emissions required to avert dangerous climate change will necessitate rapid and extreme conversion of the nation's and world's energy systems. Communities, organizations, businesses, agencies, educational and academic institutions, professionals, and individuals are aware of various aspects of the problems, consequences, and solutions in their field of expertise, and a plethora of activities and programs have resulted from this awareness. However, the interconnectedness of issues surrounding climate change, the interdisciplinary (e.g., Earth, physical, and life sciences and engineering) and transdisciplinary (e.g., social sciences, economics, policy, community planning, technology, media, and arts) nature of the problems and responses, and the range of expertise (researchers, engineers, community and urban planners, educators, decision and policy makers, energy technologists, architects, resource managers, lawyers, journalists and media specialists, and artists, among many others) needed to address climate change limit the impact of any of these activities and programs in isolation.

Social science research suggests that greater progress can be made in addressing large-scale societal issues when existing and active stakeholders with distinct and overlapping expertise can be assembled with a centralized infrastructure to develop a shared vision and framework for moving forward ("a common agenda") and a way to document progress ("shared measurement systems") in order to maximize the "collective impact" of the various efforts (Bryk et al., 2010; Hanleybrown et al., 2012; Kania and Kramer, 2011). This model provides a lens through which an effort can identify where it can make an impact, where collaboration and cooperation are most effective, and what external expertise or activities might be needed.

Many efforts, especially since the increase in federal support of climate change education activities between 2008 and 2013 (see Table I), address a range of audiences,

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TABLE I: Overview of the funding dedicated to climate change education by NSF, NASA, and NOAA in 2008–2013.[1]

	2008	2009	2010	2011	2012	2013	Total Investment	Funding Programs
NSF	$0	$10	$10	$10	$10	$2.6	$42.6	Climate Change Education program, Climate Change Education Partnerships
NSF	NA[2]	NA[2]	$1.7	NA[2]	$8.7	$13	$23.4	Cofunding and paying off commitments
NASA	$6.5	$7.4	$9.2	$7.2	$3	$0.8–$1	$31.1–$31.3	Global Climate Change Education Project/NASA Innovations in Climate Education
NOAA	$3.1	$7.3	$9.7[3]	$3.7[4]	$2.6[5]	NA[2]	$26.4	Environmental literacy grants[6]

[1]All values are in millions of dollars.
[2]NA = not applicable.
[3]Informal education; some climate, some ocean or aquatic focus.
[4]Informal and formal K–12 education; not all projects had climate focus.
[5]Only six of eight funded projects had climate focus.
[6]Not all funding went to climate change education.

methods of engagement, and local-, regional-, and global-scale issues. The Tri-Agency Climate Education (TrACE) Catalog (TrACE, 2014) identifies the efforts funded by three federal agencies—the National Science Foundation (NSF), National Aeronautics and Space Administration (NASA), and National Oceanic and Atmospheric Administration (NOAA). In addition, other efforts funded through other avenues address climate change issues (NRC, 2011). Each is successful in the context of the goals, missions, and visions set out by their projects and organizations. Yet the social issues surrounding climate change are so complex that the impact of these efforts in isolation is limited. What is needed is coordination that helps these isolated activities to share their resources and expertise, and leverage the resources and expertise of others, in order to achieve a collective impact across the individual networks that is commensurate to the scale of the problem and to the opportunity climate change presents society (Krosnick et al., 2006).

In this paper, we describe the background and work of the CLEAN Network. We then outline the theoretical basis for a collective impact and describe how a tiered system, with an overarching network that supports and enables diverse partner networks individually and facilitates sharing and leveraging across the partner networks, can most effectively enable a climate literacy collective impact. We then provide survey data from CLEAN Network members indicating the usefulness and impact of the network on their professional work in climate and energy education, and we profile the professional diversity of the CLEAN Network members. We reflect on the power that grassroots networks like the CLEAN Network have in moving forward to develop a common agenda that will enable a collective impact in improving understanding of and ability to address the social issues resulting from climate change. Finally, we examine the constraints that have thus far limited the ability of the CLEAN Network to become a robust and full-fledged backbone structure for the various climate change education efforts.

CLIMATE LITERACY AND ENERGY AWARENESS NETWORK (CLEAN)

CLEAN has two main components (Fig. 1). The first component, which we will refer to as the CLEAN Project, was funded through a 3-year NSF grant beginning in January 2010 and is composed of resources for educators, including (1) the CLEAN Collection, with 610+ rigorously reviewed educational resources, such as learning activities, videos, visualizations, and short demonstrations and experiments (Gold et al., 2012); (2) pedagogical support pages for teaching about climate and energy; and (3) recordings of CLEAN professional development workshops and interactive webinars. The second component is the community, including CLEAN partners, educators, resource developers, and other stakeholders, that we refer to as the CLEAN Network, which is the primary focus of this paper. All components are housed online in the CLEAN Portal (http://cleanet.org).

The CLEAN Collection is organized around the "Climate Literacy: The Essential Principles of Climate Sciences" (CLEP) framework endorsed by U.S. Global Change Research Program (USGCRP, 2009) through the National Science and Technology Council of the Office of Science and Technology Policy, and the "Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education" (ELEP) framework (Office of Energy Efficiency and Renewable Energy, 2012), which was endorsed by the 13 federal agencies of the USGCRP. The CLEP defines climate literacy (see Table II) in a way that encompasses the range of impacts on society and thus the range of climate literacy stakeholders beyond science and education. In particular a climate literate person "is able to make informed and responsible decisions with regard to actions that may affect climate"—and we would include "and may be affected by climate." In this sense, climate literacy, which encompasses climate change education, is relevant for all people—extending beyond the scientific and educational communities to those who, in the context of their professions, must make decisions that need to both account for a changing climate and consider minimizing impacts on the climate system.

CLEAN NETWORK

The CLEAN Network (formerly the Climate Literacy Network) was formed when the first version of the CLEP was being finalized in early 2008. The CLEP development was spearheaded by NOAA's Climate Program Office (under author Frank Niepold), the Cooperative Institute for Research in Environmental Science at the University of Colorado at Boulder (under author Mark McCaffrey), and the American Association for the Advancement of Science (AAAS) Project 2061 (under Ted Willard), with input from a spectrum of individuals from federal agencies, academic

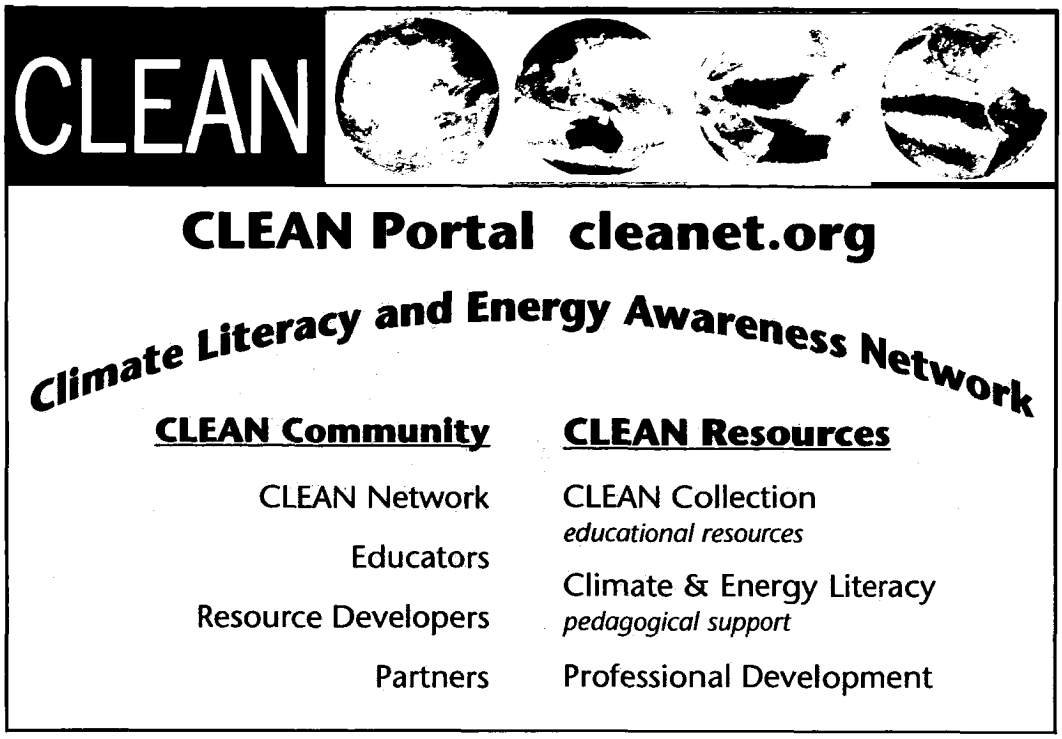

FIGURE 1: The CLEAN Portal and the components it houses: CLEAN Network (http://cleanet.org/clean/community); CLEAN educators, resource developers, and partners (http://cleanet.org/clean/community); CLEAN Collection (http://cleanet.org/clean/educational_resources); climate and energy literacy pedagogical support pages (http://cleanet.org/clean/literacy); and professional development recordings (http://cleanet.org/clean/community).

institutions, and other organizations. While the federal agencies could participate in the development of the CLEP, they could not advocate for its implementation. A group of 20 individuals who had participated in the development of the CLEP started the CLEAN Network with the initial mission of supporting the implementation of the CLEP. The CLEAN Network started with weekly teleconferences and an email list in January 2008 and has grown to more than 400 members on the email list as of May 2013, with representation from 43 of the 50 U.S. states and seven other countries. Membership in the CLEAN Network is free and open to any interested individual. Members can participate to the level that their time allows.

TABLE II: Definition of climate literacy taken from the CLEP (USGCRP, 2009).

What Is Climate Literacy?
Climate science literacy is an understanding of your influence on climate and climate's influence on you and society
A Climate Literate Person
Understands the essential principles of Earth's climate system,
Knows how to assess scientifically credible information about climate,
Communicates about climate and climate change in a meaningful way, and
Is able to make informed and responsible decisions with regard to actions that may affect climate.

The two main methods of engagement in the CLEAN Network are the email list, from which the membership is defined, and participation in the weekly teleconference. Other activities of the CLEAN Network include providing feedback on relevant national-scale documents, engagement through professional meetings, and outreach through postings on the CLEAN Facebook page.

CLEAN Network Email List

The email list is the mechanism by which members make announcements, share information, and have discussions about a variety of topics around climate and energy literacy. Figure 2 shows the monthly traffic on the email list since tracking started in September 2009 through May 2013. While quite variable from month to month, the traffic on the email list averages 77 messages per month over this period, with a steady increase over time. The topics discussed on the email list vary widely. Examples include climate of denial; extreme weather and climate change; capturing the interest of disinterested students; energy consumption and greenhouse gas inventory tools; youth-led efforts in climate change; Next Generation Science Standards (NGSS) and climate change; discussion of state bills that would allow teachers to include alternative views on evolution, climate change, and human cloning; and messaging around climate change.

CLEAN Network Teleconferences

The weekly CLEAN Network teleconferences provide an opportunity to have extended immediate discussions about

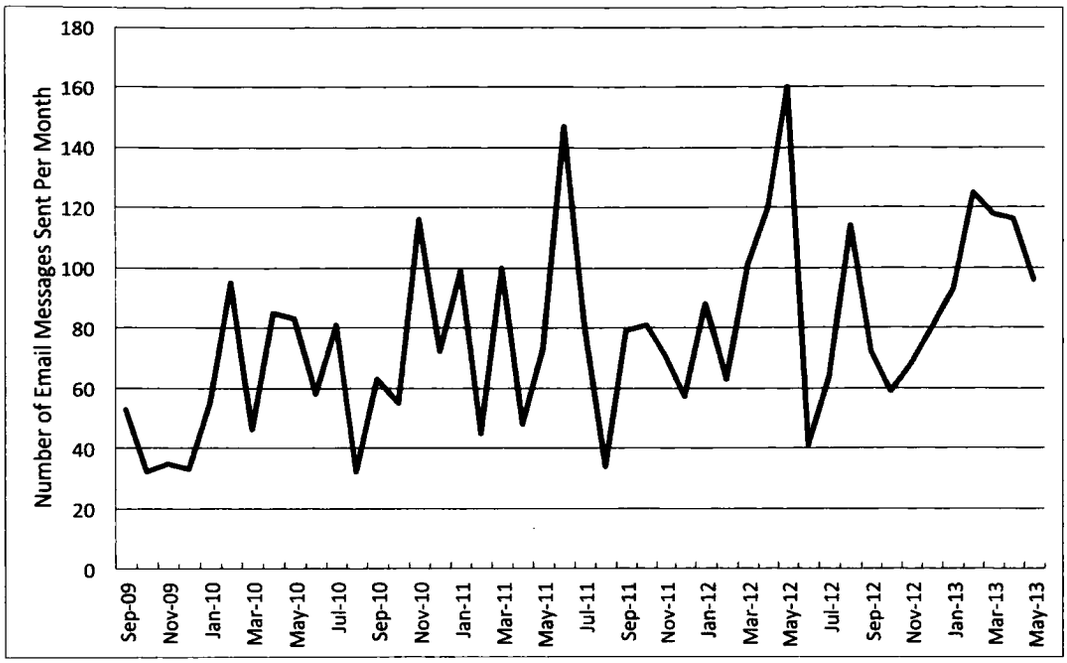

FIGURE 2: Monthly totals of messages sent through the CLEAN Network email list, September 2009 (when tracking of email traffic began) through May 2013.

issues raised in the email list or other venues. In addition to informal discussion, the CLEAN Network teleconferences are a platform for presentations by members to share expertise, get input for their efforts, explore partnership opportunities, and disseminate information about their programs. Sometimes experts are recruited to present on topics that are of interest to the members (e.g., using social media) or present on their project's progress. Abstracts, biographical sketches of presenters, and slides are posted before the presentation, and the recording is posted after the presentation for others to review asynchronously. The teleconferences occur weekly on Tuesdays at 1 p.m. ET throughout the year, and presentations are scheduled during the academic year about every other week. Figure 3 shows teleconference attendance, and Table III shows the topics of the high-attendance (>20 participants) teleconferences.

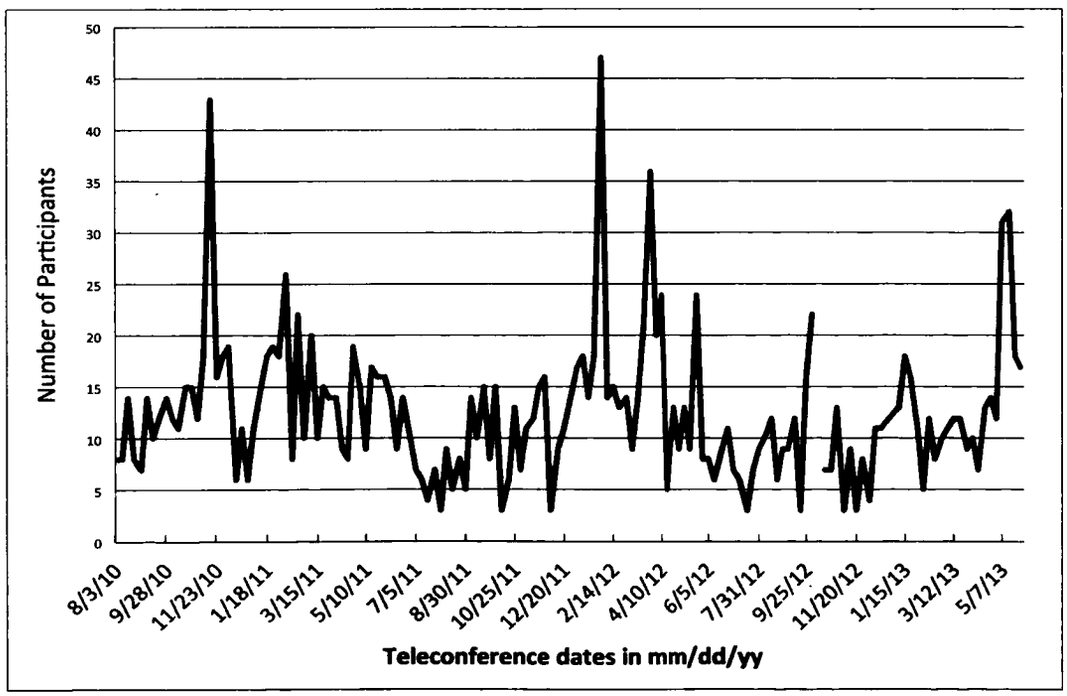

FIGURE 3: Number of participants in the CLEAN Network weekly teleconferences, August 2010 (when recording and documenting the teleconferences began) to May 2013. X-axis labels are every eighth week.

TABLE III: Topics of high attendance (>20) CLEAN Network teleconferences.[1,2]

Date	No. Attendees	Title	Presenters	Affiliation
11/16/10	43	Creation & Dissemination of Interdisciplinary Undergraduate General Education Course on Climate Change—NICE	David Blockstein	NCSE
			Andy Jorgensen	U of Toledo
			David Kitchen	U of Richmond
			Dave Hassenzahl	Chatham U
			Arnold Bloom	U of California, Davis
			Time Weston	U of Colorado
2/8/11	26	It's a Feast—NASA Climate Portal	Laura Faye Tenenbaum	NASA JPL
2/22/11	22	Wisconsin's Changing Climate: Impacts & Adaptation	Richard C. Lathrop	Science Council, Wisconsin Initiative on Climate Change Impacts
3/8/11	20	Downloadable DVD About Climate Change	Carol Landis	Byrd Polar Research Center, The Ohio State U
1/31/12	47	CLEAN: Overview & Services for CCEP-Phase II Proposals	Tamara Shapiro Ledley	TERC
3/20/12	21	Earth: The Operators' Manual Project—PBS Broadcasts, Online Videos, and Social Media	Geoffrey Haines-Stiles	Earth: The Operators' Manual
3/27/12	36	Earth: The Operators' Manual Project—Good News in Unexpected Places	Richard Alley	Pennsylvania State U
4/10/12	24	Defending Climate Change Education: Lessons Learned From the Evolution Trenches	Mark McCaffrey	National Center for Science Education
			Josh Rosenau	
5/22/12	24	NGSS Discussion for CLEAN Network—input into first draft	Tom Keller	NRC/NAS
10/2/12	22	There's NO Such Thing as a Free Megawatt: The Marcellus Shale as a Gateway Drug to Energy Literacy	Don Duggan-Haas	Museum of the Earth at the Paleontological Research Institute
5/7/13	31	Social Media: How Individuals Can Effectively Use Social Media to Receive and Dissemination Information	Emily Kellagher	CIRES, U of Colorado Boulder
5/14/13	32	Review of the Climate Science Content of Final Draft of NGSS	Frank Niepold	NOAA
			Mark McCaffrey	NCSE
			Scott Carley	College of Exploration

[1]The slides and audio recordings for each presentation and discussion are available on the CLEAN Network teleconference Web page referenced by the date of presentation (http://cleanet.org/clean/community/cln/telecon_schedule).
[2]NICE = NASA Innovations in Climate Education; U = University; NCSE = National Council for Science and the Environment; JPL = Jet Propulsion Laboratory; CCEP = Climate Change Education Partnership; PBS = Public Broadcasting Service; NRC = National Research Council; NAS = National Academy of Sciences; CIRES = Cooperative Institute for Research in Environmental Science.

Between August 2010 (when documentation of the participation in the teleconference began) and May 2013 there have been 57 presentations in 145 teleconferences with average attendance of ~13 people.

Other Efforts and Activities of the CLEAN Network

The CLEAN Network provides coordinated input when requested from the larger science education community. For example, members of the CLEAN Network individually and collectively examined each draft of the National Research Council (NRC) Framework for K–12 Science Education (NRC, 2012) and the resulting NGSS (Achieve, 2013) in 2011–2013 and provided joint input with respect to the inclusion and accuracy of Earth, physical, and life sciences related to climate science.

The CLEAN Network also has a collective presence at professional meetings such as the North American Association for Environmental Education (NAAEE), the Geological Society of America (GSA), and the American Geophysical Union (AGU). The largest presence has been at the AGU fall meetings. We have coordinated the submission of eight or nine session proposals in each of the 2011, 2012, and 2013 AGU fall meetings focused on varying aspects of addressing climate literacy. In 2013, this resulted in 11 oral sessions and 6 poster sessions with a total of more than 140 paper presentations. The collective presence of these papers in the largest professional meeting of the geosciences in North America facilitates communication among individuals representing a range of expertise and increases the visibility of the effort to the larger community present at the meeting.

TABLE IV: The five conditions of collective impact.

Common Agenda	Shared vision of change
	Common understanding of problem
	Joint approach to solving problem through agreed upon actions
Shared Measurement System	Uses data collection and results measurement that are consistent across all participants
	Ensures efforts remain aligned and all are held accountable
Mutually Reinforcing Activities	Ensures each participant's activities are seen by all as moving the common agenda forward and contributing to the shared measures of progress
Continuous Communication	Allows consistent and open communication among all participants
	Builds trust
	Enables realignment in the short term to ensure participants are pursuing mutual objectives
Backbone Support Organization	A separate organization(s) and staff with a specific set of skills is required to create and manage collective impact and serves as the backbone for entire initiative
	Coordinates participants' organizations, agencies, networks, and programs

Adapted from Hanleybrown et al., 2012.

The CLEAN Network also enables members to develop collaborations. These have resulted in numerous grant proposals and program development projects and have facilitated deep strategic thinking and research synthesis. In addition, broader outreach beyond the CLEAN Network email list is conducted through posting on the CLEAN Facebook page (http://www.facebook.com/CLEANET).

COLLECTIVE IMPACT

The societal issues surrounding climate change are so complex that the impact of the many diverse individual efforts in isolation is limited and a cross-societal effort is needed to achieve significant change. A collective impact requires setting a common agenda, developing shared measurement systems to assess progress, determining mutually reinforcing activities, enabling continuous communication, and establishing a backbone support organization (Kania and Kramer, 2011 and Table IV).

Examples of successful collective impact efforts range in scale and goals (Hanleybrown et al., 2012). An example at the local scale is the Communities That Care Coalition of Franklin County and the North Quabbin effort in Western Massachusetts that is focused on reducing teenage binge drinking. This effort, encompassing 30 municipalities, involves ~200 representatives from a range of social services, local government offices, businesses, community members, parents, and youth who are organized through a coordinating council into three working groups. In 8 years they have reduced teen binge drinking in their region by 31%. An example of successful impact at the global scale is the Global Alliance for Improved Nutrition, which has helped to reduce nutritional insufficiencies among 530 million people in 30 countries. This effort has coordinated the activities of 36 large-scale collaborations that include a range of stakeholders and service providers. While each of these efforts is complex, the issues that they are addressing are relatively focused compared to the issues presented by climate change. However, developing the common agenda and shared measurement systems for these more focused efforts was a long and difficult process.

The scope and scale of addressing the causes and impacts of climate change are complex, involving a range of audiences and spatial and temporal scales, as well as societal infrastructure and activities, so the difficulty of developing a common agenda with buy-in from all stakeholders is magnified. The common agenda that needs to be developed to effectively address the societal impacts of climate change will need to encompass the diversity of interests and needs of this range of audiences and communities, as well as provide the focus that enables all stakeholders to effectively engage in and contribute to improving climate literacy and addressing the effects of climate change.

What is needed to increase the impact of each of the individual networks is a coordination that enables sharing, leveraging of resources and expertise across networks, and scaling of these programs to wider impact. Coordinating individual activities and sharing materials, best practices, and expertise of individuals within the individual networks, as well as the organizational effort, are needed to develop and implement a common agenda and shared measurement system and to identify the mutually reinforcing activities. This kind of coordination can be done by an overarching network (an overarching backbone support organization) that enables a network of individual or partner networks to attain their goals. Each partner network would need its own backbone support organization to coordinate its efforts, and an overarching backbone support organization could provide services to support each partner network. Some of these services might help the partner network develop their common agenda and shared system of measures of progress, identify and secure sources of funding, identify synergies where some partner networks could more effectively work together, and match resources and expertise in partner networks that can be mutually beneficial.

Hanleybrown et al. (2012, p. 3) describe three preconditions before a collective impact effort is launched: "influential champion or small group of champions, adequate financial resources, and a sense of urgency for change." Here, we explore the CLEAN Network as comprising that small group of champions (although additional influential champions and adequate funding are needed) and the possible rudimentary beginnings of the overarching network that is working toward enabling individual activities to become more effective and coordinated. A fully funded overarching network will enable

TABLE V: Responses to the survey question "What CLEAN Network activities are you aware of?"

Activity Category (specific activity)[1]	Responses in the Activity Category
Email list (email list archive)[2]	71%
Teleconferences (presentations, informal discussions)	88%, 93%
Coordinated presence at professional meetings (session and presentation coordination, social gatherings)	84%, 54%
Input into the development of the NGSS (framework, drafts of NGSS)	68%, 78%
Input into development of literacy documents (CLEP, ELEP)	65%, 53%
CLEAN Facebook page	48%

[1]The items in parentheses correspond to each of the listed percentages on the right.
[2]Because respondents received the link to the survey via the email list, we did not ask explicitly about their awareness of the email list.

collective impact to improve climate literacy, not only within the scientific and educational communities but for all professionals and citizens who must consider the impact of a changing climate in their planning and decisions, as well as how those decisions might impact climate.

We see some of the elements needed for collective impact in the activities of the CLEAN Network, especially in the areas of enabling continuous communication, engaging a professionally diverse membership, and providing some coordination. However, a first step toward a common agenda is the development of a common or shared language by all stakeholders to address the needs and values of everyone. The CLEAN Network is enabling continuous communication, and thus helping the development of a shared language, through an active email list, weekly teleconferences since January 2008, and the convening of numerous sessions at science and educational conferences to share and learn from the communities' experience and research findings. Over the past ~5 years, this has enabled the sharing and leveraging of experience, expertise, and resources across professionally diverse stakeholders and communities. We are now working to get broad input into what services, coordination, and support an overarching network might provide to partner networks that would help them be more effective and broaden their impact. This is an early step in establishing the preconditions for the implementation of a climate literacy collective impact.

REACH AND IMPACT OF THE CLEAN NETWORK

CLEAN Network Survey Instrument and Analysis

In order to create a measure of the CLEAN Network's value to its members and to determine the activities members are involved in, we conducted a survey of the members in spring 2013. The survey instrument included 19 questions covering the following four topics: (1) awareness of the CLEAN Network, (2) use of and participation in the CLEAN Network, (3) personal information about the respondent, and (4) future activities for the CLEAN Network. Fourteen questions provided multiple-choice answer options, as well as an opportunity for open-ended comments for most of these questions; two questions contained a response matrix; and three questions were open ended. The questions were reviewed and refined after feedback from other members of the CLEAN Network leadership and a professional evaluator.

The survey was administered online using the SurveyMonkey platform. The invitation for participation in the survey was sent out via email through the CLEAN Network email list. The survey was open from March 18 through April 8, 2013 (membership in April 2013 was 387) with reminders being sent out to the email list periodically. All respondents were asked to fill out a consent form that was approved by the Institutional Review Board of the University of Colorado at Boulder. A total of 119 respondents signed the consent form and answered at least one survey question, and 116 respondents answered a majority of the questions, representing a 30% response rate (assuming every person on the email list saw the invitation).

Prior to analysis, responses were anonymized. The responses were analyzed using basic descriptive statistics. The open-ended questions were analyzed using basic qualitative data descriptions through coding of answers. Profiles of the professional background and interest of respondents were derived by combining responses to multiple questions for individuals.

The results of the survey described below represent the engagement and characteristics of those who participated. It is recognized that this is a self-selected group and not a random sample in that those who responded to the survey are probably more likely to be reading the messages that come through the email list and are more likely to be engaged in CLEAN Network activities. However, the results reflect the involvement and value of the CLEAN Network to those who are most engaged.

Results and Discussion of the CLEAN Network Survey

Engagement of Members in CLEAN Network Activities

As described above, the CLEAN Network email list and teleconferences are the two main avenues for communication in the CLEAN Network. In addition, the CLEAN Network hosts a Web site with information about presentations and other network activities.

In the survey, we first explored the activities of the CLEAN Network of which the members were aware. These fell into a number of categories, including the email list, teleconferences, coordinated presence at professional meetings, providing group input into the development of the NGSS, involvement in the development of literacy documents, and the CLEAN Facebook page. Table V shows the level of awareness of the CLEAN members to each of these activities. There is a high level of awareness of the main ongoing activities (email list and teleconferences), as well as most ongoing but intermittent activities (i.e., coordinated presence at professional meetings and input into the NGSS).

The proposal that resulted in the funding for the CLEAN Collection mentioned above grew out of the discussions of the CLEAN Network. However, because the CLEAN Collection was created before many CLEAN Network members joined, we explored the level to which the CLEAN Network members were engaged with the CLEAN Collection. This is shown in Table VI. Given the small number of CLEAN Network members involved in building the CLEAN

TABLE VI: Responses to the survey question "How have you interacted with the CLEAN Collection project?"

Activities Indicating Engagement With CLEAN Collection[1]	Responses Indicating Participation
Used a resource (own use, use with students)	41%, 41%
Referred someone to CLEAN Collection	51%
Submitted a resource for inclusion in CLEAN Collection	22%
Involved in the CLEAN Collection review process (conducted individual review, served on CLEAN review panel)	16%, 16%

[1]The items in parentheses correspond to each of the listed percentages on the right.

Collection, the moderate level of awareness and engagement was to be expected.

In order to understand how members are involved with the CLEAN Network we looked more deeply into the extent to which they use the email list and participated in the teleconferences. We asked the extent to which (frequently, sometimes, rarely, or never) they read messages, respond to messages, and post messages on the email list. A total of 85% of the respondents indicated that they read email list messages frequently, and 14% indicated that they sometimes do, accounting for 99% of the respondents. The numbers are lower for both responding to and posting new messages, with 31% indicating that they respond to email list messages and 21% indicating that they post new messages either frequently or sometimes.

In addition, we explored how often CLEAN Network members call into the teleconferences. The time constraints inherent in participating in a teleconference impact the level of participation. Many participants mention in their comments that they would like to participate but are either not available at that time or cannot spare the hour to call in. However, 16% of respondents indicated they call into the teleconference once or twice per month, 41% call in at least once every few months, and 64% call in at least once a year.

Figure 4 illustrates the frequency of participation in the teleconferences as a function of engagement with the email list. For each level of participation in the teleconferences, individual respondents were given a rank for how often they (1) read the email list messages, (2) respond to email list messages, and (3) post new email list messages. The comparative ranks of engagement (frequently = 3, sometimes = 2, rarely = 1, and never = 0) in each of these

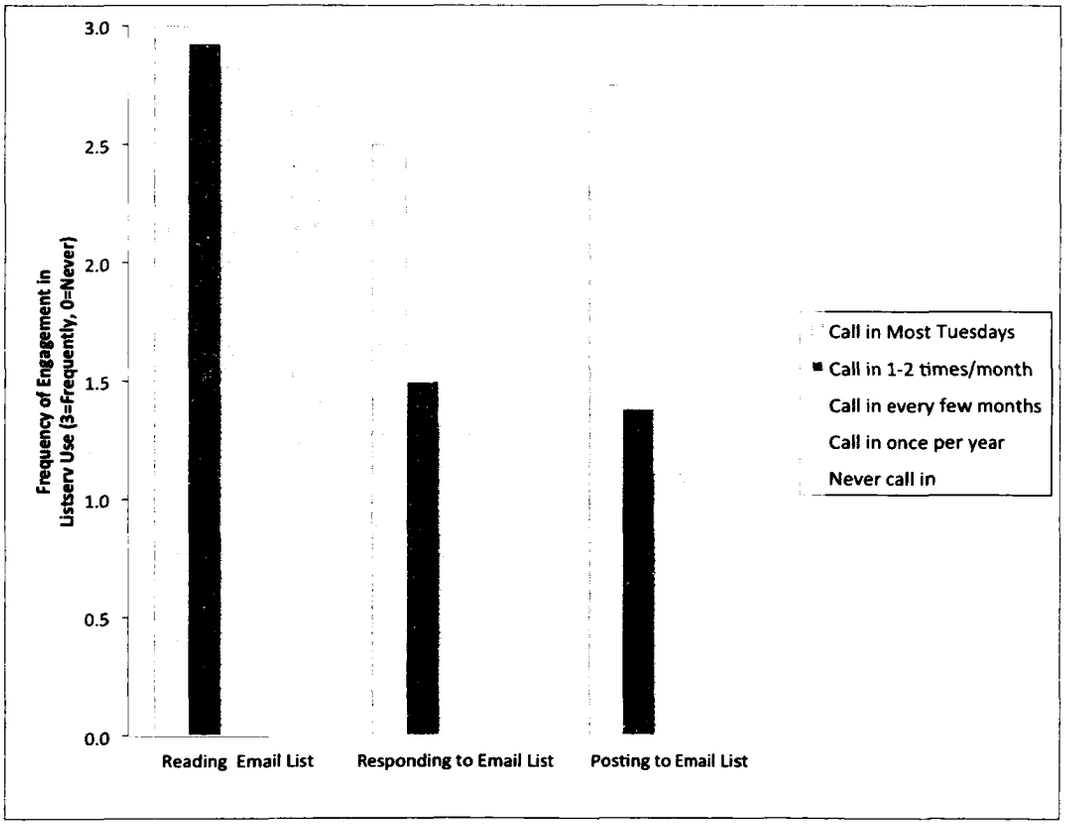

FIGURE 4: Relationship between survey respondents' email list use and participation in the weekly teleconferences. Respondents' level of use of the email list is weighted by their frequency of engagement in the teleconferences plotted for all levels of email list use. Respondents indicated, for each activity with the email list, their level of engagement from the following choices: frequently = 3, sometimes = 2, rarely = 1, and never = 0. The rankings were averaged over each category of participation in the teleconferences. For each email list activity (cluster of bars), the bars indicate the level of participation in the weekly teleconferences. From left to right, the respondents call in most Tuesdays, call in 1–2 times per month, call in every few months, call in once per year, and never call into the teleconferences.

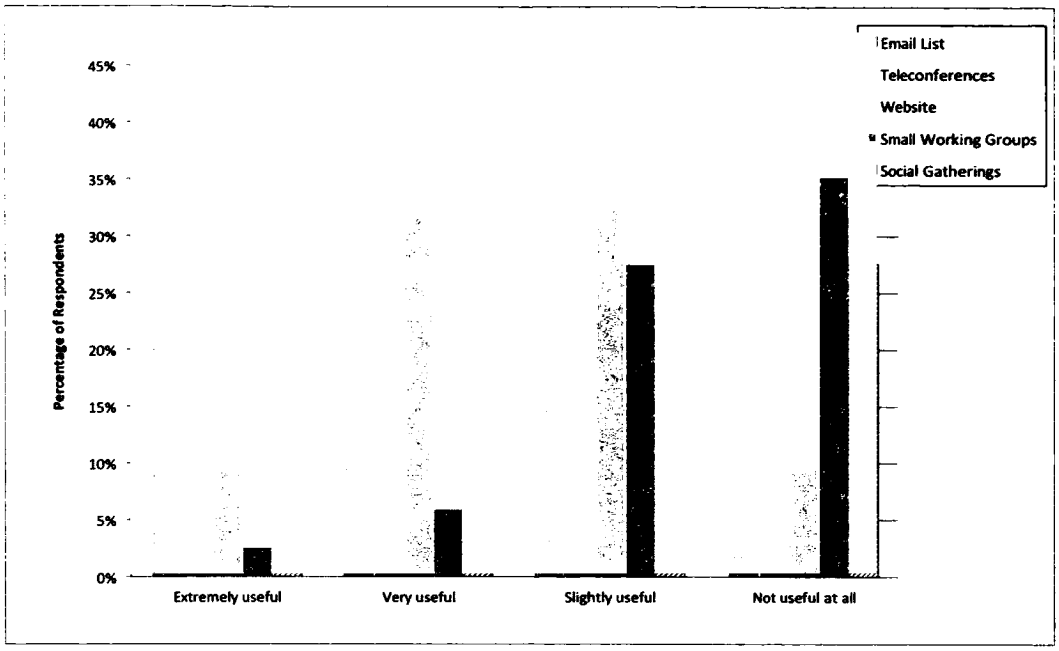

FIGURE 5: Usefulness of tools and activities of the CLEAN Network as reflected in member survey responses. In each category of usefulness, the tools and activities from left to right are the email list, teleconferences, web site, small working groups, and social gatherings.

activities was assigned, and based on these numbers, a rough comparison of engagement level of the group was calculated. We then averaged those rankings for each type of engagement with the email list and for each level of participation in the teleconference.

Figure 4 shows that those who call into the teleconferences frequently also read, respond to, and post messages to the email list and that across all levels of participation in the teleconferences (including never participating), the frequency of reading email list messages remains high. Thus, the two methods of ongoing engagement of CLEAN Network members are an effective mechanism of continuous communication as called for in enabling effective collective impact.

We also explored the usefulness of each of the CLEAN Network activities to its members (Fig. 5). A total of 81% found the email list either extremely useful or very useful, and 96% found it useful at some level; 49% found the teleconference discussions either extremely useful or very useful, and 75% found them useful at some level; and 79% found the Web site useful at some level. Respondents found the subgroups and social gatherings less useful. Since participating in subgroups and social gatherings requires addition teleconferences and/or travel, this probably reflects the fewer number of members who engage in those activities.

TABLE VII: Responses to the survey question "What have you used your involvement in the CLEAN Network for?" Multiple responses could be entered.

Activity Category	Responses in the Activity Category
Networking	47%
Discussing science or policy topics	45%
Discussing teaching ideas	38%
Getting input on an issue my organization or project is dealing with	28%
Posting/publicizing events or publications from your organization	27%
Community support	24%

Uses of the CLEAN Network by Members

One of the purposes of continuous communication is to enable members of a diverse community to begin understanding one another's efforts and move toward discussions that will facilitate the development of a common agenda for collective impact. The level of engagement of CLEAN Network members in the discussions and activities facilitated by the email list and teleconferences indicates that individuals found that these resources help move their work forward. To explore this further, we asked the purpose for which the members use the CLEAN Network. Table VII shows the distribution of responses to the provided options.

Furthermore, 26% of respondents provided additional information. A total of 14% of respondents said that they used the CLEAN Network for their professional development and for information, 5% of respondents valued the sharing that occurs on climate education, and another 5% of respondents value information about climate change educational resources. Others mention gaining insights into current discussions, hearing the viewpoint of educators, getting up-to-date information on climate research, connecting to others, and identifying advisers as beneficial to their work.

Thus, CLEAN Network members, who mainly engage with one another virtually, see a range of benefits, with those that focus on networking, sharing scientific and educational information, getting input for their efforts, and leveraging

TABLE VIII: Professions represented in the CLEAN Network based on survey results from 116 respondents. Multiple professions could be entered. All options in the survey are listed.

Profession Option	Responses in the Profession Option
Formal education—K–12	14%
Formal education—higher education	34%
Informal education	41%
Professional development provider	40%
Curriculum developer	35%
Scientist	33%
Public health specialist	1%
Social scientist	13%
Psychologist	1%
Economist	2%
Urban planner	1%
Artist	4%
Media specialist/journalist	7%
Social media specialist	4%
Technologist	2%
Lobbyist	0%

efforts being among the most important. When asked what the importance of the CLEAN Network was to their daily work, 41% indicated that the CLEAN Network was either essential or very important and 96% felt it was important at some level. In addition, 72% indicated that they have encouraged colleagues to join the CLEAN Network.

Professional Diversity of CLEAN Network Members

As described earlier, effectively addressing the societal issues arising from the impacts of climate change will require the interdisciplinary and transdisciplinary input from individuals and groups with a range of expertise. If the CLEAN Network is to be an effective mechanism to enable a positive collective impact on the climate literacy of the public and on the effects of climate change on society, then it must reflect that professional diversity.

Table VIII shows the professional diversity of the CLEAN Network as indicated by the survey results for the 16 listed professional options. In an open comments box, there were numerous clarifications about the CLEAN Network members' professions. Some of the professions named in the open-ended comments include change agent, historian, policy analyst, research and policy, government agency, and outreach coordinator. Overall, more than 20 professions are currently represented in the CLEAN Network.

Another way to look at the professional diversity of the CLEAN Network members is to examine the range of professional societies they represent. Survey respondents indicated all suggested professional societies they belonged to and then indicated additional professional society memberships in an open text box. Table IX shows the percentage of survey respondents who belong to the nine specified professional societies and those identified by more than one respondent in the open text box. The survey results show that the CLEAN Network has representation from ~60 professional societies. The societies that have the largest representation, as shown in Table IX, are the science professional societies (AGU, AAAS, AMS, and GSA) and science education societies (NAAEE, NSTA, NAGT, and NESTA). Examples of the range of other professional societies that are represented by CLEAN Network members include the Academy of Management, American Horticultural Society, Association of Natural Resource Extension Professionals, Association of Performing Arts Presenters, Center for Applied Special Technology, International Association of Energy Economists, Teachers of English to Speakers of Other Languages, and U.S. Green Building Council.

TABLE IX: Professional societies represented by at least two CLEAN Network survey respondents.

Professional Society	Responses for the Professional Society
American Geophysical Union (AGU)	42%
North American Association of Environmental Education (NAAEE)	31%
National Science Teachers Association (NSTA)	30%
American Association for the Advancement of Science (AAAS)	16%
American Meteorological Society (AMS)	14%
Geological Society of America (GSA)	12%
National Association of Geoscience Teachers (NAGT)	9%
National Earth Science Teachers Association (NESTA)	9%
Council of State Science Supervisors	3%
American Chemical Society[1]	3%
Association of American Geographers[1]	3%
Ecological Society of America[1]	3%
National Association for Research in Science Teaching[1]	3%
American Educational Research Association[1]	2%
National Association for Interpretation[1]	2%
American Society for Engineering Education[1]	2%

[1]Society not identified specifically as an option—added by respondents.

While the professional diversity of the CLEAN Network as reflected in the survey responses is weighted toward science education and climate relevant science communities, it includes a small but important group of members who represent other important stakeholders that are needed to effectively improve climate literacy and address issues raised by a changing climate. The CLEAN Network needs to increase the participation of the larger range of professionals and citizens (beyond scientists and educators), because improving their understanding of climate change and the implications that it has for the decisions they must make, as well as the impact of their decisions on the climate system, is

extremely important to effectively address the challenges presented by climate change.

THE CLEAN NETWORK: A FIRST STEP TO ENABLING COLLECTIVE IMPACT

Large-scale societal issues require the collective impact of individuals and groups with a range of expertise and capabilities to be successfully addressed. The effects of climate change vary widely in time and space, as well as in the expertise required to address them. Therefore, a large-scale collective impact is needed that integrates effective climate and energy literacy efforts for educators and scientists, as well as all professionals and citizens who need to address the implications of climate change in their decisions. Through its activities, the CLEAN Network is providing, to varying degrees, the first steps toward establishing the elements necessary for enabling successful collective impact in addressing climate and energy literacy and the associated societal problems resulting from climate change.

The collective impact element that is most robustly being addressed by the CLEAN Network is continuous communication. The weekly teleconferences and active email list have been shown, through the survey results, to be of great value to the members in moving their work forward. They allow for the sharing and leveraging of resources and expertise to address specific efforts, the development of partnerships to address emerging issues, and the development of a common language that will help enable the development of a common agenda and shared system of measures to improve climate and energy literacy and associated issues. However, the continuous communication through the email list and weekly calls, while supporting the efforts of those involved, does not meet the needs of the community, which is made up of hundreds of projects and thousands of practitioners that need to be reached and supported.

Setting a common agenda and defining a shared system of measures to identify progress is a long process that requires contributions and acceptance by an extensive list of stakeholders. In the case of improving climate and energy literacy to successfully enable society to effectively address climate change, it is suggested here that a tiered system with an overarching network that supports, facilitates, and enables partner networks—each addressing specific issues of concern to locally, regionally, nationally, or potentially globally focused audiences—is needed. As described above, the professional diversity of CLEAN Network members—while still needing to expand significantly—is beginning to reflect the range of expertise needed for a collective impact in climate and energy literacy and for mitigation and adaptation to a changing climate. Through the CLEAN Network's mechanisms of continuous communication, its professionally diverse members are learning of the needs of others and where their expertise might make the critical difference in helping individual efforts move forward. This is the first step in identifying mutually reinforcing activities that will address the common agenda and shared system of measures once they are in place. In addition, the CLEAN Network's mechanisms of communication are enabling the beginning of the collection of the shared needs of these diverse networks and activities.

Through these activities, the CLEAN Network serves as a small champion group, identified as one of three preconditions of collective impact. The CLEAN Network is a grassroots effort established by the needs of its members. It is now seeking input from as many climate literacy stakeholders as can be engaged on what an overarching backbone support organization might do to support and extend their efforts. However, the structure and activities of a backbone support organization thus far have not been defined, and no formal strategic plan to develop a common agenda has been attempted by the CLEAN Network. Significant additional financial support will be needed to build the necessary membership, partnerships, and activities and to successfully develop and implement a common agenda and shared system of measures for the overarching network, as well as to enable that network to support its partner networks. Furthermore, the partner networks need significant support to sustain and scale successful programs to address both the challenges and the opportunities presented by climate change.

There are challenges to developing and implementing the elements of successful collective impact. One of these challenges is the process of competitive grants through which most educational and scientific research efforts are supported. A key attribute of a backbone organization is the ability to help mobilize funding. Although the CLEAN Network has served to help identify funding opportunities from primarily federal grants, it has not been able to secure funding for the backbone organization, which is a key constraint that many collective impact efforts face (Strive, 2013).

In a competitive funding environment, individuals and groups that see opportunities to secure funding for their climate and energy literacy efforts through the grant process will not share their ideas, efforts, and plans in order to maintain a competitive advantage. This was most clearly seen during the CLEAN Network teleconference on January 31, 2010, titled "CLEAN: Overview & Services for CCEP-Phase II Proposals" (see Table III). This presentation was focused on the review services offered by the CLEAN Collection team to groups as they were developing proposals. This presentation was of significant interest to the broader climate change education community and had the highest attendance of any CLEAN Network teleconference (47 participants, see Fig. 3). While discussions on most other CLEAN Network teleconferences are quite active, there was strikingly little discussion or sharing of information during this one. Clearly, it is important to assure that work that is government funded is of the highest quality and effective; however, mechanisms to enable ongoing collaboration and leveraging of efforts are needed. In order to avoid conflicts between the interests of the overarching network and the partner networks, we suggest that the overarching network not compete in specific funding opportunities with the partner networks.

Despite these obstacles, the CLEAN Network will continue to build toward effective collective impact to "Enabl[e] society and the next generation to understand, address, and solve pressing local to global challenges presented by climate and global change" (AGU Workshop, 2013).

Input from the survey respondents will guide our efforts, as will the ongoing discussion of what the overarching

network can do to support the partner networks and their activities. Most survey respondents indicated that they appreciate the efforts of the CLEAN Network and supported continuation of the current activities. Additional activities that were suggested include connecting to policy makers, engaging the sustainability community, tracking and extending the reach of the network, offering more professional development for teachers, and working on a strategic framework for programs (in other words, developing the elements of collective impact).

The attributes of an effective backbone support identified by Turner et al. (2012) include six common activities that the support organization helps lead over the lifecycle of an initiative: (1) guide vision and strategy, (2) support aligned activities, (3) establish shared measurement practices, (4) build public will, (5) advance policy, and (6) mobilize funding. Because the CLEAN Network has thus far been almost entirely volunteer driven with little funding to conduct these activities, its ability to effectively pursue them has been limited. In order to achieve greater collective impact, the network will need to more closely evaluate the needs of the community, build capacity of the community to clarify the common agenda, and secure funding to pursue the initial work, as well as the cumulative goals identified through the process.

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