**Climate-Safe Infrastructure Working Group**

**Meeting #3**

**March 13, 2018, San Francisco**

**Meeting Summary**

**Introduction**

This meeting summary provides succinct highlights of the meeting discussions, decisions made and progress on the Working Group’s efforts, as opposed to detailed meeting minutes. The meeting agenda and meeting presentation provide additional information on the contents of the meeting.

This meeting was the second gathering of the Climate-Safe Infrastructure Working Group (CSIWG or WG for short). Its primary goals or tasks were fourfold, namely to:

* **Task 1**: Assess possibilities and limits for linking forward-looking climate science and impacts information with standards, codes, certifications throughout infrastructure life cycle
* **Task 2**: Identify information gaps/research needs
* **Task 3**: Identify barriers to information use and possible ways to work around or overcome them
* **Task 4**: Explore approaches to select appropriate engineering designs in light of a range of different climate futures

The key outcomes around each of the meeting goals are summarized. A review of the overall progress of the Working Group along its self-defined goals are summarized first.

**Progress on Project Goals**

In Meeting 1, the CSIWG determined goals and sub-objectives they wish to achieve over the course of the project. We note them here with progress made since that first meeting.

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| **Project Goal Areas (Developed in Meeting #1)** |
|  | **TRACKING PROGRESS** |
| **GOALS** | **Post-MEETING #3 - March 2018** |
| **Orient toward longer-term outcomes (Vision, indications of success over time)** |
| **Intended Long-term Outcome (therefore work toward recommendations that…)** | Brainstormed long-term outcomes of the work of the CSIWG (as indicators of success over time) |
| State agencies lead by example (…show clearly what the state can do immediately and over the medium- and longer-term). | WG members, several representing state agencies, discussed the infrastructure and related standards, codes, guidelines they use to plan and design infrastructure; they also identified barriers to using forward-looking climate science and brainstormed ways to overcome them. This is a first step toward recommendations to state agencies. |
| Serve as example for the rest of the country (…illustrate what barriers there are and how they could be overcome; provide examples of progress wherever possible). | The AB2800 process involves a webinar which is attended occasionally by non-CA-based interested stakeholders. Interactions with non-CA-based infrastructure experts indicates that they are closely observing what this process will yield. Facilitators made a presentation to a federally convened water-focused adaptation working group to share AB2800/CSIWG process and experiences, which was extremely well received.  |
| Resiliency is embodied in codes (… address the entire infrastructure planning, design, financing, implementation, monitoring and reassessment cycle, and use codes/standards and non-standard strategies to affect resilience). | WG identified relevant codes, standards and guidelines to in the future need to reflect resiliency goals; the WG also advanced toward a common understanding of resiliency, climate-safety, and the infrastructure systems to focus on. |
| Widely accepted climate change standards (… set up a sustained process for engaging, training engineers; and make uptake of new standards and guidelines more likely). | During WG proceedings and in the webinar series, experiences, tools, best practices and guides are collected on an ongoing basis. |
| Codes and standards are correctly implemented and used (… focus on the development and use of forward-looking science in infrastructure building as well as on implementation). | The WG invited a panel of SF Bay Area practitioners to better understand how they make decisions in light of uncertain climate futures. Insights gained help understand incentives and barriers to account for climate change in infrastructure planning. |
| Sustainable, resilient and safe buildings in a real-world social context (… reflect an understanding of the systems being designed/redesigned as social-economic-ecological-technical systems). | The WG reaffirmed its focus on infrastructure systems, rather than on isolated physical or technological structures. |
| **Produce a set of outputs by July 1** |
| Complete a report (core elements and text) that: | WG continued discussions on the level and contents of what the report should include, collected content and refined ideas. |
| … includes concrete recommendations for updating design codes. | WG continued its discussion of inclusion of climate change in all stages of the infrastructure design and upgrade process through an interactive exercise in Meeting #3. |
| … provides useable, tangible tools, techniques, guidance for people to operationalize recommendations. | Meeting discussions, panel contributions and webinars continue to surface useful tools and data platforms. |
| … offers technical and policy guidelines. | The importance of policy recommendations was reemphasized as part of the discussions in Mtg#3 |
| ... provides a path for how to implement the measures recommended. |  |
| … offers recommendations that are robust, credible and actionable.  |  |
| … is written for people who may be skeptical about integrating climate change science into engineering practice. |  |
| **Provide clear policy guidance for near-term and longer-term decisions** |
| Ensure that the Report includes overarching policy recommendations which: | Reiterated the importance of policy recommendations |
| … emphasize the importance of policy guidance. |  |
| … address the near-term opportunities of $billions of infrastructure-spending in CA. |  |
| … convey that engineers have a responsibility to create safe buildings and communities. | Progress was made on a shared understanding of resilience and climate safety. The importance of liability, which is linked to standards, has also been noted. |
| … seriously consider environmental justice. | WG members continue to emphasize the importance of recognizing legacies of past infrastructure decisions and the uneven benefits accrued by different communities. |
| .. model how to inform decisions by science and robust evidence. | The continuing webinar series, Mtg#2 discussions on inclusion of forward-looking climate science needs, and Mtg#3 panel on the actual use of forward-looking science in practical decision-making is helping the WG to better understand opportunities, barriers and limits. |
| **Address key issues for science & the science-practice interface** |
| Ensure that the Report: | Building on items identified in Mtg#1 and refined since, the WG is continually gathering report input |
| … Identifies vulnerable/critical infrastructure. | Homework sent to WG members after Meeting #1 is being completed for each sector |
| … Identifies critical information needs of engineers. | WG focused in Mtg#2 and #3 on forward-looking climate science needs and how it is being used. |
| … looks at variety of time scales over which decisions are made. | WG members recognize that time scales (design life, infrastructure life span, life cycles, planning horizons, frequency with which codes/standards get updated) vary by type of infrastructure and level of governance. |
| … Defines priorities for future research / understanding and information gaps. | WG members are beginning to identify research needs; work is ongoing |
| … Identifies ways to integrate changing science into durable designs. | WG completed exercise looking at ways of including consideration of climate change throughout the design life cycle. |
| … Describes a process for selecting engineering designs for a range of climate scenarios. | WG completed exercise looking at ways of including consideration of climate change throughout the design life cycle. |
| … Identifies barriers to integrating science into standards and design. | Homework completion ongoing to collect this information; case studies presented in Mtg #3 further advanced understanding of barriers, as did the panel discussions |
| … Provides guidance and examples for how to connect cutting-edge, forward-looking science to practice. | Examples are integrated into the WG’s deliberations through the webinar series, and case studies discussed in Mtg #3; additional case examples provided through panelists’ contributions |
| … Addresses the need for ongoing monitoring of projects so as to collect evidence on how new guidelines are working. | WG members have highlighted the importance of ongoing monitoring to validate data and to assess performance. |
| **Focus on engagement during and after the life of the Working Group**  |
| Reach out to public throughout CSIWG's process. | Organizing of webinar series is ongoing; formal public comment opportunities during each meeting; public was invited to actively participate in discussions with WG members in each WG meeting to date; project team is building growing listserv of interested stakeholders; CSIWG members invited to send names to add and spread the word about the CSIWG. |
| Seek input from and reach out to people implementing resiliency/sustainability measures in practice. | Speakers invited to ongoing webinar series offer illustrative examples. Recruitment of external speakers to future webinars is ongoing. WG and other stakeholders have sent suggestions for future webinar speakers. |
| Focus on owners/investors of state infrastructure but assume a much broader audience (non-state-owned infrastructure, engineers and decision-makers everywhere in CA and beyond). | Focus is subject to ongoing WG deliberations; overall agreement to focus on state-owned, state-regulated, and state-financed infrastructure, but to assume a broader audience. Desire for state to lead by example, serve as model, and incentivize others  |
| Ensure that report is not just for the State legislature and Strategic Growth Council but speaks directly to engineers so they can begin implementing what is being recommended for practice. | Intention is for report to include list of tools and platforms |
| Initiate or recommend the creation of a platform and sustained, adaptive process (beyond the life of this WG) to facilitate ongoing/future science-engineering communication/interaction.  | Intention is for report to include list of tools and platforms; deliberations of recommendations only begun |
| **Embody a set of principles and values throughout the Working Group’s work** |
| Reflect what we want CA government to be. | Meetings are open to the public and widely advertised; provided multiple opportunities for public input and direct engagement at each meeting between WG members and attending public. Group process transparent to all. Meeting materials shared publicly well in advance of each meeting. Post-meeting summary notes and other related materials also shared on CNRA website. WG deliberations are multi-disciplinary and provide direct opportunities for exchange between scientists, practitioners and public. |
| Ensure we take social, behavioral, economic dimensions into account in recommendations (not just physical science and engineering approaches). | CSIWG membership and project team membership embodies this range of expertise. Social science information needs are part of ongoing work of WG. |
| Contribute experience and learn from all others, (e.g., status of climate science, how real-world infrastructure decisions gets made). | Members expressed their appreciation for the diversity of expertise around the table. Diversity of expertise and perspective shared in WG meetings and webinars. Local example of changing building codes/designs was presented in Mtg #2. Practitioner panelists included in Mtg #3.  |
| Form new relationships. | Relationship building process well underway. Frank discussions among WG members indicate growing trust. Each meeting offers opportunity for informed exchange as well as in-depth break-out group and whole-group discussions. |
| Work toward solutions for social systems. | WG continues to emphasize the importance of defining infrastructure systemically. |
| Work toward real results with everyone. | WG members continue to emphasize real-world context in which decisions need to be made. |
| Meet public responsibility to meet design life expectations of expensive infrastructure. | Expressed intent of the WG, reflected in definition of climate-safety and resilience. |

The Facilitation Team summarized project goals regarding the final product into a set of project findings and project recommendations. While not yet constituting a report outline, this list provides reminders of the work already done and yet to be completed.

List of categories of project findings:

* The **infrastructure considered** in the work of the WG
* **Opportunities for state to affect how and where infrastructure is built**
* **Opportunities for integrating science into infrastructure design**
* **Critical information needs of infrastructure engineers** to address CC impacts.
* **Critical information gaps**
* **Informational and institutional barriers** to integrating projected climate change impacts into state infrastructure design
* **Considerations of a platform or other ways** to facilitate science-engineering interactions
* **Ways to select an appropriate engineering design** for a range of future climate scenarios as related to infrastructure planning and investment.

List of categories of project recommendations:

* **Policy recommendations** of how to encourage forward-looking infrastructure planning and design
* **Procedural recommendations** to affect climate-safe infrastructure development process (from planning, design, approval, construction to monitoring)
* **Principles** to guide infrastructure development, maintenance, repair to build equitable, climate-resilient infrastructure
* **Available tools and information sources** to use
* **Recommendations on how to lower/overcome barriers** to information use
* **Research recommendations** to fill information gaps
* **Recommendations on capacity building/professional development**

The focus of this meeting was to fill in and deepen discussion on several of these items (highlighted in blue).

**Possibilities and limits for linking forward-looking climate science and impacts information with standards, codes, certifications throughout infrastructure life cycle**

CSIWG member, Noah Diffenbaugh, provided comments on the climate information needs identified in Meeting #2 and through the homework. He acknowledged limits to what climate science can provide, but urged these limits not to lead to complacency, given how much in general trends is already well understood:

* Historical trends/observations suggest we are already living in a different climate than 50 years ago (and this is consistent with near- and longer-term expectations of future climate change)
	+ Longer droughts, primarily driven by temperature
	+ More extreme run-off; wet years also increasing
	+ More extreme heat (ridging > dry and warm)
	+ Less reliable snow; more challenges for flood control
	+ Sea-level rise (SLR) leading to more nuisance flooding, more storm surge and wave-driven flooding
	+ More wildfire (multiple conditions causing this; Santa Ana winds, Diablo winds critical, but also hotter, drier (after wet years > more fuel build-up))
* Future projections suggest that these historical trends will all intensify; even if the Paris agreement were met, these changes will continue to intensify
	+ At 2°C global average warming, we’re in severely warm years in CA 100% of the time
	+ Variability for some climatic events will change as well (some are better understood than others)
	+ Bias correction is a necessary step to ensure projections are continuous from past and present trends; not doing bias correction ensures the projections are off
	+ Spatial and temporal analogues can be used as exemplary of future changes, but may not account for changes in frequency/variability
* Critical uncertainties remain, e.g.:
	+ We will never know the future climate any better than the current climate (lots of noise in it as it is)
	+ One of the big innovations in climate science: we have the computational power to run the same computer model many times (not 30 models 1 time, but each model 30 times); this work has resulted in key insight:
		- Range of one model = range of multiple models
		- Range of model runs are difficult to distinguish
		- Hence model uncertainty is really not model uncertainty, but a result of internal variability in the climate system
		- Thus, we can never reduce this uncertainty; we have to plan for uncertainty
		- We can produce probabilities, but these are conditional on the underlying emissions scenarios
* What we know to be wrong is to assume that the future will be equal to the past

**Information gaps/research needs**

**The core challenge** engineers and decisions makers are facing can be described as follows: What happens when you ask an engineer to design to a number that can’t be given? The “one number” can’t be given because there is no one number for the future, only a range of possible values; in addition, available probabilities are conditional on emission pathways for which scientists are unwilling or unable to give probabilities; and, finally, some aspects of the climate system are known so incompletely that probabilities can’t be given at all (at least not at this time).

How then do engineers and/or other decisions-makers go about choosing how to build infrastructure in the face of these unavoidable uncertainties?

A panel of San Francisco Bay area practitioners was invited to speak to this challenge from their very practical experience.

Panelists included:

* Steve Reel (Project Manager, Port of San Francisco)
* John Thomas (City Engineer, City of San Francisco)
* Bob Batallio (Senior Engineer, ESA Associates)
* Kit Batten (Chief Resilience Officer, PG&E)
* Nate Kaufman (landscape architect, Living Edge Adaptation Project)

Key remarks and insights from the panel discussion include:

* Making decisions in the face of uncertainty is day-to-day work; there is also already a lot of experience of how to work with uncertainty from the earthquake side, so this helps to make decision-makers more comfortable with climate change-related uncertainties
* Active and consistent planning for SLR didn’t begin in earnest until about 2010
* State guidance has helped incentivize adaptation, and gives local officials a tool to push engineers, contractors to develop new designs (they wouldn’t do it necessarily otherwise)
* Local policy document and top-level leadership also crucial as it focuses everyone else’s work
* Having an internal committee or task force of experts advising on how to build in the face of uncertainty is helpful
* Engineering design stands between state and local regulations and state of the science – both need to be tracked all the time to advise project owners on possible designs
* Method of using future projections is fairly simplistic: use historical observations and shift them up by the high-end projections available at the time (SLR of 55 inches above 2000 levels by 2100)
* Design life is a key determinant of the relevant timeline; but planning horizons differ by type of infrastructure
* Safety is a key performance standard, but at some point decision-makers must trade-off between safety and the cost to achieve higher levels of safety
* Decision-makers are interested in averages and in tails of the distribution – as extremes are most challenging for infrastructure to withstand.
* Choice of adaptive designs so that projects can be adjusted or their lifetime extended; need to invest in adaptive capacity
* While it makes sense to design for multiple hazards (earthquake and SLR, it’s not clear how to do so)
* Dealing with existing infrastructure is fundamentally different and generally harder than dealing with new infrastructure
* Private sector (like PG&E) and local governments follow state guidance of using high-end projections for 2050, and a range for years beyond that.
* Tools developed by state may not suffice certain decision-makers; if they have the internal capacity they may develop derivative tools for internal use that better fits their data needs
* Cross-jurisdictional coordination is made difficult by different definitions of floodplains, recognition of certain levees (or not), benefit-cost analysis requirements (or not)
* At the local level, the concern is for managing the floodplain that exists (rather than one that is circumscribed in limited ways by regulation), and finding multi-benefit adaptations that consider local concerns (e.g., environmental justice, intergenerational justice), whether or not that is commensurate with regulations or requirements or other governance restrictions.
* Important to shift thinking away from just worrying about liability and thinking more about leaving a positive legacy for neighbors, the next generation, etc.
* Scenario planning, robust decision-making, and decision-scaling are useful tools to plan in the face of uncertainty, although they constitute different approaches; but need to combine that kind of planning with financing tools so that people can assess how much safety they can afford, how much risk they are willing to live with
* Focus on individual structures is problematic, because adaptive designs affect current use and surrounding areas; thus, need a more holistic, expanded geographic perspective
* State guidance needs to be translated into engineering guidance – urgent to do

Working Group members – upon reflecting on the uncertainties and decisions discussed – appear to be divided as to what the most significant uncertainties are. Some see them in the scientific factors such as variability within and between models and lack of data while others see them in societal factors, such as political will, what decision-makers value, and drivers of decisions.

**Barriers to information use and possible ways to work around or overcome them**

Two Working Group members presented case studies on infrastructure, the standards they use to build it, the climate information used in the process, and the barriers encountered or anticipated.

* Case study 1: Martha Brook – Building efficiency and energy efficiency of HVAC equipment
* Case study 2: Gurdeep Bhattal – Highway 37

Then the CSIWG worked through several additional (self-selected) cases in break-out groups.

Details on each case study compiled separately.

The barriers revealed through this exercise (as well as barriers mentioned during the panel discussions in the morning) are compiled here.

* Key barriers mentioned by the panel:
	+ Financing
	+ Attitudes toward risk
	+ ADA requirements
	+ Historic preservation regulations
	+ Different rules and regulations at different levels of government (fed, state, local)
	+ Privately developed/owed data can’t be used in public/state standard-setting
* Key barriers elucidated by the case studies
	+ Availability of temporally/spatially highly resolved data
		- hourly, instead of daily, temperature data
		- daily, instead of annual precip depth data
		- wind speed
	+ Requirements on manufacturers regarding performance of HVAC equipment
	+ Updating of standard depends on political will and level of controversy
	+ Political will to use forward looking climate data
	+ Thermodynamic limits of energy efficiency of equipment
	+ Limited use of data even when available (and use of imprecise rules of thumb instead)
	+ Lack of familiarity with regulations (e.g., Title 24)
	+ Lack of training
	+ Loss of design immunity when infrastructure is built to anything other than the existing standard, i.e., when engineers deviate from accepted/codified practice
	+ Some data not available from public sources; can’t be used in public design standard setting
	+ For infrastructure that involves the federal level (e.g., in transportation sector), standards also need to be adopted there because federal agencies mostly fund state-based projects
	+ Lag in industry adoption of new standards
	+ Regulations that prohibit use of forward-looking information or draw on certain sources of information
	+ Cost of adaptation; going above and beyond standards adds cost and that is often difficult to fund/finance
	+ Changing standards requires a different process in each standard-setting organization, even if all apply to infrastructure built in one sector

This list is incomplete; and will be continuously added to throughout the deliberations of the Working Group.

**Approaches to selecting engineering designs in light of various climate futures**

WG members were asked to choose a type of new or existing infrastructure and consider how climate change can be considered and accounted for throughout the various phases of the design/operational cycle of that infrastructure, including Planning, Design, Procurement, Construction, Operation, Maintenance, and Re-design or Decommissioning

WG members selected to work with the following examples:

* Developing high speed rail as an example of a large-scale, new infrastructure project
* Building a (World Bank financed) hydropower project
* Retrofitting existing buildings
* Upgrading an existing road
* Building a new bridge

Details on each example compiled separately.

Common themes across all examples:

* Need for workforce training for people working in each of the phases (not all the same)
* What are useful financing mechanisms
* Challenge of doing adequate economic valuations of risks and benefits (especially those accruing outside the sector of interest), cost of inaction
* What would foster professional accountability?
* Challenge of enforcement
* Need for monitoring, benchmarking and measures of success
* Need guidelines also for operation and maintenance (not just design)
* How to evaluate the quality/qualifications of bidders?
* How to incentivize switch to forward-looking designs?

**Closing Round of Comments from WG members**

WG members were asked to articulate key insights and needs going forward. Suggestions made included:

* Clarification of vocabulary/jargon
* Decision making processes in different sectors
* Professional accountability
* Scope question: staying focused on science needs vs. bigger set of uncertainties
* Support for decision-making under uncertainty
* Institutional limitations to changing how decisions get made may be bigger than the scientific ones
* Guidance on how to pick from the wealth of information and tools out there
* More discussion on flexible and adaptive designs and transitioning from current to more adaptive practice

After a review of the day’s accomplishments, the meeting adjourned at 4pm.