Paying it Forward:

The Path Toward Climate-Safe Infrastructure in California

Executive Summary

A Report of the Climate-Safe Infrastructure Working Group to the California State Legislature and the Strategic Growth Council

September 2018

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Introduction

During the fall and winter of 2017-18, California residents lived through a devastating series of disasters. After years of drought, devastating wildfires ravaged hundreds of homes from Northern to Southern California; deluge rain events after the fires led to catastrophic floods, mudslides and debris flows that washed away bare soil, houses and cars and closed stretches of Highway 101, crippling transportation routes. Over this time, the state received five Major Disaster Declarations, three Emergency Declarations and 23 Fire Management Assistance Declarations – a combination never experienced before. Sixty-five Californians lost their lives and thousands of homes, numerous roads, communication towers, phone and electricity distribution lines, fleet vehicles, parks and so on either were destroyed or sustained damages that are still being tallied and remedied. Against a backdrop of infrastructure that some describe as "crumbling," these extreme events offer a first-row seat to the fragility of our infrastructure systems and give us a glimpse of the future in a changing climate. For people to be safe, our communities must be prepared. Our infrastructure must be resilient and sustainable to withstand these growing threats, particularly from worsening extreme events. Yet California's infrastructure is not.

The state's infrastructure is aging and deteriorating and – despite recent increases in investment – still requires better upkeep and modernization. Lack of emergency action plans for high-hazard infrastructure, a long backlog of deferred maintenance projects and billion-dollar gaps in spending on infrastructure upkeep plague the state of infrastructure in the fifth largest economy in the world. These truths provide a stark backdrop to the rapidly growing need of investing in new infrastructure and preparing for the accelerating negative impacts of climate change.

Through the Climate-Safe Infrastructure Bill, AB 2800 (Quirk), and with State leadership and foresight in climate change adaptation planning, California is seeking to understand how it can better prepare its existing and new infrastructure for climate conditions that will be increasingly different from the current ones. The State is seeking to ensure a climate-safe future.

California is already experiencing the impacts of climate change as well as more extreme events that exceed the standards (and the environmental conditions underlying them) to which the state's infrastructure was built. This – together with existing infrastructure modernization needs – places urgency on State policy-makers to determine how to spend infrastructure dollars wisely. Through various propositions, the State has nearly $62 billion dollars available in voter-approved bond sales to invest in built and nature-based infrastructure. Billions of dollars in recovery funding after recent disasters, a good portion of which can be used toward rebuilding infrastructure, provide additional resources for a new generation of infrastructure.

> *Our infrastructure must be resilient and sustainable to withstand these growing threats, particularly from worsening extreme events.*

While these billions of dollars may seem like a windfall, they are only a down-payment on the statewide infrastructure investment needed. These available funds could easily be squandered on maladaptive projects if climate-safe infrastructure policies and guidelines are not put in place today. The State thus has a crucial opportunity to be a national and even international leader on modernizing and building critical infrastructure that is fit not just for today, but for a climate-change impacted tomorrow.

Mandate and Goals of this Report

AB 2800 mandated that a panel of scientists, registered engineers and architects be convened to help the State of California understand how it can best incorporate forward-looking climate information into the state's infrastructure design, planning and implementation (Chapter 1, Box 1.2). This Executive Summary highlights the Climate-Safe Infrastructure Working Group's (CSIWG) major findings and recommendations.

This report summarizes the CSIWG's deliberations in response to the mandate of AB 2800 and offers recommendations to the California State Legislature and the Strategic Growth Council. Together, these recommendations chart a path toward helping California invest in climate-safe infrastructure. The report addresses the infrastructure that was built decades, even a century, ago – from historical bridges, to major dams, highways and buildings – and the infrastructure that will be built in the coming years and is meant to last for many decades to come (Figure ES.1).

While this effort initially sought to solve the as-yet-unresolved challenge of incorporating forward-looking climate information into infrastructure design (something engineers and architects have struggled with for years), the Working Group discovered that the science challenge in moving toward climate-safe infrastructure is significant, but not intractable. Equally, if not more, difficult are those challenges that require profound shifts in values, thinking, priority setting and policy commitments.

This report responds to the legislative intent for AB 2800, which is to make California communities safer and to save lives. While saving lives is more likely if decisions are informed by the best available knowledge, science alone will not guarantee our safety. Saving lives is a matter of what and who we value as a society. It requires reckoning with what we believe deserves our dedicated investment and is ultimately dependent upon the decisions we make and actions we take. Investing in a climate-safe future for all is a way of creating a positive legacy. It is *paying it forward*.

The recommendations in this report aim to incentivize and inspire legislators, public agency leaders, engineers, architects, scientists, consultants and contractors, planners and residents to commit to creating a climate-safe future for California.

Box 1: The Mandate of AB 2800

As mandated in the AB 2800 legislation, the Working Group has a very specific charge, at a minimum, to consider and investigate:

1. The current informational and institutional barriers to integrating projected climate change impacts into state infrastructure design;
2. The critical information that engineers [and architects] responsible for infrastructure design and construction need to address climate change impacts; and
3. How to select an appropriate engineering design for a range of future climate scenarios as related to infrastructure planning and investment.

It further mandates that, in a report to the State Legislature and the Strategic Growth Council, the Working Group shall make recommendations to the Legislature that address:

1. Integrating scientific knowledge of projected climate change impacts into state infrastructure design;
2. Addressing critical information gaps identified by the working group; and
3. A platform or process to facilitate communication between climate scientists and infrastructure engineers [and architects].

Figure ES.1: Developing climate-safe infrastructure requires the establishment of a strong bridge between science and the engineering community, as well as supportive public policy aligned with the goals of resiliency. (Photo: Bixby Bridge near Big Sur, CA; Russell Mondy, flickr, licensed under Creative Commons license 2.0)

Box 2: What Do We Mean by "Climate-Safe" Infrastructure?

We define **climate-safe infrastructure** as infrastructure that is sustainable, adaptive and that meets design criteria that aim for resilience in the face of shocks and stresses caused by the current and future climate. Climate-safe infrastructure should be robust across a range of plausible climate and related socio-economic futures, as determined by the best available knowledge at the time the criteria (standards, codes and guidelines) are set. To remain "climate-safe," these criteria must be monitored and updated over time to account for changing conditions and the performance of resilience measures taken. Climate-safe infrastructure also reduces heat-trapping emissions to the maximum extent possible to not add to the climate change problem. (Mitigating climate change in this way also complies with California emissions reduction targets.) Furthermore, climate-safe infrastructure addresses socio-economic inequities so that all groups in society increasingly benefit from safe, reliable and sustainable infrastructure.

In short, "climate safety" is not a world free from change and disruption, but a world in which California has committed to seeking the greatest possible safety for all of its residents through the best available knowledge, the best technology and engineering design, a strong workforce, equitably distributed resources and sustained political will.

The Challenge

California's Fourth Climate Change Assessment (Fourth Assessment) has confirmed the consensus of the climate change science community:

- Past climate is no longer a reliable guide to future conditions;
- Science has established beyond doubt that the global climate and California's are changing rapidly;
- The dominant contribution to the observed climate change during recent decades have been greenhouse gas emissions from human activities; and
- Many trends in observed climate change are accelerating and impacts over the next several decades are unavoidable, even if human-caused emissions came to a halt today.

A growing body of studies, including those within the Fourth Assessment, offer detailed projections for, and assessments of, the vulnerability of various infrastructure sectors. Some of these are presented in the full report (Chapter 2). With this, infrastructure decisions that are made today have the benefit of considerably greater data and understanding of climate processes than decisions that were made in previous decades.

Specific localized projections of climate changes and extremes are of greatest interest to infrastructure planners, yet these will always remain uncertain. Despite the apparent perception to the contrary, the spatial and temporal variability experienced in the past is no more predictable than future spatial and temporal variability. Given the pace, intensity and makeup of California's changing climate, infrastructure planners now must contend with the uncertainties and potentially new patterns of variability that this rapid change entails.

The science challenge in moving toward climate-safe infrastructure is significant, but not intractable. Equally difficult are those challenges that require profound shifts in values, thinking, priority setting and policy commitments.

Fortunately, engineers and architects have considerable experience with building infrastructure to withstand variable conditions. It is clear now, however, that in addition to this variability, engineers and architects must also account for shifting trends in averages and for extremes around those changing averages.

Through its deliberations, the CSIWG describes an adaptive process by which infrastructure planning can proceed with the information that is currently available. It also identifies climate information gaps and needs that – if filled – would be useful moving forward. The action-oriented process entails:

- Using the information that is currently available, while allowing for more refined information to be incorporated in the future;
- Using adaptive designs for planning infrastructure; and
- Developing sustained funding source to advance climate and social science as well as adaptive engineering research to fill identified gaps.

The added threats from climate change will impact state infrastructure that is already in need of improved

maintenance and modernization (Chapter 3). As recent extreme events and disasters or near-disasters illustrate – some of California's infrastructure, across all sectors, is already at risk and vulnerable to the impacts of weather and climate extremes. As we rebuild our infrastructure, we can simultaneously seize the opportunity to make our systems more sustainable in a changing climate.

In light of existing infrastructure challenges and the climate outlook, engineers and architects will need a range of new approaches to ensure that infrastructure safety and functionality remain attainable goals. To do so, infrastructure planners and designers must confront old paradigms of stationarity (i.e., assuming statistics of climate averages and extremes remain unchanged over time), and view infrastructure not as individual structures but as whole systems embedded in a more complex and interconnected world (Figure ES.2). They must also deal with the greater constraints on, and new opportunities for, infrastructure systems. Finally, they must also address the present and coming workforce crisis.

California faces a pivotal moment at which the state's political leaders – at all levels – need to become serious about sustained leadership on infrastructure and commit to making a sustained, "climate-safe" investment in the very foundation of its economy and its communities' safety and well-being as if California's future depended on it. It does.

Figure ES.2: The interconnected components of California's water infrastructure illustrate why infrastructure should not be understood as singular physical assets but instead as systems that provide multiple functions to many different users. (Photo: Chrisman Pumping Plant; DWR, used with permission)

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A Vision of Climate-Safe Infrastructure for All: The Climate-Safe Path

Climate Safety Through Mitigation and Adaptation: The Climate-Safe Path

Through high-level policies, executive orders and laws, California has committed to reduce its greenhouse gas emissions by 40% below 1990 levels by 2030 and by 80% below 1990 levels by mid-century. This level of commitment puts the state on a responsible path toward helping the global community achieve the targets of the Paris Accord, namely to limit global average warming to 2 °C (3.6 °F) or less (1.5 °C or 2.7 °F) by the end of this century.

As the nearly two decades of international climate negotiations make clear, and as California's own path to increasingly stricter emissions reduction targets illustrates, stringent mitigation targets are not just a rational choice in light of potentially severe risks; they are a political choice. However difficult it may be to achieve, aiming for 2 °C or less is the choice that focuses the compass needle toward greater safety from some of the harmful climate impacts that would occur if emissions were allowed to further destabilize the Earth's climate system. However, the great difficulty involved in compelling the international community to make this commitment suggests that California must be prepared to contend with much greater climate impacts.

Thus, there is a parallel political choice to be made in setting adaptation targets. Over the past few years, California's political leaders and state lawmakers have laid some policy foundations for adaptation and now have an opportunity to strengthen adaptation as a political priority. They can send the same directional signal as they did with mitigation, namely, that the safety of communities and the infrastructure on which they and the state's economy vitally depend is of utmost importance. That choice, consistent with guidance from the Office of Planning and Research, is

to ensure that long-lived infrastructure is planned, and may eventually need to be built, operated and maintained, to withstand future impacts from climate change associated with the "business-as-usual" or high-emissions pathway (currently the RCP 8.5 emissions scenario) (Figure ES.3).

Should it become apparent over time that – globally – society has safely averted a high-emissions future, the adaptive approach promoted in this report should allow for an "off ramp" to adapt to the impacts associated with a lower-emissions pathway. However, determining the point in time when such a transition to a lower-safety threshold is indicated, is both scientifically and politically complex and requires dedicated research and public debate.

By reducing the causes of climate change through mitigation and simultaneously implementing preparedness and adaptation measures, California would pursue the safest of possible climate action pathways any state can take (Figure ES.4). We call this comprehensive strategy "the Climate-Safe Path for All" (Chapter 4).

Figure ES.3: Stringent emissions reduction targets are not just a rational choice in light of potentially severe risks; they are a political choice. California now has the opportunity to take a similarly strong political stance on adaptation. (Photo: Kevin Dooley, flickr, licenses under Creative Commons License 2.0).

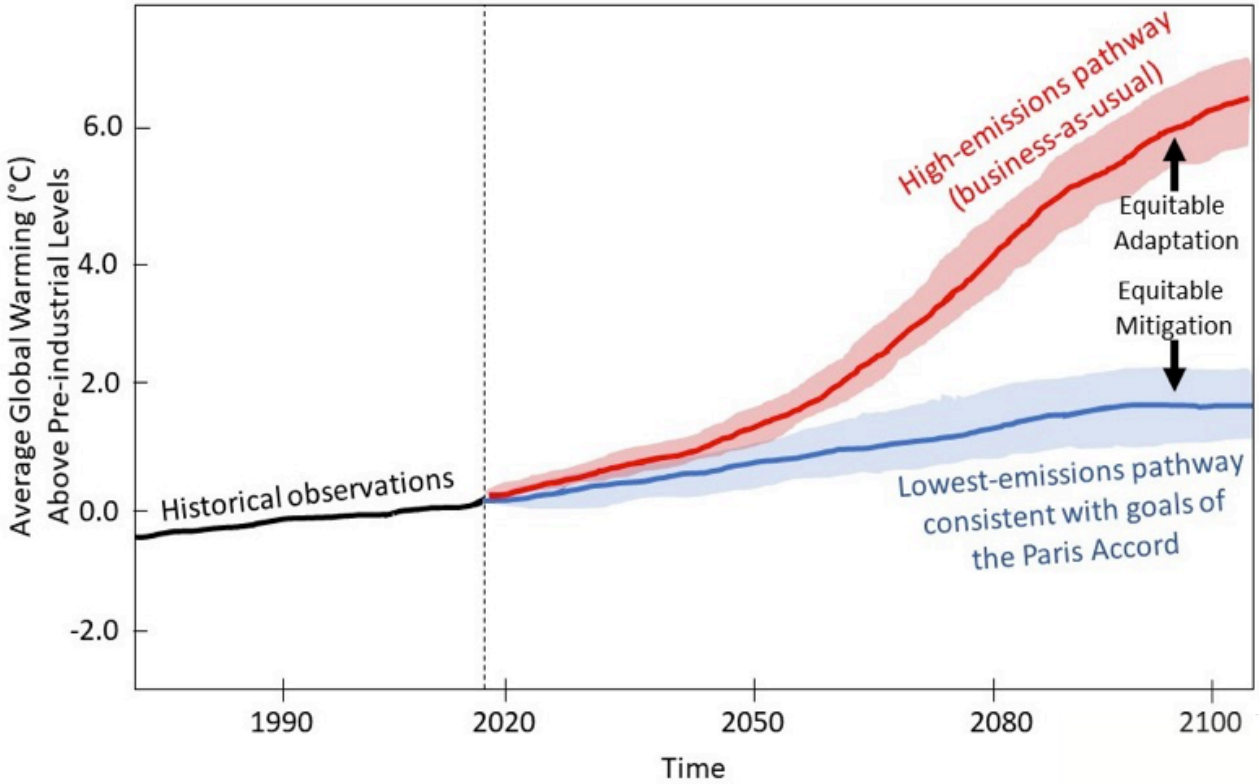

Figure ES.4: The Climate-Safe Path describes the simultaneous pursuit of stringent greenhouse gas mitigation that aims to meet the goals of the Paris Accord while charting an adaptive pathway to protect Californians against the impacts of a high-emissions scenario, both implemented with a central focus on social equity.

Realizing the Climate-Safe Path One Step at a Time: Adaptation Pathways

Preparing for the climate change impacts associated with the high-emissions pathway is an ambitious undertaking that has different implications for different types of infrastructure, for existing and newly built infrastructure, and for short- and long-term climate impacts. It does not imply that every infrastructure investment made today must build immediately to the protective level that would be required when the impacts associated with the high-emissions pathway are beginning to unfold. Realizing the Climate-Safe Path does not mean a once-and-for-all step change, but a change in many steps. This is similar to how emission reductions are achieved: not turning off all emissions at once, but successively and steadily moving toward the ultimate goal. Realizing the Climate-Safe Path means following an adaptation pathway that keeps an eye on a long-term goal but is realized through a variety of strategies in multiple stages over the course of decades (Figure ES.5).

Political leaders have laid some policy foundations for adaptation and now have an opportunity to strengthen adaptation as a political priority. They can send a directional signal that the safety of communities and the infrastructure on which they, and the state's economy vitally depend, is of utmost importance.

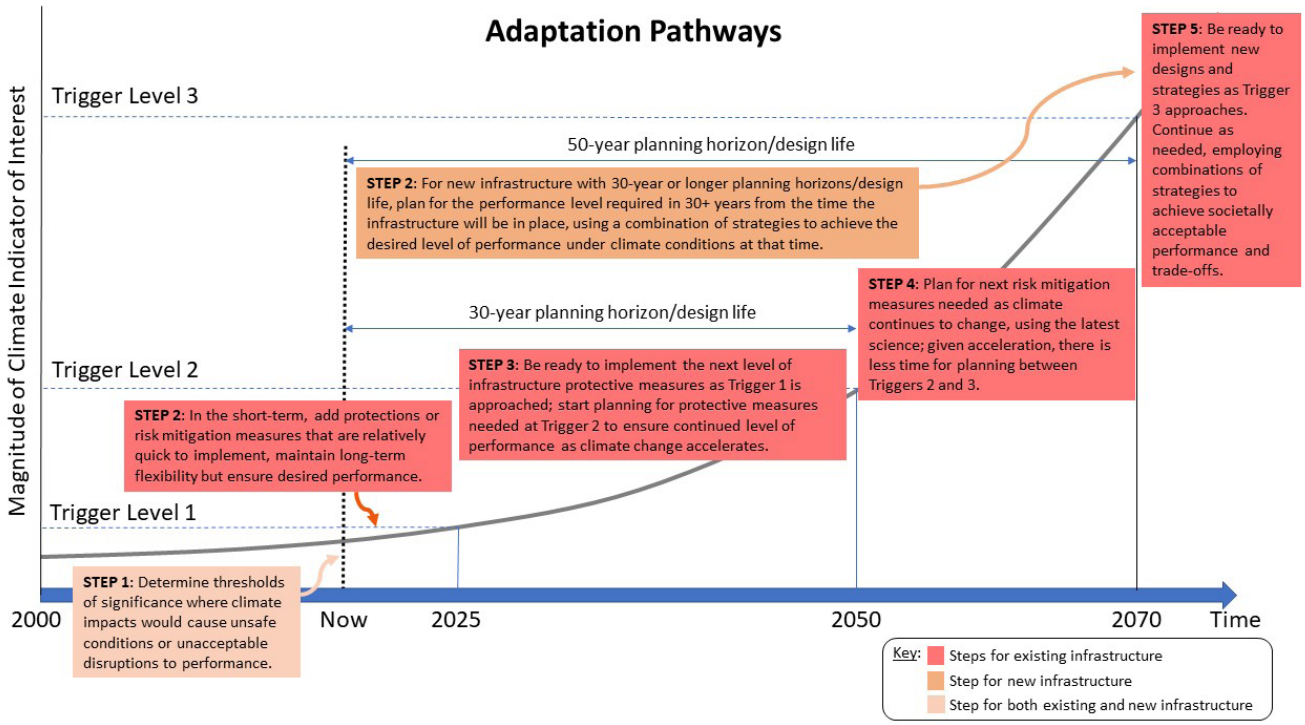

Figure ES.5 A flexible adaptation pathway begins with an agreement among relevant stakeholders as to the desired performance/service level of infrastructure. As climate change continues, thresholds will be crossed where the performance of the existing infrastructure as it is currently built no longer fulfills societal expectations and new adaptation measures must be implemented, taking into account the best available climate science, societal trends, desired performance levels and the resources society is willing to make available for adaptive infrastructure investment. (Source: Adapted from Moser 2016, used with permission)

Realizing the Climate-Safe Path: The Tactical Level

Five different, but complementary strategies can be combined to obtain desired risk aversion levels and ensure infrastructure functionality over the changing conditions that can be expected over its lifetime. They vary in how they are being applied to existing vs. new infrastructure:

- **Robustness** – building to the protective level needed to ensure acceptable functionality and reliability over the design life of the infrastructure;
- **Resilience** – developing and practicing plans for the possibility of a situation when an extreme event exceeds the protective level and infrastructure fails, so as to improve and speed up the response and adaptive recovery;
- **Adaptability** – developing plans and integrating features into the design now that would allow structures to be adapted to a higher level of protection if necessary over time;
- **Redundancy** – developing plans now and implementing them over time to help infrastructure maintain functionality when it or parts of it fail; and
- **Avoidance (new) or Retreat/Decommissioning and Removal (existing)** – avoiding or removing infrastructure development from high-risk areas when the physical defense of infrastructure is no longer viable and the functionality of the infrastructure can no longer be assured.

A Climate-Safe Path for All

The vision of the Climate-Safe Path outlined here is not a path just for the privileged. Instead, it is envisioned to be a path for all. Following the Climate-Safe Path must include an integral commitment to remedying past injustice in infrastructure investment so as to ensure the safety, health, well-being and opportunities of those who have borne insecurity, public health burdens and lack of economic opportunity the most and the longest.

The state's most outdated and dilapidated infrastructure is not evenly distributed, neither geographically, nor socio-economically. It is not affecting Californians equally. Due to decades of underinvestment and redlining (i.e., the systematic denial of various services to residents of specific, often racially associated, neighborhoods or communities), low-income communities and communities of color often confront the largest potholes, the most outdated school buildings, the leakiest pipes and the worst connectivity to modern transportation, communication and other community infrastructure. The added risks arising from climate change are not going to be equally distributed either. These same communities often have the fewest resources to deal with the risks from climate change. As such, these communities are those where the State has the greatest opportunity to make a difference.

The Climate-Safe Path must include an integral commitment to remedying past injustice in infrastructure investment so as to ensure the safety, health, well-being and opportunities of those who have borne insecurity, public health burdens, and lack of economic opportunity the most and the longest.

Inadequate engagement during the infrastructure planning and decision-making processes, systemic ways of putting low-income communities at a disadvantage through decision criteria and cost-benefit requirements, long-standing institutionalized racism and narrow thinking about the role of infrastructure across multiple sectors and within a region or community are at the root of this inequitable investment in infrastructure.

The following principles should guide equitable infrastructure planning, policy and investment:

1. Include residents in decision-making;
2. Serve underinvested communities without pushing out existing residents;
3. Improve the environmental health and quality of life for residents of disinvested communities;
4. Be equitably owned, financed and funded;
5. Create good jobs and business opportunities for local residents; and
6. Invest in workforce training.

Holding paramount the safety, health and welfare of the public is central to the code of ethics of the engineering profession. The Working Group's strong conviction is that social equity in infrastructure development should not be a last-minute adjustment of an already-decided plan, nor merely one among many criteria to guide infrastructure decisions. If the protection of lives is the goal, social equity must be considered in the beginning, middle and end of infrastructure planning and decision-making. It is the outcome that is planned for from the start, and that means a different process must prevail. Procedurally, this means, infrastructure must be planned *with* communities, not *for* them.

Ultimately, the Climate-Safe Path for All results in climate-safe infrastructure that is designed to be resilient to a changing climate and extreme events, both now and across a wide range of uncertain future conditions.

Recommendation 1

The State Legislature should establish as official State policy "The Climate-Safe Path for All", which is a flexible adaptation pathway realized through a variety of strategies, in multiple stages over the course of decades. The Climate-Safe Path for All accounts for the full life-cycle costs of infrastructure and uses a multi-sectoral, systems approach. It prioritizes infrastructure investments based upon the greatest risks and investment gaps, as well as where investment can most reduce inequality and increase opportunity. For highly vulnerable, long-lived infrastructure, State agencies should consider climate change impacts associated with a high-emissions scenario while continuing to implement all applicable State laws related to stringent greenhouse gas emissions reductions.

From Vision to Action: A Framework for Action

In order for this vision of climate-safe infrastructure for all to be realized, integrating the best available forward-looking science will not ensure that climate-safe infrastructure is actually built. Providing actionable data and analytics constitutes one part of an action-oriented framework that will result in the ultimate intent of AB 2800: that infrastructure investments get made and that climate-safe infrastructure is built. We place the provision of forward-looking science into a comprehensive framework for action (Figure ES.6 and ES.7).

- **Data and Analytics –** Infrastructure planning and design requires many types of data, model simulations and forward-looking science – appropriately used and interpreted (for detailed discussion see Chapter 5).
- **Project Pipeline –** Infrastructure projects are often years to even decades in the making. Where and what to prioritize, to what standards of performance climate-safe infrastructure should be built, and planning and deciding about them in a transparent and inclusive fashion requires effective project management and coordination. A well-developed and prioritized project pipeline is a necessary pre-condition to attract infrastructure finance and involves successful stakeholder engagement, efficient progress through the permitting process, multi-sectoral alignment and other processes (Chapter 6).
- **Governance Structures –** Many types of infrastructure involve engagement of multiple levels and different kinds of jurisdictions and can include multiple state agencies or sectors for funding and financing, review and permitting, oversight, operation and maintenance. Appropriate and effective governance structures and processes are required for complex partnerships and financing but may be lacking or need clarification and streamlining for efficient functioning. Governance also involves the rules, codes, standards and guidelines that govern where and how infrastructure is built (Chapter 7).
- **Financing Tools –** Federal and state funding sources alone are widely seen as insufficient to catch up on past inadequate infrastructure investment, resulting in a call for private sector involvement and innovative partnerships and financial tools to generate the necessary funds (Chapter 8).
- **Implementation Aids –** Engineers, architects, planners, procurement officers and operations personnel must have the necessary professional training and know-how to appropriately use available scientific data and tools. They must also be able to understand different planning or financing options and be capable of navigating complex governance challenges. Relevant staff require professional development opportunities and accountability mechanisms. They also must embrace a cyclical, iterative approach in their work, informed by ongoing monitoring and evaluation of the performance of infrastructure. This will allow them to periodically reassess climate risks and adjust infrastructure planning and design approaches over time (Chapter 9).

Figure ES.6: To ensure that climate-safe infrastructure actually gets built on the ground, California needs a support system that addresses all aspects of infrastructure planning, design and construction. (Photo: Construction workers; Elvert Barnes, flickr, licensed under Creative Commons license 2.0)

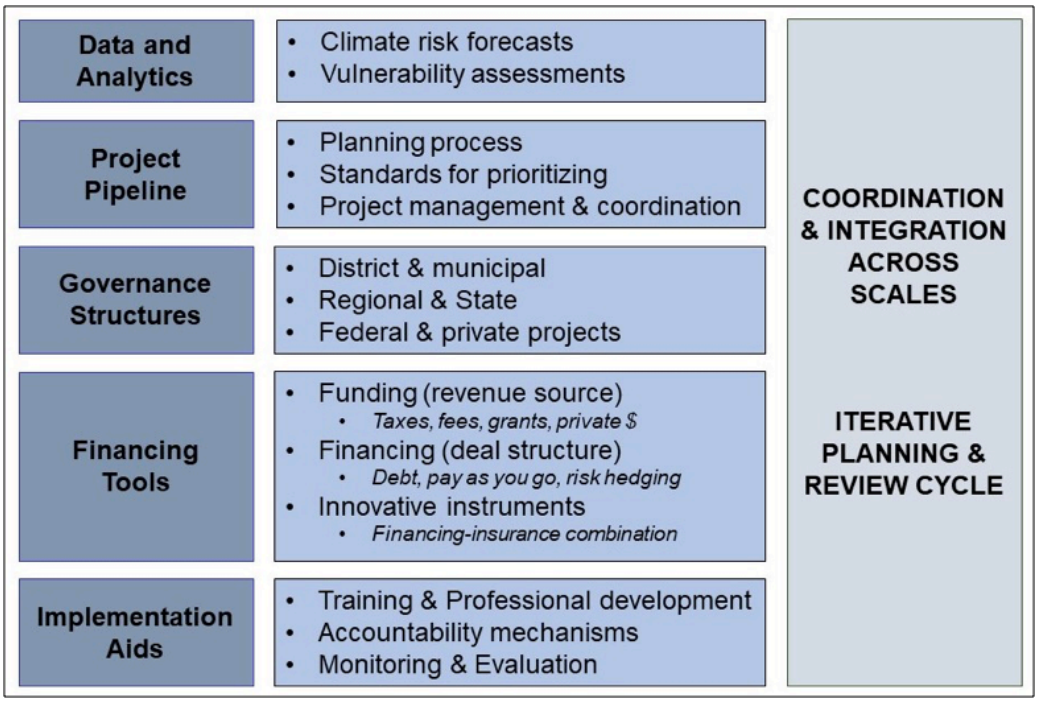

Figure ES.7: A strategic, integrated framework for action is needed to ensure that the vision of climate-safe infrastructure for all gets realized. It includes data and analytics which inform infrastructure planning and design to generate a prioritized list of projects that can be implemented with the help of appropriate governance structures, financing tools and implementation aids. (Source: Adapted from Cleveland 2018, used with permission)

Realizing the Climate-Safe Path for All

Overcoming Barriers to Building Climate-Safe Infrastructure

AB 2800 asked to identify the informational, institutional and other barriers that stand in the way of integrating forward-looking climate science into all aspects of infrastructure planning and decision-making. Through the deliberations of the Working Group, a great number of barriers were uncovered, which fall into the following categories:

- **Informational and knowledge barriers;**
- **Capacity/skills barriers;**
- **Attitudinal barriers;**
- **Political barriers;**
- **Financial barriers;**
- **Legal/regulatory barriers;**
- **Institutional barriers; and**
- **Other barriers.**

We synthesize and discuss these barriers by type in the full report (for a summary, see Chapter 10), but caution against seeing any one of these barriers in an isolated manner. Indeed, barriers of all types are encountered across the entire life cycle of infrastructure design and operation or – differently put – across every stage of the adaptation process. As barriers in the early stages of adaptation are successfully overcome, other (not yet recognized) barriers may emerge as adaptation progresses to implementation, while yet others may fade.

The remaining recommendations – each accompanied in the full report by various immediate steps to operationalize them (for a synthesis of these next steps, see Chapter 10) – either directly address or aim to help overcome these barriers.

"It Takes a System" to Realize Climate-Safe Infrastructure for All

Following the framework for action, the remaining recommendations discuss how best to bolster the state's collection of existing and needed data and analytics (Recommendations 2 and 3), develop a prioritized project pipeline (Recommendation 4 and 5), enhance existing and develop needed governance structures (Recommendation 6), create and make more accessible needed financing tools (Recommendation 7) and foster implementation through a variety of means necessary for building climate-safe infrastructure (Recommendations 8, 9 and 10).

Most recommendations point to the need for adequate funding to implement the recommendation. Agency managers have a variety of ways to meet those needs, but the Working Group feels strongly that if adaptation is a State priority, it should be adequately supported. One of the most restrictive and most frequently mentioned barriers throughout the CSIWG's deliberations is the lack of funding. Thus, the Working Group feels strongly that making climate-safe infrastructure a policy priority should be reinforced by making it a funding priority.

Recommendation 2

In the past, the State's financial support for its various climate science efforts and decision-support tools has been uneven and insufficient. At a minimum, the State Legislature should provide a permanent source of funding for the State's mandated Climate Change Assessment process, the State's ongoing Climate Change Research Program, and decision-support tools and other assistance that disseminate their findings, so as to meet the needs for improved understanding and forward-looking science information.

Building on the pioneering work of several state agencies, the state must expand its research portfolio to meet infrastructure planners' needs, and to expand state agencies' capacities to engage the climate change science community, broadly writ (Figure ES.8).

Figure ES.8: Coincident with the release of this report, the State also released its Fourth Climate Change Assessment. Through 44 technical reports and 13 summary reports on climate change, the Fourth Assessment translates global models into scaled-down, regionally relevant reports that fill information gaps and support decisions at the local, regional and state levels. Despite legislation mandating it, funding to conduct the next assessment is not assured. The Working Group believes sustained and adequate funding is an important first step to ensuring a strong foundation in research to achieve a climate-safe future.

Figure ES.9: Clockwise from left; Marty Ralph, Scripps Institute of Oceanography, Michael Anderson, State Climatologist with DWR, Jay Jasperse, Sonoma County Water Agency, and Jeanine Jones, Interstate Resources Manager at DWR, in conversation during a break at an October 2016 workshop on drought vulnerability in southern California. (Photo: Kelly M. Grow, DWR, used with permission)

Recommendation 3

Because of the diversity of State agencies, types of infrastructure and their vulnerabilities, and the specific needs for climate science, there cannot be a one-size-fits-all recipe for State agencies to engage with the climate change science community. That said, the State budget should provide full funding to State infrastructure agencies so they can dedicate time and support to their engineers and architects to substantively and collaboratively interact with climate scientists and other relevant experts in the creation of useful advice, guidance and tools on a regular and ongoing basis, in a way and at a level appropriate to their needs.

Whether it is through a national scale connection to the Sustained Climate Assessment, or through augmentation of the State's Adaptation Clearinghouse, including its Technical Advisory Group that falls under the umbrella of the Integrated Climate Adaptation and Resiliency Program, or through better use of gatherings such as the California Adaptation Forum (CAF), formalized processes should be developed in which state engineers and architects have deliberate and sustained interaction with physical and social climate change scientists from diverse research institutions and professional organizations (Figure ES.9).

Recommendation 4

During the all-important pre-development phase, projects are conceptualized, planned and designed. The State budget should improve this process by building staff capacity and greatly increasing project funding to better account for a changing and uncertain climate, by addressing social inequity, and by assessing and accounting for the true costs and benefits of integrated projects across their full life-cycle.

Critical elements of successful pre-development planning and a range of tools to assist it include:

- Effective and inclusive stakeholder engagement from the start;
- Developing a climate-screening process to help identify the level of analysis needed and prioritize projects to include in the "project pipeline;"
- Calculating the cost effectiveness of climate-safe infrastructure;
- Employing a probabilistic risk management and robust decision-making approach, in combination with other techniques, appropriate for adaptation decision-making and adaptive design in the face of uncertainty;
- Effective communication; and
- Training on adaptation principles and strategies to ensure appropriate use of these approaches.

Recommendation 5

Difficult decisions will have to be made and the impacts of potential policies or decisions on different stakeholder groups are complex and challenging to assess. It is critical therefore to engage all affected stakeholders in a meaningful way, from early on and throughout any decision-making process, using the seven principles of equitable planning and decision-making.[1] The Strategic Growth Council is well positioned to take a range of steps to encourage, improve and provide guidance on effective stakeholder engagement in the context of infrastructure development.

Stakeholder engagement is essential at every step of the process of crafting climate-safe infrastructure, from initial stages of discussion, to implementation, to maintenance and decommissioning. Decision-making at any stage should always consider whether decisions are being made *with* communities, rather than *for* communities.

*Decision-making at any stage should always consider whether decisions are being made **with** communities, rather than **for** communities.*

Figure ES.10: At "The Longest Table" event in Howard County, Maryland, 320 residents sat a a 320-foot long table and shared their respective vision for their community. This type of socially inclusive engagement ensures equitable respresentation; everyone had a seat at "the table." (Photo: Howard County (Md.) Library System, flickr, licensed under Creative Commons license 2.0)

[1] See Chapter 6, p. 2 for a list of the principles.

Recommendation 6

Consistent with Executive Order B-30-15 and AB 1482, State agencies should update all relevant (i.e., climate-sensitive) infrastructure standards and guidelines that they can directly affect. Alternatively, or in addition, they should develop new state-specific guidelines where there are gaps to address climate resiliency by incorporating forward-looking climate information in those standards and codes. Where State agencies rely on standards developed by standard-setting organizations, state engineers and architects should work through the relevant professional organizations to advance development of climate-cognizant standards. Until new standards and codes are in place, State agencies should develop guidelines that go above and beyond minimum standards and codes to meet the goals of the Climate-Safe Path for All. Where agencies don't have resources to fulfill this workload, they should be fully funded in the State budget.

State agencies differ in their technical capacity to make needed updates to existing standards and codes. Some can do so (and/or are developing new ones where needed) while others must await standard-setting organizations to provide those updated standards, which the State would then adopt. While policy guidance should be unambiguous, the manner in which it is implemented at the level of standards and codes would need to be flexible to reflect this range of in-house capacities.

Among the most important barriers are questions around liability, which constitute a large and complicated enough challenge that a separate panel should be convened to address all the nuances and complexities and to provide guidance and recommendations to infrastructure agencies.

New types of standards and procedural mechanisms (such as performance standards, standards of professional practice, standards of care, various procurement approaches and manuals of practice) provide opportunities for increased climate resiliency.

Recommendation 7

Because improving resilience is not a zero-sum activity, adding resilience in one area cannot be balanced by relaxing resilience requirements somewhere else. Adding requirements for resilience will come at a cost, so unfunded mandates are not feasible. The true costs over the full life-cycle of infrastructure projects should be assessed broadly, and the State should make efforts to help policy-makers and the public better understand the necessity of bearing these costs. Educational, promotional and other outreach should be conducted to generate support for the expenditures.

A follow-on activity to the work of the Working Group should explore the complex questions that arise about how to take climate change into account from a fiscal perspective. Moreover, the state needs comprehensive or reliable estimates of what climate change impacts and adaptation would cost at the state or local level. In addition, the Strategic Growth Council and other state agencies should launch serious engagement efforts to help Californians more fully understand why investment in climate-safe infrastructure is necessary.

Figure ES.11: Along an urbanized coast like California's, there are many complex jurisdictional and governance challenges. which also come with financial trade-offs. The recommendations in this report are aimed at helping the State make equitable decisions about infrastructure moving forward. (Photo: San Francisco skyline and Port of Oakland, Tony Webster, flickr, licensed under Creative Commons license 2.0)

Recommendation 8

The Strategic Growth Council should coordinate with the Government Operations Agency, the Labor and Workforce Development Agency, and other relevant agencies to develop a work plan on how to address the training and professional development gaps of its infrastructure-related workforce as identified in this report, and begin to implement that work plan as soon as feasible. Because the Strategic Growth Council does not currently have the staff capacity and funding to implement this task, it would require adequate funding to do so.

California needs to have the skilled workforce to get climate-safe infrastructure appropriately designed, built, operated and maintained. In addition to proper training in all the "hard" and professional skills needed by today's engineers and architects, this workforce development must address climate skepticism; lack of understanding of climate science; lack of familiarity with sophisticated risk and uncertainty assessment and decision-making approaches; sophisticated economic analysis methodologies and related tools and platforms; lack of knowledge of and disconnect from the adaptation literature and field; lack of comfort with performance standards; lack of familiarity with adaptive design approaches and techniques; resistance to integrative and systems thinking that crosses silos; lack of skill in effective stakeholder engagement and communication; and lack of cultural competency in working with diverse stakeholders on infrastructure projects.

Figure ES.12: The "climate-ready" workforce of the future must be trained in both the traditional "hard" engineering skills and in the professional skills needed to navigate complex science, governance, finance and stakeholder engagement issues. (Photo: Folsom Lake water purification; USACE)

California needs to have the skilled workforce to get climate-safe infrastructure appropriately designed, built, operated and maintained.

Recommendation 9

The State should establish a Standing CSIWG to devise and implement a process for coordinating and prioritizing Climate-Safe Path related resilience policies and actions at the highest level. This panel would provide a needed forum for agencies to coordinate their policies, take advantage of synergies, address potential conflicts and learn from one another. As AB 2800 is slated to sunset in 2020, the work of a standing CSIWG would require an extension of AB 2800 and adequate financial support to conduct its business.

The CSIWG proposes the development of a standing CSIWG, which would have the following roles:

- Coordination;
- Central point of contact for infrastructure across the state;
- Forum to advance climate-safe infrastructure questions; and
- Leadership in incorporating forward-looking information in engineering standards.

Some of the immediate tasks this standing CSIWG could address include prioritization of identified research needs, exploration of liability issues, assessment of the pros and cons of different procurement approaches for different types of climate-safe infrastructure and development of guidance on effective stakeholder engagement for infrastructure agencies.

Recommendation 10

The State budget should provide full funding to State agencies to make deliberate efforts in reducing or eliminating the barriers that hinder or slow down adoption of State-level climate-safe infrastructure policy into practice. Key focus areas include the translation of Climate-Safe Path policy into practice manuals and contracting language, providing incentives to account for climate change in infrastructure projects, identifying metrics of success for monitoring and evaluation and developing a best-practices compendium.

Ultimately, for all of these recommendations to be used by on-the-ground contractors (those who implement the plans developed by state architects and engineers), they must be translated and made accessible to all those working on infrastructure. This includes creating guidance on how to translate State-level climate-safe policy into contracting language, building capacity to assess and manage bids, developing model contract language, incorporating inclusive procurement procedures and other enabling steps.

In Closing

Through all of its climate-focused activities, the State of California has been laying the foundation for the work of the CSIWG. AB 2800 allowed the Working Group to propose new paths for infrastructure planning in the state (Figure ES.10). In using the systemic, action-oriented approach offered here to move from vision to implementation, and in following the recommendations that provide the bricks for the Climate-Safe Path for All, California has the opportunity to *Pay it Forward*. It must make these investments today to ensure the safety, well-being and prosperity of all Californians tomorrow.

Figure ES.13: California has the opportunity to "pay it forward." It must make sustained investments in climate-safe infrastructure investments today to ensure the safety, well-being and prosperity of all Californians tomorrow. (Photo: Sacramento-San Joaquin Delta; Paul Hames, DWR, used with permission)

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Disclaimer. Members of the Climate-Safe Infrastructure Working Group were selected on the basis of their expertise. Their expert opinion reflected in this report does not constitute endorsement from the agencies and institutions in which they are employed.