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Integrated Approach to Renewable Energy Deployment in California: Summary of Conclusions and Recommendations

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Abstract: The on-going global shift to renewable energy (RE) as a preferred option for electricity and fuel supply has its roots in early experience with renewable energy deployment in California. California's experiment with electricity market restructuring has overshadowed and impeded further renewable energy deployment over the subsequent twenty years. However, recent policy initiatives aim to create conditions for renewable energy deployment to resume. In this context several questions demand attention, i.e. related to why California RE deployment stalled, what steps are necessary to get it back on track, the potential role of utility rate-payer funded research, deployment scenarios, and their benefits, costs and barriers. In summary, the analysis presented in the paper supports the following recommendations:

1. Conduct rigorous analysis of the factors enabling and impeding California' current approach to RE deployment
2. Specifically target deployment of RE heating and cooling solutions, including solar and geo-exchange
3. Initiate planning, road-mapping and policy support for RE Secure Communities and Buildings
4. Develop and fund a permanent, on-going program of RE economic research
5. Serial, competitive development and demonstration solicitations focused on RE technical integration solutions.
6. Build up a university based technology, economic and environmental assessment capacity and related public databases.
7. Emphasize research collaboration with integrated energy service providers and national laboratories
8. Establish long term, stable policy support for the RE deployment scenario that best integrates building, community and utility scale resources.
9. Develop a peer-reviewed vision for a renewable-based intelligent energy infrastructure for California:
10. Identify technology- and scale-specific scenarios for California renewable energy deployment

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Introduction: In recent years the global renewable energy (RE) industry has become one of the largest and fastest growing industries in the world. Investment increased by 450% in four years from 2004 levels. At $140B in 2008, RE investment exceeded investment in new fossil fuel capacity ($110B) for the first time. The pace of change, innovation and scale in RE markets and industries has changed dramatically and probably permanently.

It has become clear to national industrial and economic policy makers around the world that renewable energy is no longer “alternative” energy. It is an essential part of the global energy mix. The key question is not: “How much RE supply can be accommodated?” It is: How must RE supply and the current supply and delivery infrastructure be adapted to one another as RE penetration increases to economically and environmentally preferred levels?” These levels will not be static but rather will represent a moving target that reflects technology improvements, cost trends, and policy evolution, globally and locally.

California has occupied an envied and respected position in the eyes of RE advocates ever since it led the world in RE deployment in the 1980s. Counter-intuitively, the sea change in RE deployment globally has no parallel in California. For the past two decades, California’s per capita RE use decreased by nearly 1% per year, as production varied and population steadily increased.

Ambitious RE deployment goals were enacted in 2002, but 2008 production was the same as production in the peak years from 1990 to 1994. This creates reasonable doubt whether California’s current approach to RE deployment is working.[a] This paper examines related issues and asks the basic question: Is there a better way?

California justly celebrates the fact that its per capita energy use has not increased over the past two decades. Meanwhile, California’s RE supply per capita has actually decreased by an average of nearly 1% per year over a comparable period notwithstanding aggressive, well publicized targets for RE deployment established in the early part of the current decade.

This working paper reflects evidence that the on-going the global shift to RE is driven by fundamental forces that are permanent. Therefore, California’s must bring the full menu of technically and economically competitive RE solutions into play. This will require an unprecedented and even revolutionary level of integrated resource planning and deployment.

This paper thus outlines the structure and elements of an approach to more rapidly and cost-effectively integrate new RE supply into California’s energy supply infrastructure. It also raises important related questions and advocates the substantial, sustained effort that will be needed to address them.

Question of primary and immediate importance are identified and discussed briefly in this executive summary and in more detail in the remainder of the working paper

Why is California RE power plant deployment stalled?

[a] It also suggests the need for analysis of the political, economic and technical factors underlying California’s current approach.

High quality, abundant RE resources: every state has one or more - California has them all - world class in all categories. California should be leading…it has all the necessary means to do so. RE deployment could be economically advantageous in many contexts, including global economic competition. So, why is RE deployment stalled in California?

California's approach to RE deployment has been consistent with the structure of its electricity markets, a structure that has so far been highly effective in deploying new natural gas based generation….but there are fundamental differences between the attributes of natural gas based generation and most RE options that may partially explain the contrast in deployment results. Is California is over-playing its presumptive RE trump suit, i.e. the opportunity to supplement centralized electricity supply by exploiting load-isolated pockets of premium RE resources?

RE supply development is capital intensive and its financing depends strongly on managing risks related to first cost. Natural gas based plants involve less capital at risk for the same supply capacity. Risks related to long term natural gas price uncertainty are mitigated by the ability to adjust utility revenues as required to cover fuel costs.

California's default generation expansion option apparently is additional natural gas based generation. California has been willing to consider RE electricity purchases if they were priced at or below estimates of the future cost of electricity from natural gas based generation. This addresses the risk of paying too much for renewable energy supply but fails to account for the notorious volatility of natural gas prices. If long term natural gas prices turn out to have been underestimated, the natural gas share of California's generation mix will be larger that it would have been if estimates had been more accurate - less new RE supply will have been financed and deployed), and the adverse consequences to ratepayers will be greater.

There is global competition for RE project development investment just as for any other type of investment. Project development investment is the key to actual projects. Projects are being deployed elsewhere under conditions of greater regulatory certainty and more expeditious permitting. These conditions favor timely project realization.

Timely and predictable project development and execution schedules are especially important at the early stages of a project where outcomes are at greater risk. Overall, California's RPS targets may not be receiving the level of early stage project development attention and investment necessary to achieve timely financial closure and move to construction of actual projects.

Finally, California's mechanisms for sourcing energy supply, while relatively well adapted to highly centralized deployment, fail to effectively facilitate development of many commercially proven RE conversion solutions applicable to California resources, i.e. solutions that apply to community and building scale energy supply..

<u>Recommendation – Question 1:</u>

Evaluate factors enabling and impeding current approach to RE deployment: The above qualitative analysis points to issues in need of clarification and resolution. What are the political, economic and technical factors driving California's current approach? Superficially, many obvious factors seem to favor RE deployment in California. However, other less visible factors apparently suffice to neutralize the favorable factors. More rigorous analysis is imperative if California is to confidently navigate toward its ambitious near term RE deployment goals and to effectively position itself to achieve longer term outcomes, e.g. outcomes consistent with AB 32.

<u>Question 2: What technology, program and policy solutions are available to put RE deployment in California on track consistent with California legislation?</u>

RE deployment patterns in Europe and elsewhere reflect approaches that work in regions less well endowed with seemingly easily accessible, diverse and high quality RE sources. The basic attributes of these approaches are diversity and integration.

Diversity has two primary dimensions: 1) resource and conversion technology diversity, and 2) application scale diversity. These two dimensions are well characterized by the taxonomy presented in Figure S1.

√ = primary application	**Deployment Venues**		
√ = secondary application	Utility-Scale Renewables	RE Secure Communities	RE Secure Buildings
Technology/ Resource	Utility-scale power plants and bio-refineries	Smaller energy plants exploiting high-quality local resources	Modular systems for building and industrial power, heat, cooling and lighting
Wind Power Plants	**√**	**√**	
Geothermal Power	**√**	√	
Hi Temp Solar Thermal	**√**	√	√
Biomass Power	√	**√**	√
Water	√	**√**	
Solar PV	√	**√**	**√**
DG Wind		√	**√**
RE Space/Water Heating		√	**√**
Direct Geothermal		**√**	√
Geothermal Heat Pumps		√	**√**
Biofuels	**√**	√	√
Energy Storage		**√**	**√**

Figure S1… RE conversion options organized according to application scale

Integration is essential to managing diversity, i.e. to exploiting the benefits and complementarities of a diverse portfolio of RE supply solutions. It has two important dimensions: 1) state-wide supply and delivery systems, and 2) more localized supply and delivery systems for communities and buildings.

Complete integration in both dimensions optimizes the economic performance of a state-wide and regional energy systems that include a mix of centralized RE supply and also decentralized sources serving communities and buildings. The latter are sized according to the extent of high quality local resources, fuel transport costs, and on-site demand. They serve buildings or locally aggregated demand and are economically optimized accordingly. They are also integrated with existing infrastructure that includes centralized RE resources.

Energy supply deployment at the community and building scale also opens opportunities for closer integration of RE supply, end-use efficiency and smart-grid features. RE heating and cooling, for example, has the same effect in a building, community or state energy system context as energy efficiency. RE heating and cooling systems reduce demands for natural gas and electricity and related carbon emissions. [+]

There are even deeper levels of integration that offer their own economic rewards, including the RE integration topic currently attracting the greatest attention, i.e. "grid integration". Grid integration currently emphasizes the adaptation of transmission systems to accommodate higher penetration of variable, centralized RE sources.

The flip side of grid integration can be termed "supply integration". Supply integration is also concerned with adaptation, i.e. of RE solutions to existing and future energy infrastructure. For example, the overall energy system would benefit from re-engineering variable RE resources into "dispatchable" resources, e.g. storage coupled solar plants and systems.

Supply integration would manifest itself as community scale and building scale energy supply systems that include an optimized mix of RE and non-RE sources along with end use regulation and minimization measures, e.g. lighting and HVAC efficiency, demand response, and energy saving building envelope features.

[+] Building thermal energy use accounts for 27 % of California GHG emissions, and RE heating and cooling can cost-effectively reduce this figure and thereby add to the climate benefits of rooftop solar PV deployment and the state's energy efficiency programs. [b]

Real time operational integration will also be required. Timely and reliable information, ultimately including the free and conveniently accessible flow of real-time data informing a smart grid, will be essential to achieving the full benefit of integrated, full menu RE deployment.

Likewise, modeling is critically important to an integrated approach to RE deployment, because it informs both private and public investment. Over the long term, hundreds of billions of capital dollars must be wisely deployed. Both information and modeling needs require planned, organized, collaborative and, most importantly, sustained, long term expert attention.

A particularly important enabler of integration is the ability to plan according to cost and operate according to cost.

Recommendations – Question 2:

Deploy RE heating and cooling solutions: California should target deployment of RE heating and cooling in the same time frame and with the same carbon emissions impact as building-based solar electricity, i.e. carbon emissions displacement equivalent to 3GW of solar electricity deployment. The program strategy and methods of the California Solar Initiative could be applied. In this case, geo-exchange heating and cooling should be included in the scope of the program to ensure that it begins to receive comparable policy support to that which is accorded other energy efficiency measures.

Planning and policy support for RE Secure Communities and Buildings: A roadmap for integrated community and building scale RE deployment should be prepared in consultation with leading California communities, utilities, national programs. The roadmap should have reference to experience in other states and countries where community scale RE deployment is occurring and/or receiving favorable policy attention. The roadmap should draw on the lessons from PIER's RESCO program but should not be limited to RD&D measures. It should ultimately be submitted to the California legislature for consideration as a part of more comprehensive and integrated RE deployment legislation.

Develop and fund a permanent program of RE economic research: The program should have permanent staff with expertise in RE finance, RE cost analysis and modeling methods that determine the integrated economic value of RE supply systems and collateral investments, e.g. in energy storage. The program should have a goal to support both planning and operational integration of RE in California. The program should build on efforts by PIER to inform California's integrated energy policy updates and biennial reports. It should address the issues identified in 2009 IEPR workshops related to RE costs.

Question 3: What is the best role for public benefits RD&D that would support timely and cost-effective RE deployment in California?

The 21st century will feature a fundamental re-engineering of our energy infrastructure, the course of which cannot be predicted with accuracy.

Recent years have offered a preview of the speed and scale of change ahead. Clean energy venture capital has mushroomed. At the same time there has been a rush of new market and finance entrants along with a surge of investment capital behind them. In parallel, major new market opportunities have risen up outside traditional areas of concentration. First tier manufacturers have been displaced or acquired, supply and distribution chains relationships have been re-engineered, and materials and equipment pricing have been volatile, while the cost and availability of project capital for project execution has been in a turbulent phase. In short, it is a new ball game for public benefits RE RD&D seeking market connectedness and relevance.

The fundamental implication of the accelerating changes in the global RE industries and markets is that public benefits RD&D strategies must also change in order to deliver timely, relevant results. RE RD&D strategies must be adjusted to new market dynamics, esp. to the much faster pace of deployment and innovation.

The best public benefits RD&D is that which anticipates and drives change in directions consistent with the public interest. California public benefits RE RD&D ought to be at a scale commensurate with the investments at stake, and perhaps, if funding of collaborative R&D among the state's utilities were to resume, it could be.

However, if commensurate scale is not feasible, then PIER should focus decisively on a small number of important strategic needs where its resources apply and can make a difference. The need for technical integration solutions in certain emerging deployment venues, e.g. energy secure communities, may be one such need. The need for accurate, independent and increasingly in depth assessments of technology, economic and environmental factors may be another. Development and maintenance of public databases used in planning, analysis, modeling and decision-making may be a third.

California's energy policy development is informed by a variety of inputs, including public workshops, topical studies, public agency staff analysis and stakeholder processes relying on out-sourced engineering and staff analysis. California's research community contributes research results that from a host of individual researchers and a growing number of topical centers funded by Federal and state agencies. As the complexity and diversity of energy systems and solutions increases, and especially as renewable energy becomes a more prominent contributor, the policy development process could benefit from a more programmatic approach to funding analytical inputs to its policy process. The competitive framework for electricity sourcing presents an additional obstacle to planning in that the cost experience and technical plans of project developers and their vendors is closely held. Accordingly, policy development could benefit from access to independent and deep expertise in emerging renewable technology options, e.g. solar and wind, where innovation is continually reshaping commercial offerings and industry development. There is an opportunity to shape the further development and research agendas of California's renewable energy collaboratives to respond to these needs.

Recommendations – Question 3:

Competitive development and demonstration solicitations: The best application of PIER's competitive sourcing process will be to support work on solutions that need identification, piloting, continuous refinement, experience based maturation and scale-up over a period of decades. For example, a series of solicitations following on the initial RESCO solicitation could serve to provide on-ramps for new program participants, application of lessons learned in earlier projects and generally, the opportunity for program participants to have RD&D support consistent with their stage of preparation, piloting and deployment.

Research: PIER should aim to building up dedicated, mature RE research capacity in areas of current and long term need, e.g. assessments and related databases related to technology readiness, economic value analysis, cost monitoring and modeling, market research and environmental assessments. The dedicated research team supporting PIER should have the capacity to develop roadmaps and otherwise advise state policy and generally provide a credible an effective link to the broader national and global RE research communities.

Collaborative research relationships: The California Renewable Energy Collaborative should be tasked, and funded, to develop effective research collaborations with the National Renewable Energy Laboratory and California laboratories and research centers conducting renewable energy research. CREC should serve as window for the state on the progress of renewable energy technology and research globally and as a vehicle to assemble interdisciplinary teams to help chart California's RE Future. It is important to note that NREL and other public and private centers of renewable energy research are able to flexibly regulate their efforts according to the needs of their sponsors. The funding instruments that apply are basically annual budgets and operating plans rather than the traditional contracts used by government agencies to secure short term engineering and technical services.

Question 4: How does a scenario integrating a robust portfolio of RE supply options compare with a scenario that does not?

Figure S3 is an outcome of extrapolating current RE deployment trends in California into the future. This "current trends" scenario[c] assumes investment in

[c] Both scenarios summarized here define penetration percentage to encompass centralized and local deployment, regardless of RPS eligibility. They also accounts for the electricity equivalent of thermal RE applications as part of local deployment.

current plans to achieve RE deployment targets primarily by deploying centralized, variable supply in high quality resource areas lacking commensurate transmission capacity. While penetration for RPS qualified capacity in the current trends scenario may fall short of RPS targets, perhaps 20% overall penetration can be reasonably forecast by 2020. However, getting to 33% penetration, the currently proposed target for utility scale electricity alone, would is shown to occur after 2035 in Figure S2.

Decentralized supply is also shown to grow from the current base, albeit more slowly than centralized, primarily because it has less stable and effective policy support, and because decentralized projects face similar development requirements and time-scales but do not typically attract the development attention by globally active companies having access to strategic and “patient” project development capital.

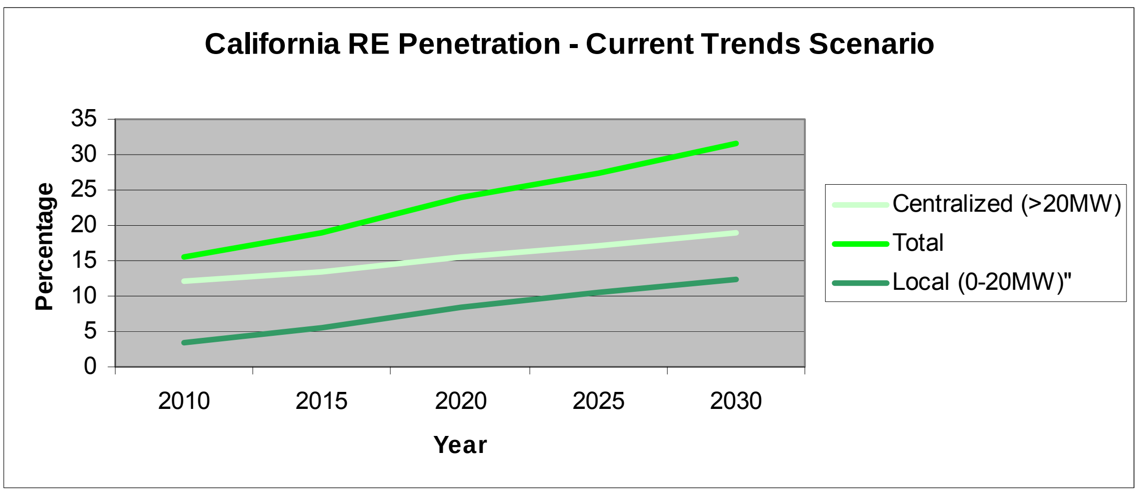

Figure S2…California RE penetration percentage in current trends scenario outlined above

Figure S3 presents total RE penetration estimates that assume policy support for the full menu of RE supply options shown earlier in Figure S1. These estimates also assume full and effective integration of utility, building and community scale deployment. The full menu scenario specifically assumes RE deployment will be facilitated by sources of investment and solutions currently on the sidelines. Figure S3 assumes investment as necessary to absorb variable RE supply more evenly across the energy system, coupling it with: 1) electricity storage and local base load RE resources, e.g. community scale bio-power, 2) demand suppression using natural gas enabled RE heating and cooling, 3) under-utilized two-way power flow capacity in the electricity distribution system, and 4) thermal storage-coupled central station solar power plants that more load new dedicated transmission capacity at higher capacity factors than can be achieved without high temperature thermal storage.

Figure S3 shows the relative contributions from utility scale, building scale and community scale deployment and reflects the mutual benefits of parallel deployment in these interconnected and complementary market domains.

Even though utility scale penetration does not reach 30% until 2030 in the full menu scenario, total penetration by that time exceeds utility scale penetration by a factor of two and also exceeds total penetration in the current trends scenario by a factor of two. Note that the RE penetration rates and levels shown in Figure S3 assume an early and decisive move by California to re-assert global leadership in RE deployment. Such a move is not under consideration at this time, but it does merit detailed definition and evaluation, particularly out of concern for California's long term economic competitiveness in an increasingly globalized economy. Depending on how long it takes to move to a fully integrated approach to RE deployment in California, total penetration results will fall somewhere between the total levels shown in Figures S-2 and S-3.

Note that uptake of renewable energy in the building and community market domains is shown in Figure S3 to be more rapid than uptake in the utility scale market in later years. This is likely to occur for several reasons, not least that smart grid technology will facilitate building and community level deployment; in addition, such deployment may enable accelerated utility scale deployment and therefore is likely to receive increasing policy support as RE deployment proceeds.

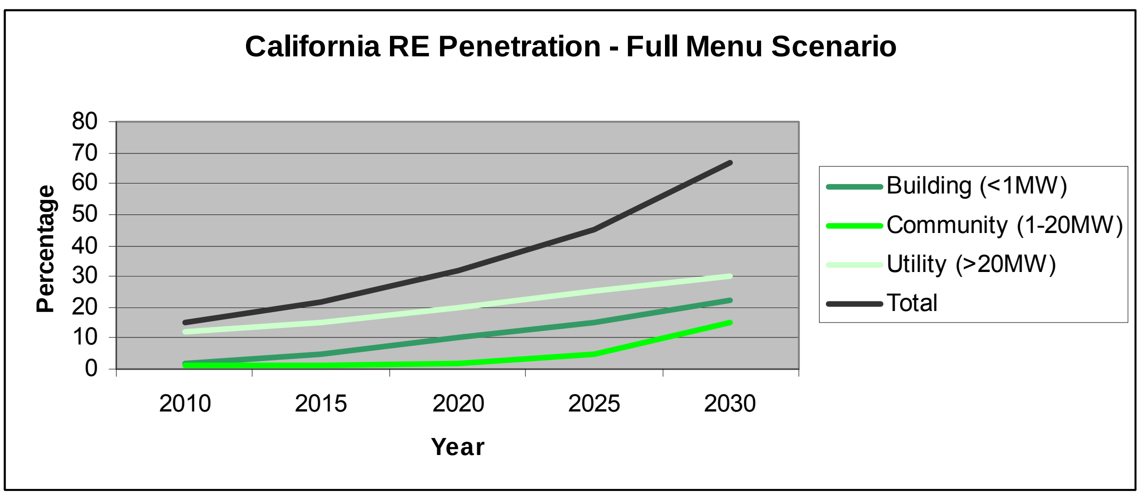

Figure S3…California RE penetration in the integrated, full menu scenario outlined in Table 1 of the working paper.

Recommendation – Question 4:

Long term, stable policy support for a "full menu" RE deployment scenario: Properly resourced efforts should begin immediately to identify a long term scenario supported by stable policy that features maximum cost-effective integration based on commercially available RE solutions. Stable policy is essential because some key elements of the scenario will take at least one and in some cases two decades to be deployed at scale.[d] The scenario should assume and include actions to ensure profitable industry capacity across the full spectrum of California RE resource/technology combinations and scales of end use aggregation. It should respond to US policy and legislative initiatives as well as to goals set in California law. California's potential role in piloting high penetration RE deployment for the nation should be addressed and steps recommended that would lead to California taking up this role.

What are the benefits, costs and barriers of a more integrated RE deployment approach?

Benefits: Both basic RE deployment scenarios referred to above involve integration, but the current trends model achieves integration only in the limited sphere of centralized plants and high voltage transmission. Integration benefits of the full menu approach include integration within and between deployment venues, e.g. deployment of hybrid RE/natural gas heating and cooling may facilitate better matching of aggregated supply and demand.

Costs: Integrated, full menu deployment would reduce overall deployment cost for a given level of RE penetration by:

- Locating a greater amount of RE supply closer to points of energy use
- Shortening deployment lead times by increasing the proportion of overall deployment that does not require new high voltage transmission corridors.
- Complementing and minimizing concentrations of new supply in areas not currently subject to industrial, commercial or residential development.
- Optimizing energy systems according to local resource opportunities
- Decentralizing energy infrastructure planning and investment
- By involving communities, creating stronger linkage between energy infrastructure planning and project permitting, resulting in better decisions on both sides.
- Unlocking additional sources of capital for RE deployment by encouraging community and building infrastructure investments that benefit from integrated RE.
- More efficiently deploying capital based on more numerous and geographically diverse project opportunities where long term operating costs are insulated from fossil fuel price volatility.

[d] For example, off shore wind deployment using technology suitable to California's relatively deep water resource areas is only in early development and demonstration stages at this time, and multiple stages of deployment will be required to acquire necessary experience and identify preferred engineering and environmental solutions.

Barriers: Inertia is the primary and most obvious barrier to an integrated approach. At the state-wide energy system level, inertia can be overcome by piloting and evaluating new finance and deployment models, and in parallel, by developing robust data collection and forecasting capacity supporting these models.

At the level of individual RE solutions, profitability is the key to overcome inertia. Profitable companies and industries can grow and thereby demonstrate their viability to investors, customers and policy-makers. Incentive programs designed to launch local and state industries but not provide permanent subsidies have been successful in other economies and may be needed to ensure a "full" menu of supply choices. Menus that emphasize a narrow range of project scales or favor one potentially viable RE industry over others may produce sub-optimal economic results over the long term.

In general, either-or choices do not harness the powers of diversity and integration. Thus, there is a need to move away from "either or" thinking in order to embrace "both and" thinking.[e] There is a need throughout the clean energy community to recognize that no single option or grouping of options, whatever its merits, can take the place of an integrated energy system where many solutions are used to best advantage as a result of being harnessed with one another.

Environmental impacts: An integrated approach to RE deployment, by opening all viable pathways, allows a broad and diverse base of experience to accumulate that can shape least cost, least overall environmental impact integrated deployment strategies of the future.

Recommendations – Question 5:

Vision for Renewable-Based Intelligent Energy Infrastructure: Models are needed that account for the trade-offs and efficiencies possible based on the explosion of real time data involved in full fledged "smart" energy infrastructure. More detailed analysis is needed to confirm and adjust (or refute and correct) the hypothesis that greater scale diversity combined with integration among and within utility, community and building scale deployment categories would result in significantly lower long term delivered energy costs.

Technology- and Scale-Specific Deployment Scenarios: There is a need for to understand the barriers and cost-effective accelerators of the individual options identified in Figure S1, both in order to realistically estimate penetration rates but also to identify environmental and industry capacity issues needing policy attention, e.g. technician training and product rating and system output metering in the case of RE heating and cooling.

[e] Either-or thinking can, for example, even take the form of raising the bar for renewable energy deployment in order to leverage increased energy efficiency investment.

- Each renewable energy option in Figure S1 has its own unique supply chain, financing methods, etc. There is a need for individual deployment scenarios for the individual options identified in Figure S1, both in order to realistically estimate penetration rates but also to identify environmental and industry capacity issues needing policy attention, e.g. technician training and product rating and system output metering in the case of RE heating and cooling.