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Integrated Approach to Renewable Energy Deployment in California: Solutions and Scenarios

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1…Introduction: In recent years the global renewable energy (RE) [a] industry has become one of the largest and fastest growing industries in the world. Investment increased by 450% in four years from 2004 levels. [b] At $140B in 2008, investment in RE exceeded investment in new fossil fuel capacity ($110B) for the first time.[1] 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 a level consistent with stabilizing climate change?"

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 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.[c] 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. Will California's energy efficiency investments alone support its intended climate change response if RE deployment remains stalled? Will current trends achieve for California what other economies are seeking to achieve by investing strategically in both energy efficiency and RE?

This working paper reflects the author's judgment that they will not, that the global shift to RE is driven by fundamental forces that are permanent, and therefore a course correction is needed that amplifies what the current approach

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[a] For brevity's sake the acronym RE is used consistently throughout to denote "renewable energy".
[b] according to the United Nations Environment Program, in 2008, with more than 65 GW (40 GW of new RE plus 25 GW of new large hydro) in new nameplate capacity, renewable energy overall represented at least 41% of total new power sector capacity globally.
[c] It also suggests the need for analysis of the political, economic and technical factors underlying California's current approach.

can deliver while changing the approach to be more integrative and to bring currently untargeted RE solutions into play.

The paper addresses, in a partial and preliminary way, the following questions:

1. Why is California RE power plant deployment stalled?
2. What technology, program and policy solutions are available to address this problem?
3. What is the role and scope of public benefits RD&D that would improve and remove barriers to these solutions?
4. How does a scenario that integrates a more robust portfolio of RE supply options compare with a scenario that does not?
5. What are the benefits, costs and barriers of the more integrated RE deployment approach?

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 examines the possibility of approaching RE deployment in California in a more integrated way in the future than in the past.

1.1…Why is California RE power plant deployment stalled?

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?

Perhaps 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. California's approach to RE deployment is 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.

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. The message to RE project developers is that California is willing to consider RE electricity purchases if they are priced at or below estimates of the future cost of electricity from natural gas based generation. However, in this case, 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 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 that may be assumed to favor timely project realization. Timely and predictable project development and execution schedules create an attractive context for investment at the early stages of a project where outcomes are less certain. California's RPS targets may not be receiving the level of costly project development attention necessary to achieve financial closure and move to construction of actual projects. Finally, California's mechanisms for sourcing energy supply are poorly adapted to certain commercially proven RE conversion solutions applicable to California resources, i.e. solutions that apply to community and building scale energy supply but are less well adapted to highly centralized deployment.

1.2…California RE Deployment Status: Part of the motivation for considering a more integrated approach is the current status of RE deployment in California which raises questions regarding the efficacy of the current approach, i.e. specifically:

- Deployment of central station solar, wind, bio-power and small hydro-electric facilities in the 1980s, in combination with prior geothermal deployment, accounts for the lion's share of current in-state renewable electricity supply.[d]

- California non-hydro RE electricity supply reached 26,000 GWh in 1990 and remained above 25,000 GWh until 1994.[2] In 2008 it was 25,083 GWh.[3] Meanwhile, according to Census Bureau statistics[4], California's population increased by close to 7 million, resulting in a 19% reduction in per capita grid RE electricity supply since 1990.

- Power purchase agreements totaling several GW of new central station renewable power capacity have been executed between project developers and California load serving entities since enactment of RPS legislation in 2002. There is no authoritative estimate of the amount and timing of actual deployment resulting from existing agreements.

- Deployment of rooftop solar electricity systems began in the 1990s and is accelerating in the framework of the California Solar Initiative, which is administered by the CPUC and the CEC.

- Deployment of other commercially available building and community scale renewable sources is not accelerating.

[d] According to California RE portfolio standard legislation, large hydro-electric facilities do not qualify as part of the state's renewable energy portfolio.

1.3…Integrated RE Deployment Approach Defined: What does the term "integrated approach" mean as applied to RE deployment? "Integration" is defined as "an act or instance of incorporating or combining into a (coordinated, harmonious) whole".[e] However, more is implied in the RE deployment context, e.g. completeness, balance, mutual adaptation, economic optimization, environmental compatibility, sustainability, etc.

Why is integration important? First, an energy system incorporating RE supply must function reliably. Second, it should provide maximum benefits at minimum cost and risk.

Portfolio theory applies to energy supply and infrastructure investments. For example, pre-restructuring[f] electric system planners sought an economically optimum balance among supply resources having different economic attributes. Peaking resources had low capital and high fuel costs – base-load resources had the opposite, and intermediate resources had intermediate capital and fuel costs. An economically optimum electric supply system required all of them in the proper balance, plus balance among the various fuel and hydro-electric sources flexibly manage fuel cost volatility and to dispatch the least cost mix of supply at a given time based on time dependent forecasted demand.

Some RE options have traditional base-load economic attributes; some have intermediate; none have peaking. Peaking requirements can be met with energy storage in its various forms, i.e. heat, cold, electricity, and heat and electricity potential of fuel.

Economies of scale of non-RE thermal power plants have historically resulted in emphasis on integration of large power plants and high voltage transmission.

However, RE deployment brings a relatively new dimension of cost-effective supply investment and integration to the fore, i.e. the opportunity to integrate large centralized supply systems with smaller RE systems sized according to the extent of high quality local resources, fuel transport costs or on-site demand. The need is to internally integrate RE based supply systems serving buildings or locally aggregated demand and also to externally integrate them with the larger existing infrastructure that includes centralized RE resources. Less centralized energy supply deployment also opens opportunities for closer integration of RE supply, end-use efficiency and smart-grid features.

1.4…Current RE Deployment Approach – Recommendation: There is an apparent need for systematic and transparent evaluation of factors enabling and impeding California's current approach to RE deployment**.** The above qualitative analysis points to issues in urgent need of clarification and resolution. What are

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[e] This comports with the first definition in the 1997 Random House Webster's College Dictionary

[f] The California electricity market was "re-structured" in the early 1990s as a means to create a competitive market for electricity supply. Restructuring put an end to planning for investor owned utility investment in power plants in their franchise areas.

the political, economic and technical factors driving California's current approach? Superficially, many 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 consistent with AB 32.

2… What technology, program and policy solutions are available to put RE deployment in California on track consistent with California legislation?

2.1…California RE Deployment Critical Issues - Discussion: Existing goals and policy trends affecting RE deployment in California raise three major questions:

1. What level of penetration of renewable sources into California's energy mix is technically feasible?
2. How rapidly can the overall RE contribution be increased prudently and cost-effectively.
3. How can public expectations for sustainable and low impact deployment best be met?

Answers to these questions form a working hypothesis, i.e. *an increasingly integrated RE deployment approach drawing from a complete menu of viable options can facilitate high RE penetration at low risk, while strengthening California's economy and immunizing local economies from energy supply and price dislocations.*

This hypothesis has intuitive appeal but nevertheless requires quantitative confirmation which in turn requires:

- In depth quantitative assessment,
- Deployment pilots,
- Technical integration demonstrations, and
- Reference to relevant integrated deployment experience outside California.

Even if confirmed analytically, integrated, full menu RE deployment represents a change in approach that will be resisted unless it is driven by a strategic vision having broad public support. Much depends on California's preferred role in US and global RE markets, e.g. as importer, exporter, innovator or a blend of all three. What would be the long term rewards for committed leadership and related investments? What is the price of such leadership, and to what extent can California afford to provide it or accept the risks involved in not providing it?

Reliable and up-to-date answers to these questions will require monitoring the growth and profitability of global RE industries, global and national mechanisms for the monetization of environmental costs, and trends in Federal regulation that enable or impede RE deployment.

The following list is suggestive of the economic and technical integration issues that will require thorough, detailed and sustained attention:[g]

- Understanding the sensitivity of cost (of capital and projects) to California industry capacity and internal competition, e.g.:
  - Understanding the European approach and experience jump starting profitable RE supply industries
  - Understanding the deployment consequences of California's current RE cost suppression strategy

- Minimizing cost of project capital in diverse ownership contexts, i.e.:
  - Public ownership
  - Investor ownership
  - Project finance, accounting for significant variations in weighted average cost of capital among RE solutions
  - Integrated finance, i.e. incorporation of RE supply in:
    - community infrastructure (e.g. water and waste-water systems)
    - new building envelopes and systems (e.g. electricity supply and storage, heat collection for combined water and space heating or combined cooling and heating)

- Maximizing cost-effective contribution from utility scale renewable sources
  - Storage deployment planning and strategy
  - Evolving role of natural gas driven by:
    - cap and trade and/or other carbon regulation
    - opportunities for cost-effective RE/NG hybrid solutions, e.g. especially in the context of building and industrial scale heating and cooling

- Portfolio optimization in relation to cost drivers including:
  - Resource supply curves
  - Progress curves of growth industries
  - Options subject to fuel logistics costs, e.g. biomass

- Assessment and deployment roadmaps for major emerging utility scale contributors, e.g.
  - Off-shore wind
  - Concentrating solar thermal power plants that include high temperature thermal energy storage

[g] Some are discussed in more detail in later sections and are subjects of an expanding body of RE integration analysis by technical consultants and national laboratory and university based research teams. The California-IRES website will provide links to selected research publications.

- Assessment, piloting and deployment of integrated community scale solutions:
  - RE powered micro- and min-utilities[h]
  - Centralized RE cooling and cold storage
  - RE District heating

- Maximizing cost-effective contributions from building-scale renewable sources:
  - Rooftop solar electricity for critical loads and electric and hybrid vehicle charging
  - All-electric solutions vs. hybrid solutions involving thermal sources

- Smart grid deployment strategies and outcomes:
  - Integrating real time RE supply and demand information to optimize economic operation of building scale and community scale RE systems
  - Open access to forecasts and real-time data for weather impacted RE supply, e.g. solar and wind.
  - Market models and value driven pricing for "dispatchable" RE supply at all levels of deployment

2.2…California RE Deployment Solutions - Discussion: California, like the US and other global economies, needs a strategic plan to ensure that RE supply options are taken up in the California market at the most economical and rapid rate. The key success factors for such a plan would be:

1. **Robust Portfolio:** "The full menu of renewable energy supply solutions is being fully exploited." Referring to Figure 1, this means that primary applications of applicable conversion technologies are receiving effective policy support and/or RD&D according to their development status and expected relative energy supply portfolio contributions.[i]

2. **Effective Scale:** "Where possible, primary applications are mature and demonstrated at scale in California, and related California supply chains and market frameworks are also operating at scale." Referring to Figures 2 and 3, a number of primary applications do not yet meet this criterion and in some important cases are receiving little or no RD&D or policy support.[j]

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[h] Sometimes characterized as to as "micro-grids"

[i] In cases of applications that have not been demonstrated, policy support would require on-going and rigorous monitoring of RD&D efforts funded by others, plus gap analysis to identify RD&D that would address resource, technology, economic and environmental feasibility and assessment questions as well as technology solutions of unique interest in the context of California's resources and markets. In cases of applications already commercially proven in California or other global markets, policy support would include determining and seeking to create conditions for industry profitability, growth and stability.

[j] In cases of applications that have not been demonstrated, policy support would require on-going and rigorous monitoring of RD&D efforts funded by others, plus gap analysis to identify RD&D that would address resource, technology, economic and environmental feasibility and assessment questions. Also

3. **Investment Plan:** "A long term (20 year minimum horizon) RE deployment forecast exists and is used in planning and policy development." Such a forecast would identify expected amounts, sources and timing of public and private sector investment in new supply, new infrastructure and RD&D. Such a forecast is not currently available.

Note that factors 1 and 2 are only partially met, and 3 is not being addressed. This should be considered in relation to the discussion of RE deployment status and progress in Section 1.

2.2.1…RE Technology Solutions - Discussion: Two categories of technology solutions need attention, each in near term and long term time frames:

1. **Conversion technology solutions – near term (2010-2020):** Lead times involved in development and commercialization of a fundamentally new energy resource conversion technology are nominally in the 20 year range. So, technologies contributing most or all of the new RE supply capacity over the next decade may be assumed to be those already being deployed commercially either in California or elsewhere. They are subject to incremental innovation driven by production and deployment experience. Their further maturation will also be driven by opportunities for technical mitigation of environmental and carbon impacts. Technical mitigation of grid integration costs will be driven by market competition in the case of wind and solar.

2. **Integration technology solutions – near term (2010-2020):** As with near term conversion technology solutions, technology to accommodate expanded RE deployment is already being deployed in transmission operations centers. Technology to expand the carrying capacity of existing corridors is also on the horizon.[5] Diffusion of advanced SCADA and forecasting capability will begin at utility scale and later begin to couple with smart grid metering and demand response capacity at the end use level. Eventually such capability will drive automated real-time dispatch of RE sources down to the community and customer level.

3. **Conversion technology solutions – long term (2020-2050):** Technology variations will be introduced that expand the accessible resource base for wind, geothermal and bio-power. Likewise a variety of high temperature thermal energy storage configuration solutions will be available to allow utility scale solar resources to deliver increasing levels operating flexibility and eventually full block loading dispatch.

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required would be identification of technology solutions of unique interest in the context of California's resources and markets.

4. **<u>Integration technology solutions – long term (2020-2050):</u>** Energy storage will be the locus of integration technology solutions in this time frame, including compressed air storage that is either co-located or located independently of utility scale sources. Vehicular battery storage may come into play in support of local reliability as well as ground transportation efficiency. Diffusion of advanced SCADA and forecasting capability will accelerate and extend to community scale energy systems configured around distributed RE and NG sources and efficient, smart grid coordinated end uses.

√ = 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		**√**	**√**

<u>Figure 1… RE conversion options organized according to application scale</u>

<u>2.2.2…Candidate RE Conversion Technology Solutions:</u> As suggested in Figure 1, generic groupings of RE resource conversion technologies applicable in California are numerous. Each has vendor-specific variations. Applications scales often span wide ranges, and site constraints result in additional variations. A recent PIER funded effort by KEMA[6] provides a technical and cost overview of groupings of RE solutions organized according to application scale.

The study assessed not only current costs but also cost drivers and future costs and considered them in the context of pricing bench-marks. Most importantly, it focused on solutions for which there is sufficient basis in commercial experience to inform accurate cost and performance related assumptions. Results will be published as part of a final report containing more detailed cost analysis for utility scale RE supply options.[7]

Resource data is available to inform site selection and deployment of RE resource conversion options in California. Solutions are proliferating as the global market expands and drives innovation…they are subject to significant incremental innovation in cases where industry growth is rapid. Because maturity varies from solution to solution, individualized attention is required in terms of site selection, permitting, operation, etc. Regrettably, regardless of their merits and benefits to California, some generic groupings of options continue to face daunting market entry and expansion barriers. This condition may be expected to persist until effective policy measures are implemented to encourage their deployment. Recent bio-power deployment experience illustrates this point.[8]

C = Commercial	Deployment Venues		
E = Emerging	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	C	C	
Geothermal Power	C	C	
Hi Temp Solar Thermal	C/E	C/E	E
Biomass Power/CHP	C	C	C
Ocean/Wave	E	E	
Solar PV	E	C/E	C
DG Wind		C/E	C/E
Solar Heat & Cooling		C/E	C/E
Direct Geothermal		C	C
Geothermal Heat Pumps		C	C
Cellulosic Biofuels	E	E	E

Figure 2…RE conversion options organized according to commercial readiness

C = Capable	Deployment Venues		
D = Developing	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	C	D	
Geothermal Power	C	D	
Hi Temp Solar Thermal	C/D	D	D
Biomass Power/CHP	D	C/D	D
Ocean/Wave	D	D	
Solar PV	D	C	C
DG Wind		D	D
Solar Heat & Cooling		D	D
Direct Geothermal		D	D
Geothermal Heat Pumps		D	D
Cellulosic Biofuels	D	D	D

Figure 3…RE conversion options evaluated according to industry capability and maturity.

Impact of delivered energy cost at the integrated system level is a key differentiating factor among the conversion technology solutions, just as it will be among the integration solutions that will emerge as RE penetration increases. In spite of recent progress in assessing RE project costs and performance[9], there is not commensurate progress toward accurately assessing integrated deployment cost, at least not yet in the California context.

A discussion of cost assessment needs is provided as Appendix A. In summary, there is a need to assess cost in relation to economic value to an integrated energy supply and delivery system and in two dimensions, project cost and weighted average cost of capital. Fortunately, the tools to accomplish the former were in routine use by system planners prior to California market restructuring. They can and should be adapted for detailed near term forecasting and cost optimization purposes. For longer term strategic planning purposes, more generalized and resource data driven models are being developed by NREL and others.[10] They are being used in scenario analyses related to lowering carbon emissions targets at the national level. Some appear to have the potential to be adapted for use in California scenario analysis

2.2.3…RE Deployment Program Solutions - Discussion:

Utility scale RE deployment is moving ahead far too slowly and with far too much risk to investors and to the public interest in program success. Risks of contract failure and program failure appear to be mutually reinforcing. Project cost in most cases will be driven at least in part by risk and delay.

2.2.3.1…Need for Utility Scale RE Deployment Program Course Correction:

The current California RE deployment program must begin to differentiate between projects involving technology not yet demonstrated at scale and projects employing more mature solutions. The state has an interest in nurturing innovation without making a default assumption that all contracts are equally likely to be fulfilled. Transmission investments should be linked to projects for which financing is demonstrably available on terms consistent with PPA pricing. Public (Federal or state) cost sharing of projects requiring major scale-up from current commercial experience should be made available, especially in cases where long term savings forecasts have a credible basis and where PPA terms provide for recapture of the public cost share. Public benefits RD&D funding of independent scale-up risk assessment should be an integral part of the overall program.

2.2.3.2…Need for Building scale RE Deployment Program Expansion:

Building scale RE deployment programs should be expanded to address RE heating and cooling as effectively as they now address RE electricity. This will have the effect of broadening California's RE portfolio and creating a parallel RE deployment supplementing and complementing utility scale deployment that is currently stalled and energy efficiency programs that are funded by California ratepayers[11]. 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.[12],[13]

2.2.3.3…Need for Community Scale RE Deployment Roadmap and Program: As a complement to utility and building scale deployment programs, California should have a community scale RE deployment program that is supportive of the clean and locally sustainable energy supply aspirations of dozens of California communities. A roadmap for such a program should be developed with their full participation and should draw on the lessons from PIER's RESCO program. It should not, however, be limited to RD&D measures. California legislation that was intended to enable communities to influence their own energy futures through RE deployment appears to be having no effect, and there is a need for trouble-shooting and corrective action, including creation of alternate pathways less burdensome to California investor owned utilities. For example, one such pathway that should not wait for an overall roadmap is community net metering.[14]

2.2.4…Need for RE Deployment Policy Review: The term "policy" is generally defined as "a course of action". California policy would reasonably be a course of action determined by California government. What can be inferred about policy if a course of action is determined but no action ensues? Does action, or inaction, speak louder than words?

Based on actual courses of action, we might infer that California's energy policy is to fund efficiency programs to minimize energy intensity of the California economy[15] while expanding natural gas supply and conversion infrastructure as needed to meet increases in overall energy demand[16]. We cannot draw inferences about current US policy except to say that recent economic recovery related adjustments in US investment and production tax credits and other tax code provisions pertaining to RE do create windows for more profitable project development. Combined with emissions trading frameworks before Congress, these adjustments have, and may continue to have, the effect of increasing project developer and investor interest in opportunities to sell RE electricity for delivery in California.

The fundamental policy solution not yet in place is to create a stable and predictable investment environment for parties having a strategic need to invest in RE deployment and also having access to low cost investment capital. These include commodity energy suppliers that utilities and utility scale project developers, communities and incorporated entities with bonding capacity, and property owners. At this time a stable and predictable investment environment exists only for utilities. However, their weighted average costs of capital are relatively high in the utility scale RE deployment environment.

2.3…Integrated RE Deployment Approach - Discussion: Consideration of RE deployment patterns in Europe and elsewhere reveal 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 1.

Integration is essential to managing diversity, i.e. to exploiting the benefits and complementarities of a diverse portfolio of RE supply solutions. Like diversity, 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 exploits the opportunity to optimize the economic performance of a state-wide energy system that includes a mix of large centralized RE supply systems and a potentially even more diverse mix of decentralized RE supply systems serving communities and buildings. Figure 4 summarizes German experience with RE heating and cooling and suggests the extent of this additional diversity.

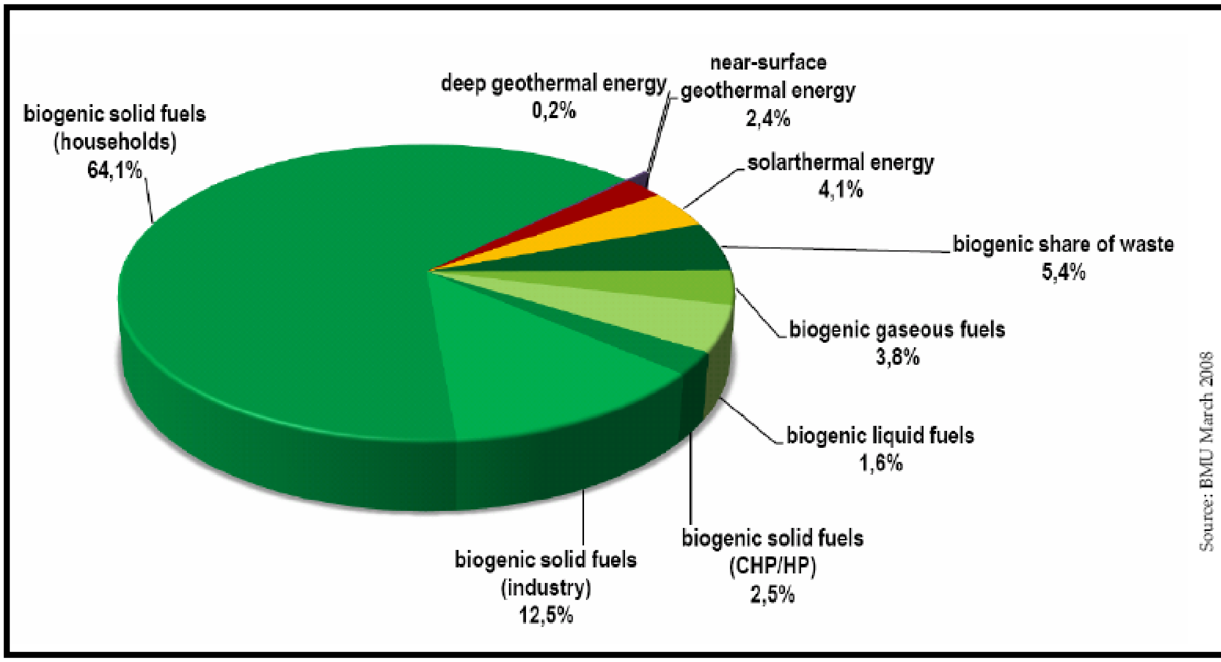

Figure 4…Renewable Heat Supply in Germany[17]

Community and building scale RE supply systems are sized according to the extent of high quality local resources, fuel transport costs or on-site demand. They serve buildings or locally aggregated demand and are internally integrated. 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. [k]

There are even deeper levels of integration that offer their own economic rewards, including the RE integration topic currently attracting the greatest amount of policy discussion, 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.

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, and 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.

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[k] As noted in Section 3.2.3.2, 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.

2.4…RE Deployment Solutions - Recommendations:

2.4.1…Deploy RE heating and cooling solutions: A program should be initiated and funded to target deployment of RE heating and cooling in the same time frame and with comparable (or greater carbon) emissions impact as building based solar electricity, i.e. targeting carbon emissions displacement equivalent to 3GW of solar electricity deployment. Geo-exchange heating and cooling should be included in the scope of the program to ensure that it begins to receive policy equivalent to that historically accorded to other HVAC energy efficiency measures.

2.4.2…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 and 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 legislature for consideration in the context of existing RE deployment legislation.

2.4.3…Develop and fund a permanent program of RE economic research: Such a 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 the 2009 IEPR process and should address the issues identified in 2009 IEPR workshops and in Appendix A related to RE costs.

2.4.4…Initiate and complete a review of alternative policy solutions: The most fundamental and desirable policy solution for the slow pace of RE deployment in California is to create a stable and predictable investment environment for RE deployment. An independent panel should be organized to address this question and submit its findings for inclusion in the next update of California's Integrated Energy Policy Report.

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

3.1…RE RD&D Role – Introduction: Public benefits funds for RE RD&D are under managed by the California Energy Commission. The Commission recently embarked on new development and demonstration programs that target RE technical integration solutions demanded by the integrated, full menu RE deployment approach discussed in this paper. These new programs are briefly described in Appendix C.

In general terms, the new programs are intended to fill gaps in the array of solutions that will be needed as California RE deployment proceeds and accelerates in future decades.

In parallel with its new development and demonstration programs, PIER is looking to the California Renewable Energy Collaborative to develop a research agenda that will systematically address fundamental questions on which long term deployment cost minimization will hinge, i.e. questions that resource, technology, market, economic and environmental assessment and modeling can resolve.

3.2…RE RD&D Role - Discussion: RE RD&D can be viewed as a fourth "solution" area along with commercial RE solutions, RE deployment programs and RE deployment policy. Appendix C contains relevant background and a discussion of factors determining the best role for public benefits RE RD&D.

Based on current global trends, the 21st century will likely feature a fundamental re-engineering of global 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 deluge of new market and finance entrants along with an unprecedented wave of investment capital backing 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. The cost and availability of project capital for project execution has experienced exceptional turbulence. As a result, it is a new ball game for public benefits RE RD&D programs seeking market connectedness and relevance.

Accelerating changes in global RE industries and markets require commensurate changes in public benefits RE RD&D programs seeking market connectedness and relevance. For example these programs must be attuned to the pace and magnitude of Federal and global RE RD&D investment. What will it take to maximize the benefits to California of USDOE RE RD&D expenditures which now exceed PIER expenditures by a factor of 300 at current Federal RD&D investment rates?

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. Perhaps, if funding of utility R&D programs were to resume, it could be.

In relation to RE deployment activity in California in the past decade, Energy Commission funded RD&D may have been at the right level. However, at deployment levels consistent with California targets, current public benefits

RD&D funding levels will not attract the interest of industries most actively involved in deployment.

If public benefits RE RD&D cannot scale with deployment investments, then it must be more focused than in the past, i.e. 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.

As an alternative to sourcing topical studies through support contracts, an important element of strategy for policy driven RE research should be to provide long term stable funding to world class research teams. These teams should have having the capacity and imbedded expertise to respond quickly to important technical questions and problems as they arise. Their mission should be develop and exercise organizational capacity to address critical deployment issues.[1] For example, independent and objective technology scale-up and project viability risk assessment should be an integral and continuing part of California's utility scale RE deployment program. As long as power purchase agreements are the only avenues available to technology developer seeking access the California RE market, contract failure risk will be a costly and disruptive factor for California's RE deployment program. It will require active management based on technically sound and independent advice.

3.2…Role of RE RD&D – Recommendations: PIER's new RE programs also can be a complement to the California utility and industry RD&D investments. Specifically:

- **Technical integration leadership development:** PIER should develop the capacity to manage RE technical integration development and demonstration investments programmatically. Technical leadership development should be emphasized along with maintenance of technical contract management excellence. Without it PIER funds cannot be effectively leveraged.

- **Program-coupled RE research capacity:** PIER should support the development of program-coupled research capacity at the California Renewable Energy Collaborative as a complement to the excellent education-coupled research capacity already in place. Collaborative research relationships should be established in order to apply NREL expertise and capacities to California-specific questions. The goal should be to create a cadre of California researchers able to focus on California-specific questions and needing sustained long term attention.

[1] National laboratories play a similar role in a national program context.

- **Utility RE RD&D programs and teams:** PIER RE RD&D is under-resourced in relation to targeted RE deployment investment, venture capital investment, etc. California utilities should be allowed and encouraged to proceed with RE RD&D targeting and piloting utility scale research experiments, prototypes and demos in collaboration with the USDOE, vendors, other utilities and utility funded research institutes. In parallel, PIER might then focus on earlier stage and longer term RD&D where it could have a greater impact. PIER should continue to advocate funding of utility RE RD&D programs and teams.

- **California university and national laboratory RE research:** PIER RE programs are among a fragmented, proliferating and uncoordinated array of California based programs, laboratories and university based research centers. They involve overlapping pre-commercial RE RD&D missions, most of which lack a stable funding base. PIER, in consultation with CREC, might consider how a portion of its RE RD&D investment could be directed toward effective facilitation of collaboration, information exchange and industry engagement by and within this burgeoning research community.

- **RE innovation technical assistance:** For a variety of reasons, including the tens of billions of dollars otherwise available for RE RD&D programs and projects, PIER competitive solicitations and agreements no longer attract proposals from strongly market connected organizations and teams. However, response from California parties interested in deploying RE solutions but lacking RD&D capacity has been strong…..e.g. the large number of proposals generated by the first RESCO solicitation. PIER should consider this experience in prioritizing further RE RD&D investment.

- **Targeting results for relevance:** The "time constant" for scale, technology and cost changes in RE applications and markets has shortened dramatically in recent years. This means public benefits RE RD&D programs must either accelerate the pace of their programs and projects or set their sights on longer term goals. For the sake of example, consider projects that target one sequential step in a development and demonstration sequence, e.g. a successful operation of bench scale prototype. In the current PIER framework, such a project might consume several years from initial scoping, through budgeting, solicitation, contracting, project execution, and project wrap up. Relative to the pace of change in global RE industries the project would be at considerable risk of being over-taken by technology and market shifts occurring independently at a much faster pace.

- **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 participant to have RD&D support consistent with their stage of preparation, piloting and deployment.

- **Research:** PIER should aim to build 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. A dedicated research team supporting the PIER RE Program should have responsibility monitoring technology trends and updating technology roadmaps, while providing a credible an effective link to broader national and global RE research communities.

- **Collaborative research relationships:** The California Renewable Energy Collaborative should be expected, and funded, to develop strong and durable research collaborations with the National Renewable Energy Laboratory and California laboratories and research centers conducting renewable energy research. CREC should serve as window for California on the progress of renewable energy technology and research globally. In the near future it should tale the lead in assembling interdisciplinary technical teams to envision California's RE Future.

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

4.1…Integrated Deployment Scenarios - Introduction: Utility scale integrated RE deployment reached its zenith in the 1980s in California. As RE deployment occurred in the PURPA framework, operational integration was achieved along with supply diversification, but the planning element of integrated deployment was clearly missing. By the end of the decade California had the most diverse and integrated electricity supply infrastructure in the world. Utility deregulation, or "electricity market restructuring" as it is now referred to, substituted a generation expansion mechanism well adapted to deploying new utility scale natural gas generation resources. Progress toward cost-saving distributed generation and storage deployment was curtailed and utility RE RD&D efforts were terminated.

In the context of pre-restructuring experience, renewable energy integration is actually not a novel, nor especially daunting, issue at current or likely near future penetration levels in California. Smart grid initiatives notwithstanding, the transmission system is actually quite advanced – driving intelligence down toward the customer level is what smart grid progress will be mostly about in the near term. There are, however, avoidable though still plausible, scenarios that would impose stringent conditions on transmission system planning and operation sooner than otherwise. These include:

- Continued RFO contracting for power from utility scale wind and solar plants lacking even short term storage capacity. While the historical paradigm considers bulk energy storage to be a natural "system resource", the actual planning and deployment of "system resources" in California stopped approximately 20 years ago and has not been reactivated.[m]

- Deployment of utility scale wind and solar plants to comparable penetration levels throughout the western grid. Absent system storage, this could eventually result in periods when regional RE supply exceeded regional electricity demand.[18] In this case, California could not count on the ability to off-load excess in state solar and wind supply into other markets[n].

Targeted future deployment patterns that include utility scale RE can be viewed as a resumption of supply portfolio diversification that was interrupted by a wave of natural gas generation deployment in the past two decades. Mechanisms are not yet in place to resume integrated deployment according to past practice, i.e. deployment that creates a balanced, diversified supply portfolio that is robust, i.e. 1) significantly insulated from fuel supply and price dislocations, and 2) in which each supply resource contributes to the economic optimization of the whole electric system.

How could or should future integrated RE deployment differ from integrated RE deployment in the past? What are the likely and/or desirable scenarios?

4.2…Integrated RE Deployment Scenarios - Discussion: Scenario development is already underway in two particularly relevant contexts:

4.2.1…USDOE Renewable Energy Futures Study[19]**:** This effort can be characterized as an attempt to determine the feasibility of long term high penetration RE deployment on a national scale that is consistent with carbon caps contained in climate change mitigation legislation that may be enacted in the US Congress. The term "high penetration" is intended to characterize the result of a forty year RE deployment that transforms our total national energy supply from carbon based to 80% RE based. Such a transformation would require an order of magnitude increase in domestic RE supply.

Because scenarios developed in the study will be influenced by both technology progress expectations and the carbon emissions allowance levels and allocations in legislation, they will reflect a business as usual bias as to the role of incumbent industries and a transformational bias as to the effects of RE RD&D. In any event the models and data used in the analysis have considerable potential

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[m] California adds resources to its electricity system based on competitive processes, and it is highly desirable that these processes deliver the right mix of resources, including storage coupled solar and wind plants. The value of such plants in a baseline 33% RE penetration scenario should be determined and used to evaluate bids from solar and wind plants that include "dispatchable" storage.

[n] The Western Solar and Wind Integration Study did not fully account for RE deployment in California or power exchanges with California but did identify the need to do so.

applicability to more detailed and near term oriented analysis individual states may undertake. States will need to understand the consequences of Federal legislation and establish policies that position their economies to benefit from Federal policies and investments.

4.2.2…California Renewable Energy Transmission Initiative[20]: This effort is creating scenarios for utility scale RE deployment in areas lacking existing generation resources or requiring expanded transmission capacity to permit interconnection of additional RE supply. Because scenarios developed through the RETI process will be influenced by considerations of near term investment cost and specific environmental constraints, they too will reflect a business as usual bias as to the role of project developers, utilities and economic regulators.

In both cases RE deployment scenarios are being structured according to generalized assumptions regarding generic supply options. The overall RETI purpose is to create a level of confidence regarding the likelihood and timing of both RE project development and transmission corridor development. If it meets this purpose, it will result in financial bets being placed and stakes being raised to a level that will likely impact state policy and RE deployment investments.

4.2.3…Need for integrated approach: There are good reasons to consider an integrated approach to RE Deployment:

1. Consideration of RPS implementation to date leaves considerable doubt as to whether and when RPS targets for utility scale RE deployment will be reached.

2. The US is already considering levels of RE deployment nationally that exceed California's targets and is making RD&D investments accordingly.

3. Even if US climate legislation and national RPS legislation before Congress were to be abandoned, the California energy market is not insulated from a major transformation in global energy markets that may be in store in any event. This market is likely to involve renewable energy deployment that is pervasive and not limited to central station electricity generation facilities.

An integrated approach to RE deployment considers not just what to deploy and where but at what scale with what sources of capital investment. Major questions that will eventually demand economically sensible answers can be anticipated and addressed by considering an integrated approach.

For example, PV deployment on residential rooftops appears to require only modest and probably temporary state subsidies, in part because residential and even commercial system owners have access to relatively low cost capital. Utility scale PV deployment would benefit from modest scale economies and therefore incurring lower capital costs per unit of installed capacity and better plant performance in some remote areas. However, it still might require higher subsidy levels over longer periods based on the costs of capital inherent in utility or project finance.[o]

So, there are important questions. What is the best mix of rooftop PV vs. utility scale PV based on total deployment costs and the state's capacity to subsidize early stages of deployment? Where does community scale PV fit in the optimum mix? Answers based on independent integrated analysis will be a better guide than intuition in such cases.

4.3…Scenario Development - Discussion: Enabling and limiting factors will how California can, should, and will deploy renewable supply in the future. Briefly, some important examples include:

4.3.1…Enabling Factors: A major enabling factor is experience based on existing deployment. California has, arguably, the most complete and high quality of renewable resources in the world. A separate analysis will assess these resources and related technologies. California invests in environmental protection and sees deployment of renewable energy as a means to sustainable economic development at the community level. California embraces energy efficiency. It could also embrace building scale RE supply that complements energy efficiency investments. Finally, California's economy is large and robust, as is its industrial base, creating favorable conditions for project finance, construction and operations.

4.3.2…Opposing factors: California's energy infrastructure, while robust and flexible, is also extremely large and complex, creating inertial resistance to changes that would add complexity or require attention to decentralized options and industries. An impressive menu of nation-scale issues distracts state attention from sustained and effective follow through on goals that require significant change or that would inconvenience powerful interests.

4.3.3…RE Deployment Scenarios: Scenarios should account for current trends as well as decisions that could put California RE deployment on a new path. Accordingly, two scenarios have been defined:

- **Current trends:** This scenario reflects current trends and postulates their extension into the foreseeable future.

- **Integrated, Full menu:** This scenario recognizes that RE deployment in California is currently constrained to occur in a market context in which the major active RE markets are limited to; 1) the supply of wholesale electricity to the state's utilities, and/or 2) on-site uses of solar electricity that depend on incentive programs administered by the state's investor owned and publicly owned utilities. The term "integrated, full menu" refers to strategic

[o] Sandy Miller, with the California Energy Commission Renewables Office, has raised this issue, and it deserves careful evaluation in the context of maximizing California's return on its RE deployment investment.

deployment of the viable but under-utilized community and building scale RE solutions identified earlier in Figures 1, 2, and 3. This scenario assumes there is incremental demand for renewable energy outside existing market constructs. It also assumes such incremental demand could be served by a mix of community and building scale RE supply based on locally accessible resources unlikely to be exploited through existing utility power purchase arrangements.

4.3.4…RE penetration percentage: In the scenarios discussed in this paper, RE penetration percentage is defined as "actual electric plus equivalent thermal energy" supply divided by "total electric plus equivalent thermal supply". Equivalent RE thermal energy supply is a factor in both scenarios, but a much more significant factor in the full menu scenario. "Current trends" do not include significant programmatic or policy support for expanded RE heating and cooling and RE industrial and agricultural process heat supply.

Other than electricity generation that would be directed to charging of electric and hybrid vehicles, transportation uses of RE is not considered in either the full menu or current trends scenario. Bio-fuels market growth is occurring, especially nationally and globally, but in the context of resource limitations and competing sectoral demands. Clear trends have yet to emerge regarding California market up-take of bio-fuels and also regarding relative proportions of fuel imports vs. in-state production.

Further, it is unclear whether Federal policy regarding bio-fuels will emphasize surface transportation markets or aviation markets. In any event current trends suggest that indigenous California biomass resources will serve in-state bio-power markets for the foreseeable future rather than in-state bio-fuel markets. Thus, "current trends" assumptions render transportation RE deployment mostly a potential outcome of Federal rather than state policy and market dynamics.

4.3.5…Current trends RE deployment model: In this scenario, the proportion of California's electricity supply based on natural gas conversion continues to increase according to the logic presented in the 2009 Integrated Policy Report proposed for adoption in December, 2009.[21] The report argues that additional deployment of utility scale solar and wind resources will create problems for transmission system operators that will need to be mitigated by additional strategically sited natural gas fired power plants.

Increasing the proportion of natural gas based generation, combined with assumptions that energy efficiency programs will constrain demand growth and even lower overall demand creates doubt regarding the scale of further RE deployment in California. Related uncertainties may weigh against the transmission system expansion needed to facilitate utility scale RE deployment. Further, the scale of RE deployment theoretically possible based on contracts in place has raised environmental concerns that may impede licensing and deployment until they are resolved to the satisfaction of relevant decision-makers and interests.

California's RE RFO process has produced a large and growing number of power purchase agreements for solar, wind and other RE projects. In spite of the potential for a high percentage of contract failures and permitting delays, it is reasonable to assume that significant additional utility scale RE capacity will come on line over the coming decade. A current trends scenario for RE deployment in California would also assume some level of continuing PV deployment under the terms of the California Solar Initiative. It would further assume some steady state PV market activity thereafter, perhaps comprising a mix of rooftop and centralized deployment. Community scale deployment, while a matter of strong and growing interest among local jurisdictions, is currently stalled by lack of effective policy support. Based on current trends it is reasonable to assume there will be no near-term remedy.

It is also reasonable to assume that new legislation confirming a 33% RPS target will not necessarily result in an acceleration of deployment unless accompanied by legislative actions that materially change the pace of project deployment or project economic attractiveness. Such actions are not on the horizon. Current trends include the effects of a five to ten year bubble of near term deployment that may be stimulated by the temporary Federal tax incentives embedded in economic stimulus legislation. The scenario assumes California deployment will be enhanced but not driven by this factor.

4.3.6…Full menu RE deployment model: Some significant considerations argue for a change in deployment strategy. They include:

- California's implementation of AB 32 combined with implementation of pending Federal GHG cap and trade legislation.

- Awareness and response to state, community, local business and individual economic sustainability risks and opportunities, e.g.:

    - As a matter of risk management, California communities, businesses and individuals whose economic competitiveness is significantly influenced by energy costs may turn their attention to community and building scale renewable energy supply, coupled with energy efficiency measures, in order to insulate themselves from potentially volatile and unpredictable grid electricity and fossil fuel costs.

    - As a matter of strategic economic opportunity, California may consider exploiting its high quality RE resource base in order to position the state and its industries as leading exporters of renewable energy products. Europe and Japan have amply demonstrated that strong domestic markets for RE solutions result in industrial capacity able to compete successfully in global markets.

- As a matter of managing the long term cost of energy supply to the state economy, it may be shown that the current leisurely pace of deployment is not optimum. It may also be shown that a combination of resource diversity and deployment scale diversity creates the best energy supply portfolio for California. The ability to move forward with deployment at the community and building scale may be the best incentive for industries invested in the utility scale segment of the California energy to deploy RE resources in the most timely and economic manner possible.

An integrated full menu RE deployment scenario would assume that the above considerations have the effect of accelerating deployment of not only utility scale but also community and building scale RE supply as suggested in the scenario outlined in Table 1.

4.5…Scenario Results: The figures below provide a technically informed and intentionally thought provoking guess as to quantitative scenario outcomes. They are offered primarily to suggest the direction and need for further analysis.

4.5.1…Current trends RE Penetration: Figure 5 is an outcome of extrapolating current RE deployment trends in California into the future. As mentioned above, it defines penetration percentage to encompass centralized and local deployment, regardless of RPS eligibility. It also accounts for the electricity equivalent of thermal RE applications as part of local deployment. While RPS qualifying penetration may fall short of RPS targets, 20% overall penetration can be expected by 2020. However, getting to 33% penetration, the currently proposed target for utility scale electricity alone, would occur after 2035.

Figure 5 introduces the counter-intuitive possibility that California may neither lead nor lag other states in future RE deployment. Two factors can be suggested that may significantly alter this scenario, accelerating deployment in one case and retarding it in the other:

- Stable national or state programs that provide tangible economic incentives for RE deployment would have an accelerating effect. There is little precedent for such programs, although California's PURPA implementation program was sufficiently stable for long enough to drive significant deployment.

- On the other hand, national programs providing tangible and stable incentives could actually slow deployment in California if project development resources were allocated to viable markets in other states. This would occur if other states were judged to afford shorter project development lead times and greater certainty regarding utility scale project licensing and permitting.

	2010-2015	2015-2020	2020-2025	2025-2030
Electricity Use	- solar displaces 20% of electricity for water heat - all new water heaters are at least 50% solar on a measured annual basis	- geo-exchange cooling in 20% of new commercial buildings - solar displaces 50% of water heat electricity	- solar displaces 75% of electricity for water heating - no electric resistance space heating	- 20% RE share of EV/hybrid vehicle charging by building based renewable electricity
NG Use	- NG use for power generation capped at 2009 levels beginning in 2014	- 50% of NG water heater replacements are solar	- 100% of NG water heater replacements are solar	20% of NG use supplements primary RE supply
Smart Grid	- pervasive but under-utilized capability for two-way grid/building communication	- majority of distribution sub-stations are “smart”, resulting in “ISO-like” automated supp./demand coordination capability	- “real time” pricing information available to all electricity/NG users @ feeder level.	- web-based open access to real time RE resource and delivery status and forecasts at all sources, including buildings
USRE (Utility-Scale Renewable Energy)	- USRE share increases from 12% to 15% - 10% of new wind/solar deployment includes energy storage	- USRE share increases from 15% to 20% - 50% of new wind/solar deployment includes energy storage	- USRE share increases from 20% to 25% - geothermal = 4000MW - 10% of wind total is off-shore	- USRE share increases from 25% to 30% - geothermal = 5000MW - 50% of wind total is off-shore
RESCO (Renewable Energy Secure Communities)	- “Munis” pilot community micro-grids - IOUs implement community net-metering	- RESCO share increases to 2% - Pilot programs for direct access to RE supply	- RESCO share increases to 5% - Full implementation of RE direct access	- RESCO share increases to 15% - RESCOs market excess supply
RESB (Renewable Energy Secure Buildings)	- RESB share increases from 2% to 5% - 20% of RESB share from net positive RE supply buildings (1)	RESB share increases from 5% to 10% - 40% of RESB share from net positive RE supply buildings	- RESB share increases from 10% to 15% - PV/battery supply of critical loads standard in new buildings	RESB share increases from 15% to 22% - 60% of RESB share is from net positive RE supply buildings
Note 1: Net positive RE supply is interpreted to mean that renewable energy production in or on the building exceeds building energy use and allows the building to be a net exporter of energy.				

Table 1…Full Menu RE Deployment Model Assumptions

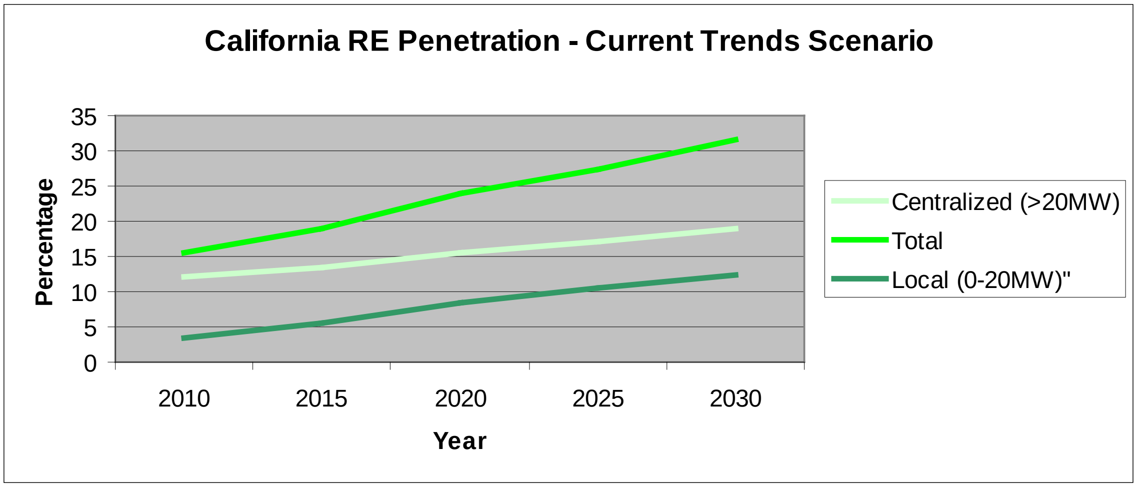


Figure 5…California RE penetration percentage in current trends scenario

4.6.2…Integrated, Full menu RE Penetration: Figures 6 and 7 offer an outlook or expectation that California's RE deployment will be facilitated by sources of investment and solutions currently on the sidelines. Figure 6 shows the relative contributions at the three deployment scales indicated.

RE penetration rates and levels indicated in the Figure assume an early and decisive move by California to re-assert global leadership in RE deployment. Such a move is not even an active possibility 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. By combining centralized and local PV deployment and also accounting for thermal RE applications as part of local deployment as in the current trends scenario, 20% penetration can be expected by 2020. However, getting to 33%, the current target for utility scale electricity alone, will take much longer, even beyond 2035. The major factors affecting the pace of this scenario include those discussed above, plus unprecedented changes in California's energy infrastructure and markets:

- Implementing the integrated, full menu scenario would require a decision to not only allow and encourage deployment of decentralized energy supply, but also to support efforts to pilot and actively facilitate deployment of integrated renewable energy systems at the community and building scale.

- The timing of such a decision will determine when sustained acceleration of RE deployment in California begins.

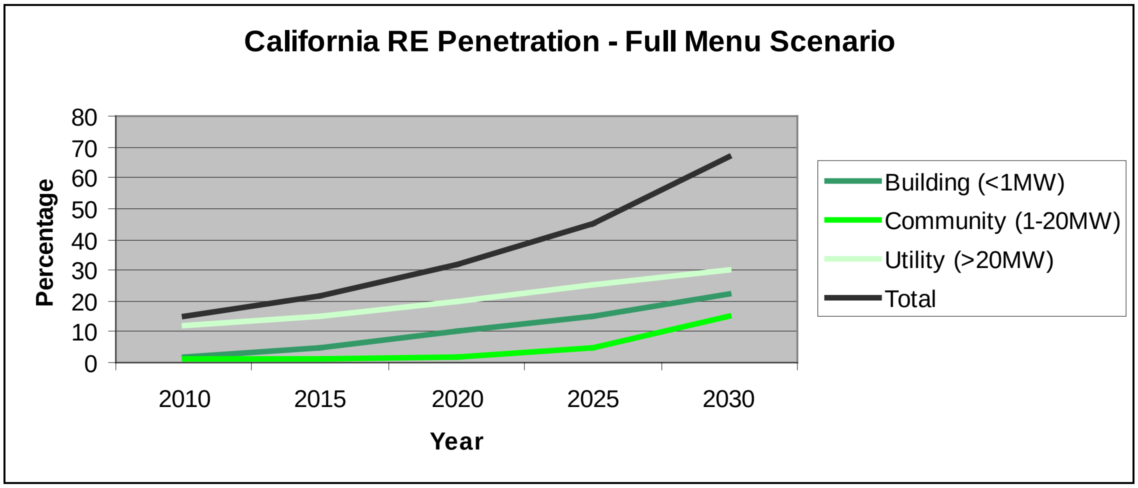


Figure 6…California RE penetration percentage in the integrated, full menu scenario

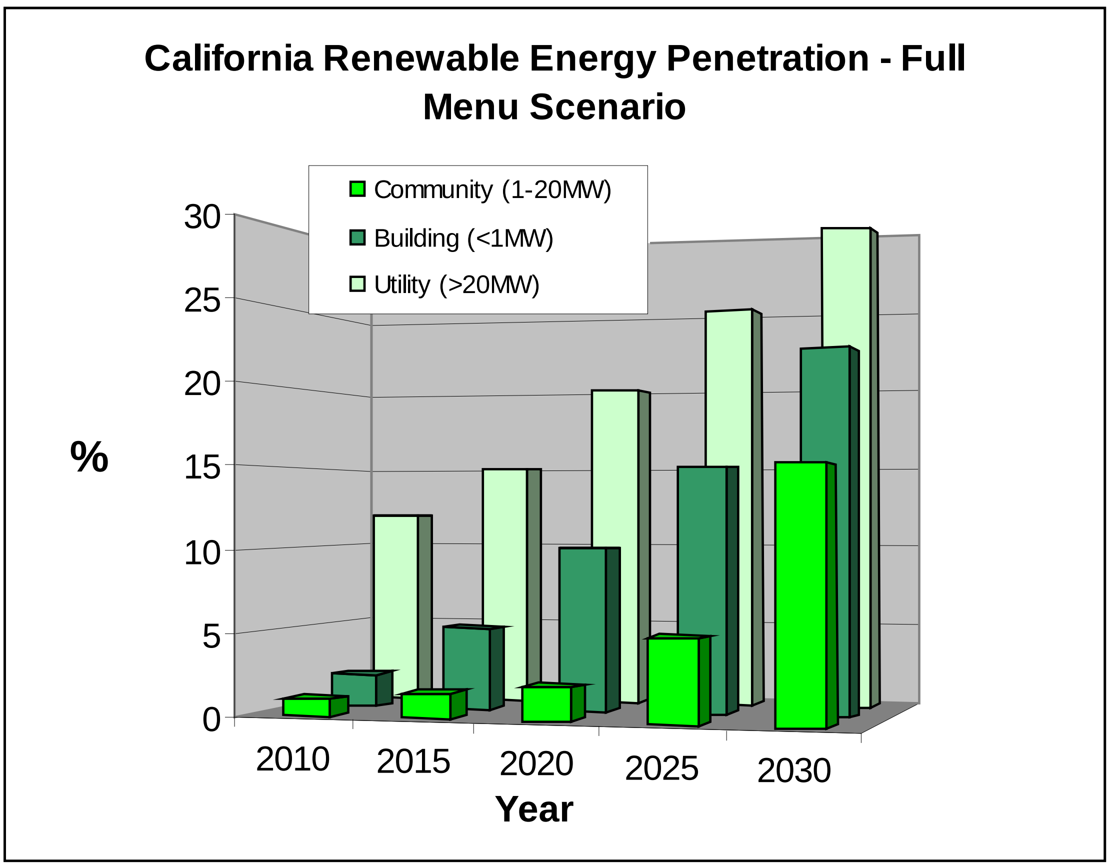
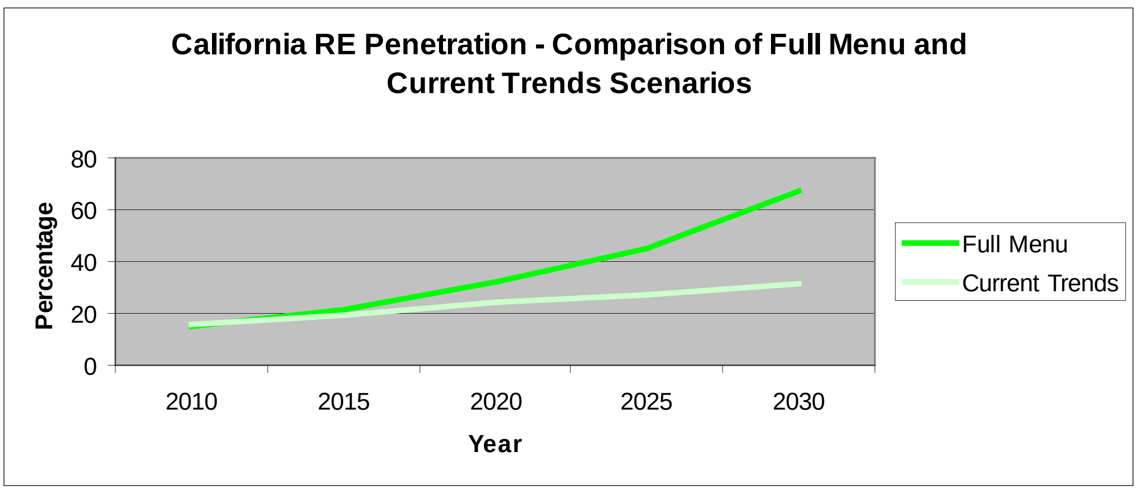


Figure 7…Integrated, full menu penetration percentage according to RE deployment scale

4.7…Scenario Comparison: A graphic comparison of the two scenarios outlined above is shown in Figure 8. From this comparison it is inferred that current patterns of policy support for RE deployment will likely result in something like the current trends scenario, i.e. slower RE deployment than would be consistent with California's GHG reduction goals, to say nothing of its goals for RE deployment in the utility scale electric generation sector.

Changes in current policy support for RE deployment that align with the integrated, full menu scenario offer the possibility of significantly de-carbonizing California's non-transportation energy supply within the life expectancy of a typical central station power plant, i.e. over the next 25-30 years. Aggressive implementation of the integrated, full menu scenario would likely place California in a global leadership position regarding de-carbonization of energy supply and might be supported by a Federal government interested in piloting the strategies and solutions needed to effect energy sector de-carbonization.



<u>Figure 8…RE deployment scenario comparison, integrated, full menu vs. current trends</u>

<u>4.8…Integrated RE deployment scenarios – recommendation:</u> Properly resourced efforts should begin immediately to identify a long term scenario that features maximum cost-effective integration based on commercially available RE solutions. 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.

<u>5…What are the benefits, costs and barriers of an integrated, full menu RE deployment approach?</u>

5.1…Integrated, full menu RE deployment - Introduction:

The two scenarios defined and evaluated in the preceding section differ in concept and detail:

- **Current trends**: Invests in plans to achieve RE deployment targets primarily by deploying centralized, non-base-load supply in high quality resource areas lacking commensurate transmission capacity.

- **Full menu:** Invests in absorbing 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 fully load new dedicated transmission capacity than lower capacity factor plants.

5.2…Benefits of integrated, full menu RE deployment: Both RE deployment models considered in Section 4 involve integration, but the current trends model achieves integration primarily in the limited sphere of centralized plants and high voltage transmission. Integration benefits can certainly be captured in this model but are restricted to the extent they rely on well synchronized deployment of both delivery infrastructure and supply solutions.

Integration benefits of the full menu approach include integration within and between deployment venues, e.g. deployment of natural gas enabled RE heating and cooling may facilitate better matching of aggregated supply and demand. It may also enable building scale solar electricity systems and efficiency measures to more economically enable achievement of net zero energy targets. Likewise, both models can offer benefits from supply portfolio optimizations, but it is quite clear that the full menu model offers greater portfolio diversity and greater risk mitigation potential, as well as potentially more rapid and higher penetration RE deployment.

The pace and diversity of RE deployment in the integrated, full menu scenario increases opportunities for optimization of California's non-transportation energy system. This scenario actually suggests an alternative and more realistic approach to envisioning long term outcomes and their feasibility. Traditional efforts to envision the energy future of the US have focused on the mix of central station electricity supply options.

The full menu scenario suggests a need to also focus on the mix of utility, community and building scale supply options and as a result to determine the appropriate mix of options at each scale. This opens up optimization and acceleration possibilities that are obscured by assuming all energy flows are from highly centralized sources to highly aggregated demand sinks.

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.

5.2…Costs of integrated, full menu RE deployment: Previous sections have suggested ways integrated, full menu deployment would save costs. Major cost saving opportunities relate to:

- Locating a greater amount of RE supply closer to points of energy use
- Shortening deployment lead times by reducing the need for additional centralized infrastructure development
- Reducing environmental concerns related to 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
- Stronger linkage between energy infrastructure planning and project permitting, resulting in better decisions on both sides.
- Accessing low cost capital for community and building scale RE deployment.
- Efficient deployment of capital resulting more predictable, numerous and geographically diverse project opportunities.

Centralized RE deployment can offer cost savings as well, depending on the scale economies of a particular supply solution and other site depended economies. However this paper argues 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. More detailed analysis is needed to validate or refute this hypothesis.

5.3…Barriers to integrated, full menu RE deployment: As discussed above, inertia is the primary barrier. It can be overcome but not without piloting and evaluating new finance and deployment models, and even before that, developing the data collection and forecasting capacity supporting these models. Energy data for the US and California, without evident exception is organized according to the structure of the existing energy systems. Supply, delivery and end use statistics are organized around electricity and natural gas sources, delivery systems and end uses. Public data is currently not aggregated according to scale of supply, scale of related end use or geographic proximity of sources and uses. Data that is aggregated according to application scale as well as conversion technology will be needed in evaluating and optimizing integrated RE deployment strategies and decisions.

There are intellectual and insight barriers as well. Industries do not spring up instantaneously but rather need years of profitable operation to mature, develop supply chains, drive out unnecessary costs and overcome scale related diseconomies through sustained business growth. Researchers using simplified economic evaluation models may fail to account for this important commercial reality.

There is a related over-simplification, an application of “first things first”, that demands that potentially synergistic solutions be deployed sequentially according to their static price- and performance-driven economics rather than in a parallel, integrated, blended and adaptive fashion.

An extreme application might insist that all possible end use efficiencies be achieved before any new RE sources were deployed, or that the grid must achieve a certain standard of “smartness” before connection of distributed supply solutions would be permitted.

Such barriers are hard to overcome because faulty premises and model dependencies are sometimes masked by otherwise impressive analysis.

5.4…Environmental consequences of integrated, full menu RE deployment:
Integrated RE deployment as envisioned here takes advantage of a suite of solutions. Many are subject to decision-making at a level where energy users and their communities can help determine environmentally and economically sustainable combinations and uses. At this level social and environmental costs can be considered and weighed in the balance along with more easily monetized costs of energy supply.

An integrated, full menu RE deployment strategy taking advantage of viable supply solutions at every scale inherently eliminates a portion of the social and environmental costs inherent in other strategies. Relying primarily on the highest quality and/or largest scale RE resources has environmental consequences that may not scale linearly with total deployment. For example, an integrated full menu strategy may relieve pressure to create new energy delivery corridors involving unresolved environmental concerns. By opening multiple deployment pathways the integrated, full menu approach allows experience to accumulate that can shape least cost, least impact deployment integrated deployment strategies of the future.

5.5…Benefits, costs and barriers – recommendations:

- 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.

- 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.

- More detailed analysis is needed to confirm (or refute) 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.

6…References

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