California Advanced Combined Heat and Power Collaborative:

Program Goals and Targets

Environmentally Preferred Advanced Generation
Public Interest Energy Research Program
California Energy Commission

June 30, 2003

I. PURPOSE

The Environmentally Preferred Advanced Generation (EPAG) area of the California Energy Commission's Public Interest Energy Research Program is conducting this *Advanced CHP Collaborative* to increase the application of Combined Heat and Power (CHP) technologies in California. The CHP program will focus on system level technologies to increase overall utilization efficiencies, reduce installed costs and maximize value to California end users. Advancements to, and commercialization of, CHP system technologies that accomplish this will accelerate the implementation of CHP in California. This program will complement ongoing Energy Commission *Distributed Generation RD&D* on engines, turbines, micro-turbines, fuel cells and utility interface technologies.

As part of this *Advanced CHP Collaborative*, EPAG is planning to issue a solicitation in late summer or early fall of this year directed at overcoming technology barriers to CHP Systems. The purpose of this document is to set forth the program goals and targets of the proposed solicitation. An earlier draft of this document was made available for public comment on the Energy Commission Website. Two workshops were held to present the goals and targets and to allow interested parties to discuss them in an open forum. The first workshop was held on Tuesday, May 13, 2003, at the Radisson Hotel in Newport Beach. The second workshop was held on Friday, May 16, 2003 at the Lowes Coronado Bay Resort in San Diego. These workshops were attended by representatives of a broad range of organizations with expertise in CHP, thermally activated technologies, and project development. (The attendance list is provided in *Appendix A* to facilitate team building among potential bidders.) For those who could not attend the workshops, public comment was possible through direct contact with Commission staff up until May 27, 2003.

Advanced CHP technologies include factory integration of absorption chillers and other ancillary equipment for targeted applications, more cost effective thermally activated cooling technology, and value-added features such as grid communication interfaces and uninterruptible power supplies. Value-added features should provide an accretive revenue stream or displace the need for traditional equipment, improving the economics of a CHP system designed only to displace electric and gas purchases.

Work in this area is already ongoing by various stakeholders including the Department of Energy, manufacturers, packagers, system integrators and others. The Energy Commission desires to build upon this work to tailor applicability and to accelerate commercial use in the California market. Accordingly, cost sharing and collaboration are important aspects of this planned program.

II. BACKGROUND

CHP is the sequential production of electricity and recovery of waste heat. CHP meets energy services with a lower consumption of fossil fuel, reduced costs and increased productivity for consumers, reduced global warming potential, and often an overall reduction in emissions of criteria pollutants. At the heart of CHP technologies is a prime mover and generator; prime movers include reciprocating engines, combustion turbines, steam turbines and more recently micro-turbines, Stirling engines and fuel cells. Power generation systems create large amounts of heat in the process of converting fuel into electricity. In a heat engine cycle, only about one-third or less of the input heat energy is converted to shaft power for the generator. The remaining heat produced by the prime mover can be made available for additional useful work such as for water heating, space heating, process energy, space cooling, refrigeration, dehumidification, drying, etc. Electrochemical cycles, such as fuel cells, are capable of higher theoretical efficiencies than heat cycles, but still produce waste heat that can be utilized on-site. End users with significant thermal and electrical needs can effectively meet these needs with a CHP system.

A. CHP Benefits

CHP systems typically have overall efficiencies of 60-80% as compared to power-only systems that average less than 40% efficiency. The resulting benefits of deploying CHP systems can include:

- Energy cost savings as compared to supplying heat and power loads separately
- Power Quality and reliability improvements associated with distributed generation
- T&D support associated with distributed generation
- Reduced air emissions as compared with supplying heat and power loads separately
- Natural gas conservation when the alternative electric power or thermal energy supply is fueled with natural gas.

B. Existing CHP in California

There are approximately 700 CHP systems installed in California with an electrical capacity of approximately 6,500 MW. Although the number of CHP installations is distributed roughly equally among commercial, industrial and institutional sectors, the industrial sector dominates overall CHP capacity. Other characteristics of the existing population of CHP systems in the state include:

Fuel Type	• 90% use natural gas • Coal, waste fuels and wood are minor contributors
Installed Base	• 5,700 MW (industrial) • 320 MW (commercial) • 480 MW (institutional)
System Size	• 25 MW (avg. industrial)

- 1.3 MW (avg. commercial)
- 2.4 MW (avg. institutional)

Technologies

- Reciprocating engines (66% of sites)
- Combustion turbines (85% of installed capacity)
- Fuel cells and micro-turbines (minor)

C. Decline of CHP in California

Growth of CHP in California dramatically increased with the passage of the Public Utility Regulatory Policies Act of 1978 (PURPA), enacted as a reaction to the energy crisis caused by the middle East oil embargo. Before its passage, there were less than 12 CHP systems operating in the state. Over the next ten years, more than 380 additional systems were installed. The decade from 1988 to 1997 added over 270 more systems. Annual growth in CHP capacity went from less than 1% in the 1970s to 27% in the 1980s. However, by the 1990s, the annual growth rate had slowed to just over 4%. In 1998, after nearly sixteen years of double-digit plant additions, only one CHP plant was added.

The tremendous growth of CHP in California was driven by high power costs and further facilitated by regulatory treatment that provided favorable standard offers to cogenerators. As wholesale power markets became more competitive in the 1990s, utilities had access to lower cost power. While wholesale power costs were declining, retail rates remained high. However, further CHP development was effectively stifled by a combination of lower avoided costs, high standby rates, demand charges, a costly interconnection process, and more stringent state environmental regulations.

D. Remaining Technical CHP Market Potential in California

Substantial CHP opportunities still exist in California. **Tables 1 and 2** show the estimated remaining potential for CHP in California by major economic sectors.[1]

Table 1. Remaining CHP Technical Potential in California's Industrial Sectors

Industry	CHP Technical Potential (MW)
Petroleum Industry	2,100
Food Processing	1,400
Pulp and Paper	1,000
Chemicals	700
Lumber and Wood	500
Other	800
Total	**6,500**

[1] *Market Assessment for Combined Heat and Power in the State of California*, California Energy Commission, prepared by Onsite Sycom Energy Corporation, Carlsbad, California, 1999.

Table 2. Remaining CHP Technical Potential in California's C&I Sectors

Sector	CHP Technical Potential (MW)
Education	2,300
Restaurants	1,100
Hotels and Lodging	900
Apartments	700
Health Care	300
Other	300
Total	**5,600**

While there are still some traditional CHP applications (i.e. heavy steam users – refining, chemicals, Pulp & Paper) that haven't yet incorporated CHP, the vast majority of California's remaining potential is in the commercial and light industrial sectors. Commercial and light industrial heat loads will not be the large steady steam loads that have historically been linked to CHP plants. Cost effective integration of thermally activated cooling will often be key to obtaining the operating benefits necessary for cost effective CHP projects in the commercial and light industrial sectors. Another unique characteristic of California is its stringent environmental requirements, which may add cost and complexity to a CHP project.

E. Critical Market Factors

The extent to which this potential CHP market can realistically be penetrated is difficult to estimate. Policies and regulations critical to CHP are still being formulated. How these rules are shaped and implemented will have significant impact on customer and utility interest in CHP. Critical factors for the future development of this market can be summarized as follows:

- CHP performance and cost attributes that can provide net power service below the California market clearing price.
- Technology Advancement – Cost-effective environmental compliance techniques; higher overall utilization efficiencies; lower cost heat driven cooling systems; application benchmarking designs
- Government Policies – Recognition of societal and economic benefits; regulatory treatment paralleling that for energy efficiency and renewables; stable and long-term government commitment to enable multi-year investment decisions by users; simplified and less costly permitting and monitoring procedures
- Utility Attitudes – Recognition that CHP provides capacity/T&D support; fair backup & standby rates; user friendly interconnect guidelines
- User Awareness – Public outreach for CHP; case studies; stable government support.

F. CHP Technology Needs

The gap between technology available today and the application needs in the commercial, institutional, and industrial sectors is a significant barrier. The current needs of those wanting to promote or use CHP are as follows:

- Less costly, complex, and maintenance intensive CHP, heat recovery, and thermally activated technologies.
- Cost-effective, efficient, reliable and ultra-low emission prime movers
- A single source for integrated equipment (which is likely to reduce acquisition and installation costs); currently, a CHP package is made up of separate products from a variety of manufacturers.
- A better understanding of application energy use characteristics and in particular the coincidence (or lack thereof) of thermal and electric needs
- Economically recovering and using energy from low temperature heat sources.
- Less costly and cumbersome integration of existing CHP products with existing building or manufacturing systems, such as rooftop units, air handling systems, and heat exchangers.
- Better awareness of CHP applications and benefits among customers, engineers, architects, regulators.
- Integrated controls for CHP system components

Other needs, although less technical in nature, that add knowledge and enable low cost design solutions, include:

- User friendly design tools
- Quantification of ancillary services associated with CHP such as reliability and power quality to both sides of the meter.

Developing more effective CHP systems that overcome these technical barriers is the primary focus of the proposed solicitation.

III. CALIFORNIA PIER CHP COLLABORATIVE PLAN

EPAG plans to address the CHP technology needs listed above through its RD&D solicitation. The program will have near-term and long-term goals. The near-term goal is to increase the use of CHP in California by overcoming technological barriers. Longer-term goals are to bring into economic reach a large portion of the remaining CHP potential in California. EPAG plans to release this solicitation in late summer or early fall of this year. The estimated funding for this RFP is up to 6 million dollars. At this time, EPAG anticipates funding 2 - 6 projects at a level up to 2.5 million dollars each. Following the solicitation, EPAG will reassess its CHP activities in about a year and plan for additional programs if warranted. When released, the solicitation will be posted on the Commission's website (http://www.energy.ca.gov/contracts/index.html).

Beyond the solicitation, EPAG is interested in other collaborative efforts that will lead to increased use of CHP in California. For example, EPAG recently facilitated applications to a DOE solicitation for Regional CHP Applications Centers.

A. Scope of CHP Solicitation

The scope of the planned solicitation will be open to a wide spectrum of research, development and demonstration projects directed at commercial, institutional, and/or industrial market segments of sufficient size to warrant PIER Program funding support. The technical focus of the planned solicitation is as follows:

- Component Integration Optimizing Overall Energy Utilization – Most current CHP systems involve the custom integration of disparate pieces (prime mover, generator, controls, heat recovery, cooling, dehumidification, other thermal processes). Integration of these functions and hardware into more efficient and less costly prepackaged systems is an important development goal. This area can also include innovative demonstration projects that offer the prospect of being reproduced at multiple sites.
- Cooling, heating, dehumidification – Absorption cooling equipment optimized to lower temperature heat sources, development of air-cooled cycles, integration of multiple uses, e.g., absorption and desiccant systems, improved efficiency systems, lower cost and maintenance, demonstration of new cooling/dehumidification technologies.
- Application matching, control systems, and diagnostics – This area may include software tools to design and optimize CHP systems to applications, software and hardware to provide effective system control including economic dispatch of competing thermal applications, and operation and maintenance diagnostics and to create standard designs (benchmarking) for common applications.
- Heat Transfer and Heat Storage – Heat exchangers, optimization of collection and use of multiple heat sources and temperatures, decoupling of supply and use through storage, integration with prime mover package designs, direct use of prime mover exhaust.
- Premium Power – CHP integration in high power reliability applications can reduce capital costs, save energy costs, and enhance power quality and reliability.
- Utility interface and control – Equally as important as matching the building thermal needs to the system is the need for CHP systems to interface with the utility to maximize benefits. Such strategies may include coordination of scheduled and forced outage maintenance, and the ability to override thermal load following operation.
- Prime Mover – Improvement to fuel cells, engines, turbines and microturbines cost, efficiency, and emissions characteristics is the focus of other California Energy Commission research programs work and ***is not*** the focus of the CHP systems solicitation. However, improvements to enhance the quality or useability of heat from the prime mover would be an acceptable part of an overall systems development and demonstration project.

The Energy Commission is open to the type of effort that best serves the proposed target market segments. Projects can include system technology research, integration/packaging, product development, supporting software/design tools and system

demonstration and deployment activities. Below are **examples** of possible projects that could be considered for this solicitation:

Category	*Possible Projects*
Integrated Energy Systems for Buildings	• CHP/HVAC integrated packages • Optimized absorption chiller design and integration (reduced cost and size, lower temperature heat utilization, increased COP, reduced maintenance) • Design Benchmarking and Outreach to standardize designs, component specifications and installation practices. • Ultra-simple installation requirements at site (hot and chilled water line connections, single integrated controls connection, single power connection, single fuel connection to package) • Utilization/integration of thermal storage to match building needs with system output • Heat recovery integrated with the prime mover and optimized for thermal technologies, e.g. application of multiple heat sources and temperatures from reciprocating engines • Demonstration of advanced cooling or dehumidification cycles that can be coupled with power generation equipment. • Air-cooled, cost effective, thermally activated cooling systems. • User-friendly Applications and Design Software to enable cost optimized sizing and operating strategies. • Improved Absorber/DX (Rooftop package) Interface Technology • Low-cost Small CHP hot water interface module • System building interface controls package and operating system diagnostics
Industrial Process CHP	• Direct use of turbine exhaust (rather than a heat recovery steam generator) • Optimized steam or advanced bottoming cycles (such as Organic Rankine Cycle) for power to thermal flexibility • Low NOx Supplemental Firing Combustors for Gas Turbines • High Temperature Fluid Heating from

	power generation equipment thermal output. • Low temp absorber integration for process refrigeration applications
Enhanced Value Markets	• CHP integrated Premium Power/High Reliability Systems • CHP Operational Tracking for Resource Planning, demand side response valuation and Standby Tariff design • CHP specific Utility Interface for congestion management and maintenance scheduling.

B. Targets and Stretch Goals

Development projects should be directed at meaningful California market segment(s) and show significant improvement to the baseline systems, representing what could be installed today or that would naturally develop without EPAG funding. **Table 3** shows example project targets and stretch goals for both the near-term (targets) and the mid-to-long-term (stretch goals). The near-term (less than 2 years to commercial introduction) proposals should target 20% or more improvement in CHP cost-effectiveness from current levels for intended markets. Mid-term proposals (3 to 4 years to commercial introduction) should have a stretch goal of 30% or more improvement. Longer-term goals (10 years) are not listed in this document but proposers are encouraged to include appropriate stretch goals for 2014.

Specific targets and stretch goals with corresponding levels of improvement may vary by project and targeted application(s). The targets and stretch goals illustrated below are intended as examples and should be adjusted to fit the particular size(s) and targeted applications proposed. Some of the targets and stretch goals may not apply to some of the proposed projects.

1. The proposed system technology should be sized for the targeted market segment.
2. The target/stretch goals should define a system that is economic in California in the near-term and should enable widespread implementation in the mid- to longer-term.
3. Viable technology paths and budget/business plans to reach the stated target/stretch goals should be evident in the proposal.

The Energy Commission is seeking to fund a balanced portfolio of projects:

- Near-term and mid-term projects with a slight emphasis on nearer-term
- Diversity of applications and technologies.

Table 3. Example Project Targets and Stretch Goals

Ex. 1: Small Commercial CHP Package

A complete CHP system skid mounted in a single package that includes prime mover, heat recovery, absorber, pumps, heat exchangers and switchgear that is designed for minimal engineering and installation labor. Near-term priorities are aimed primarily at cost reduction. Mid and longer term emphasis balances cost reduction with performance improvements. Proposals addressing system sizes of 25 to 500 kW are envisioned. However, performance parameters and targets need to be adjusted to fit the size.

Parameter	**Baseline**	**Near Term 2005**	**Mid Term 2007**
size (kW)	100	100	100
Absorber size (tons)	25	28	35
Absorber COP	0.6	0.65	0.8
Package Cost ($/kW)	1500	1000	800
Installation Costs ($/kW)	1000	500	300
Emissions (CARB)	2003	2003	2007[1]
Electric Efficiency (HHV)	28%	30%	32%
Package Efficiency (HHV)	70%	75%	80%
Maintenance ($/kWh)	0.02	0.016	0.012
Availability	92%	94%	96%

Other parameters: service support, dimensions, weight, noise, heat quality

Ex. 2: Integrated Cooling Module

A skid mounted container, that includes the absorption chiller, cooling tower, pumps, genset interface, and controls interface. Near-term emphasis is on cost reduction and maintainability through component standardization and factory packaging. Mid-term emphasis also includes absorber performance improvements.

Parameter	**Baseline**	**Near Term 2005**	**Mid Term 2007**
Size (tons)	100	100	100
Module Cost ($/ton)	1,000	700	500
Absorber COP	0.6	0.65	0.8
Heat input Temp (^{o}F)	210	230	250

Other parameters: O&M, dimensions, weight, noise

[1] Compliance with the 2007 CARB emissions requirements as currently stated must be planned for in any response to the solicitation. However, due to the planned CARB 2005 review and potential changes to the 2007 emissions standards, a proposal will not be automatically disqualified if it cannot prove adherence to the 2007 standards. In that situation, a detailed explanation must be included in the proposal that documents why the 2007 standards are not applicable.

Table 3 Continued: Example Project Targets and Stretch Goals

Ex. 3: Engine Heat Optimized Absorber

Single-effect absorption chiller optimized for medium temperature heat from a natural gas engine. Near-term goals are directed at optimizing absorber sub-systems for engine quality heat. Mid-term activities stress absorber performance improvements and higher quality engine heat.

Parameter	**Baseline**	**Near Term 2005**	**Mid Term 2007**
Size (tons)	200	200	200
Absorber Cost ($/ton)	400	250	200
Absorber COP	0.6	0.65	0.8
Heat input Temp (^{o}F)	210	230	250
Foot-print (ft^2)	120	90	75

Other Parameters: to be defined by proposer

Ex. 4: Supermarket CHP-Refrigeration/Subcooling Package

Continuous CHP sized electrically for minimum night-time load with absorption subcooling of the refrigeration system. Integrated systems to replace reclaim heat with CHP heat to further optimize refrigeration efficiency.

Parameter	**Baseline**	**Near Term 2005**	**Mid Term 2007**
CHP Size (kW)	75-250	75-250	75-250
Chiller Size (tons)	20-90	20-90	20-90
Chiller Cost $/ton	$2,000	$1,200	$750
Chiller COP (on thermal input)	0.7	1	1.2
Maintenance ($/kWh)	$0.02	$0.02	$0.01
Integration	Separate	Integrated Module	Integrated System
Controls	Custom	Standard	Standard
Installed System Cost ($/kW)	$2,800	$1,800	$1,200
Overall Efficiency (HHV)	60%	65%	75%

Other Parameters: O&M, dimensions, weight, noise

Table 3 Continued: Example Project Targets and Stretch Goals

Ex. 5: CHP Benchmarking

For specific application(s), develop standardized design methodologies to reduce site-specific engineering, permitting, procurement, and maintenance costs and to increase system reliability. Proposals addressing system sizes of 500 kW to 5 MW are envisioned. However, performance parameters and targets need to be adjusted to fit the size.

Parameter	**Baseline**	**Near Term 2005**	**Mid Term 2007**
size (kW)	1,000	1,000	1,000
Absorber size (tons)	200	220	250
Absorber COP*	0.6	0.65	0.8
Installed Cost ($/kW)	2000	1500	1200
Emissions (CARB)	2003	2003	2007
Electric Efficiency (HHV)	32%	34%	38%
Overall Efficiency (HHV)	70%	75%	80%
Maintenance ($/kWh)	0.015	0.012	0.010
Availability	92%	94%	96%

Other parameters: service support, dimensions, weight, noise, heat quality

* Example absorber COPs are for reciprocating engine-based systems. A turbine-based system should have higher COPs.

Ex. 6: Industrial Direct CHP

Utilization of the exhaust heat from a prime mover for direct process heat thereby eliminating the cost of the heat recovery steam generator.

Parameter	**Baseline**	**Near Term 2005**	**Mid Term 2007**
size (kW)	3,000	3,000	3,000
Equipment Cost ($/kW)	800	650	550
Installation Costs ($/kW)	500.00	350.00	250.00
Emissions (CARB)	2003	2003	2007
Electrical Efficiency (HHV)	25%	26%	28%
System Efficiency (HHV)	70%	75%	80%
Maintenance ($/kWh)	$0.009	$0.007	$0.005
Availability	96%	97%	98%

Other parameters: service support, dimensions, weight, noise, heat quality

Table 3 Continued: Example Project Targets and Stretch Goals

Ex. 7: High Reliability System for Data Centers			
A CHP system that actively contributes to power reliability in premium power applications reducing dependence on, and cost for, conventional uninterruptible power supply (UPS) systems. The Baseline case is a conventional UPS system with redundant utility services, batteries, diesel gen-sets, and chillers. It does not include a CHP plant.			
Parameter	**Baseline**	**Near Term 2005**	**Mid Term 2007**
Raised Floor Area (ft^2)	80,000	80,000	80,000
Size (kW)	15,000	15,000	25,000
Reliability (# 9s)	5	6	6
Installed Cost ($/kW)	5300	4000	3400
Overall Efficiency (HHV)	N/A	70%	75%
Absorber COP	N/A	.65	1.0
Absorber Cost ($/ton)	N/A	300	250

Other Parameters: O&M, dimensions, weight, noise

C. Typical Proposals Requirements

Along with addressing the targets and stretch goals set forth above, a proposal for the upcoming CHP solicitation will generally also have to address the following items:

- Target specific market/application segments – specify new, retrofit or both - and explain how this market/application is particularly suited for California.
- Discuss prior CHP experience in identified market sector(s) and factors impeding further deployment
- Describe proposed technology advancement and how it will help overcome current market obstacles
- List specific project goals with reference to existing baseline levels; should comply with the California Air Resources Board Emission Requirements
- Describe linkage to relevant past or ongoing development work
- List sources of co-funding
- Teaming is encouraged to fully address the technical, financial, market, and business aspects of a successful development and commercialization proposal.
- If appropriate, applicants may include an upfront task to more thoroughly assess target market and goals.

Appendix A, Attendance List for CHP Collaborative
Newport Beach Workshop, May 13, 2003

Name	Company	Phone	Email
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