Demand Response (DR) Enabling Technology Development (ETD) Project

Ron Hofmann

DR Program Advisor

June 4, 2003

INTRODUCTIONS

- Presenters
  - Ron Hofmann (introduction & process, consultant)
  - Paul Wright (initial subcontract, UCB Professor)
  - Roger Levy (meters and prices, consultant)
  - Alexandra von Meier (power delivery system, CSUS Professor)
  - Gaymond Yee (RONs, DR ETD project manager, CIEE)
- Behind the scenes
  - Laurie ten Hope (CEC/PIER ESI team lead)
  - Maureen Barnato (DR ETD task administrator, CIEE)
  - Karen Sharp (workshop facilitator, CIEE)
  - Art Rosenfeld (CEC Commissioner)
  - Carl Blumstein (UCOP/CIEE director, UCEI researcher)

PURPOSE OF THIS WORKSHOP

- **Introduce an energy-related R&D project**
  - initial funding $3 MM over 30 months
- **Purpose of funding is to develop enabling technologies for a state-wide demand responsive electric power delivery system with "10/10" objectives**
  - 10 times the capabilities
  - 1/10th the cost
  - Create disruptive technology
- **Leverage R&D spending by other institutions**

BACKGROUND

- **CA energy crisis of 2000-2001**
  - Market power (Enron, et al)
  - Aging fossil fuel plants (pollution)
  - Flaws in deregulation (AB 1890)
  - Disconnect between wholesale and retail prices
- **Supply approach** (build more plants)
- **Demand approach** (load as a resource)

ELECTRIC POWER INDUSTRY IN CALIFORNIA

- **Energy companies (Enron, Calpine)**
- **CAISO (California Independent System Operator) manages transmission system**
- **UDCs (Utility distribution companies manage local distribution systems)**
  - IOUs (investor owned utilities, e.g., PG&E)
  - Munis (publicly owned utilities, e.g. Alameda)
- **Agencies (e.g., FERC, CPUC, CEC)**

REGULATORY AGENCIES

- **FERC http://www.ferc.fed.us/**
  - Regulates the transmission and wholesale sales of electricity in interstate commerce
- **CPUC http://www.cpuc.ca.gov/**
  - Regulates privately-owned utilities in CA
- **CEC http://www.energy.ca.gov/**
  - Created in 1975 for siting electric power plants
  - Responsible for standards & policy analysis

BRIEF HISTORY OF RECENT CALIFORNIA ELECTRIC R&D

- Investor Owned Utilities (until 1996)
- EPRI (created by utilities in 1973)
- CIEE (funded by utilities starting in 1989 to manage energy efficiency R&D)
- PIER (created in 1996 by deregulation [AB1890] and initially funded in 1998)
- PIER http://www.energy.ca.gov/pier/
- PIER has ~$60 MM/year through 2012

PIER R&D AREAS

- Environmentally-Preferred Advanced Generation (EPAG)
- Buildings End-Use Energy Efficiency
- Agricultural/Industrial/Water End-Use Energy Efficiency (AIW)
- Renewable Energy
- Energy Related Environmental Research
- Energy Systems Integration (ESI)

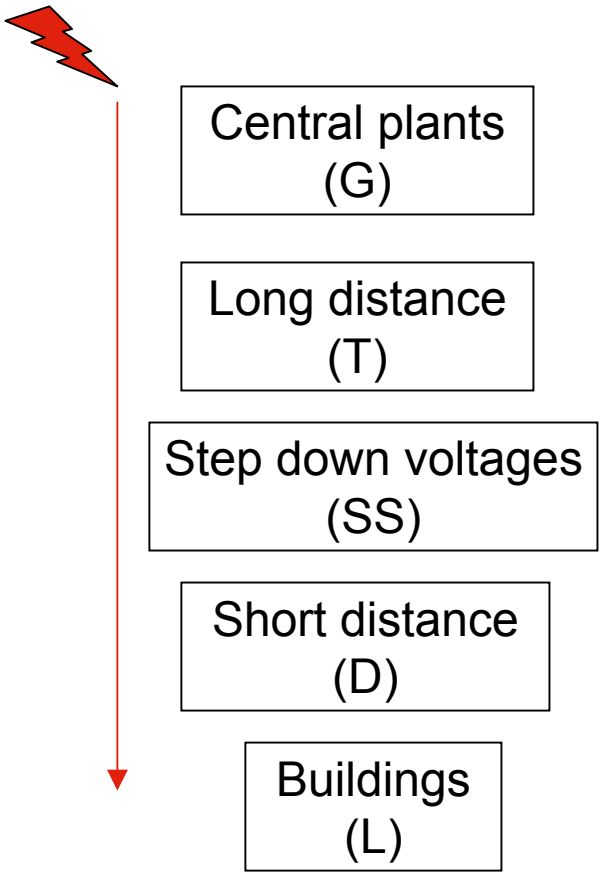
ESI

- Improved Efficiency and Reliability of the Transmission System (T&D)
- Distributed Energy Resources Systems Integration (DER)
- Strategic and Enabling Technologies (e.g., storage, seismic, tools for market analysis)
- Demand Response to Electricity Prices and System Contingencies (DR)

WHAT IS DR?

- Demand response (DR) for this project is the ability of electricity users to respond "automatically" to time- and location-dependent price and contingency signals (that have varying amplitude and duration) to reduce/shift loads.
- DR is different from energy efficiency (EE), e.g., transient vs. permanent

DR INVOLVES THE ENTIRE POWER DELIVERY SYSTEM



- **Generation (G)**
- **Transmission (T)**
- **Substations (SS_T)**
- **Sub-transmission**
- **Substations (SS_D)**
- **Distribution (D)**
- **Local transformers**
- **Loads (L)**

WHAT ARE SOME DR ENABLING TECHNOLOGIES?

- Wireless communications
- MEMS sensors
- Network management
- Systems integration
- Low-cost packaging
- Energy scavenging and storage
- Real-time operating systems

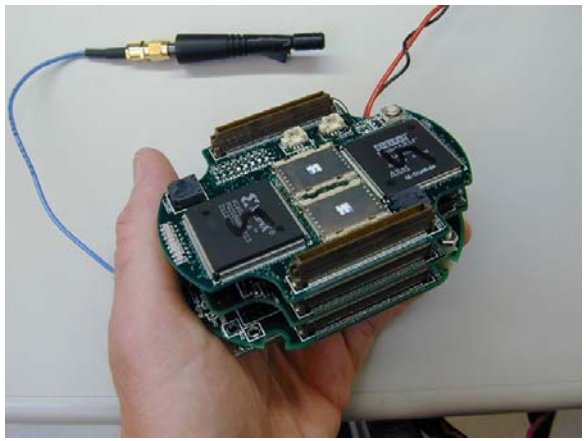
HISTORY OF DR ETD PROJECT

- **Approved by CEC June 2002**
- **Trial workshop October 28, 2002**
  - Meters, thermostats & sensors
  - UCB, LBNL, LLNL invited
- **First proposal funded March 2003**
  - 5 UCB research teams
  - Disruptive technologies (10/10)

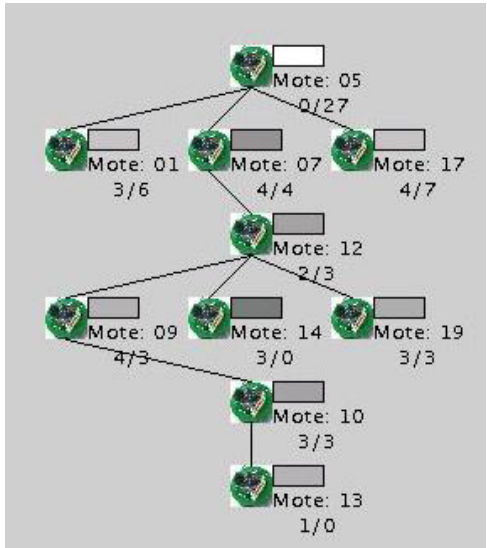
WHY START AT UCB?

- **Disruptive (10/10) technologies**
  - Smart dust (integrate more for less)
  - Tiny OS (self-organizing networks)
  - Pico radio (low-power communications)
- **Leverage other funding**
  - DOD (e.g., DARPA)
  - Private Industry (e.g., Intel)
  - CITRIS (e.g., sensor test bed)

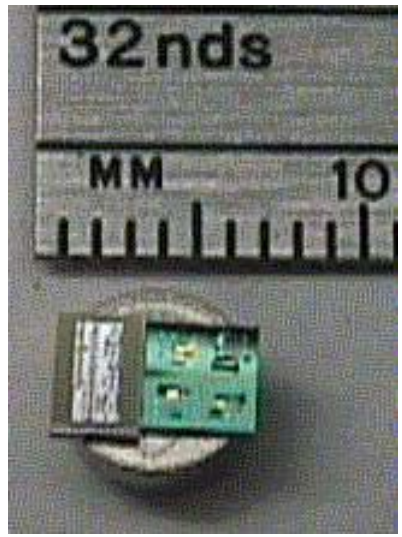
UCB TECHNOLOGIES*



Pico radio
Ultra-low energy (<5nJ/bit)
Ultra-low power (<100 µW)



TinyOS
Event-based operating system for sensor networks.



Smart Dust
Ultra-small (<1 mm^3)

*this slide provided by Cliff Federspiel, UCB

INITIAL APPLICATIONS

- **Long lead-time items**
  - Meters
  - Thermostats
  - Appliance Sensors (future)
  - Distribution Line Sensors (future)
- **Simplest to define**
  - Straightforward specifications

GOALS OF A "10/10" METER

- **Installed costs of <$50**
- **Flexible communications capability**
  - Cannot be "stranded"
  - Compatible with water and gas metering
- **Support for dynamic tariffs and DR**
- **System Platform capable of supporting**
  - Sensors
  - Actuators
  - Communications Links

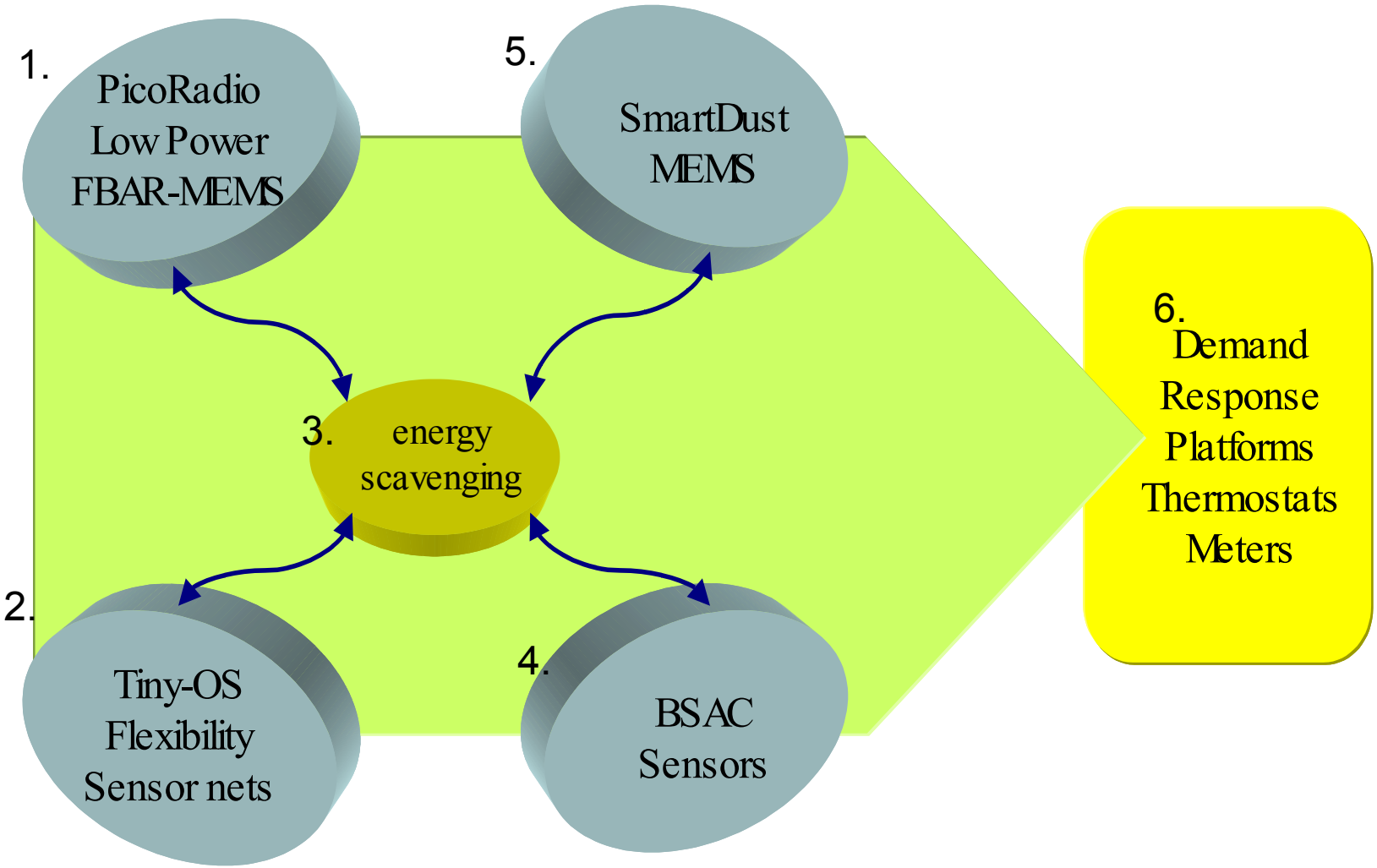
GOALS OF A "10/10" STAT

- Installed cost <$30
- Communications range 10-300M, efficient wireless network
- Easy installation
- Scavenge Energy for operation
- Support for dynamic tariffs and DR
- Increased functionality, humidity, comfort, etc.
- Clear and intuitive user interface

INITIAL SUBCONTRACT

- Integrate silicon-based radio, computer, memory, sensors, and power supply into one chip
- Research Team
  - Ed Arens, Cliff Federspiel (Architecture, buildings)
  - David Culler (Intel, TinyOS)
  - Jan Rabaey (BWRC, Pico radio)
  - Dick White (BSAC, sensors), Kris Pister (Smart dust)
  - Paul Wright (ME department, energy scavenging)

Specific UCB technologies



1.) PicoRadio Project (Rabaey)

- DARPA originated project in 1998
- Low power radio: Version 1

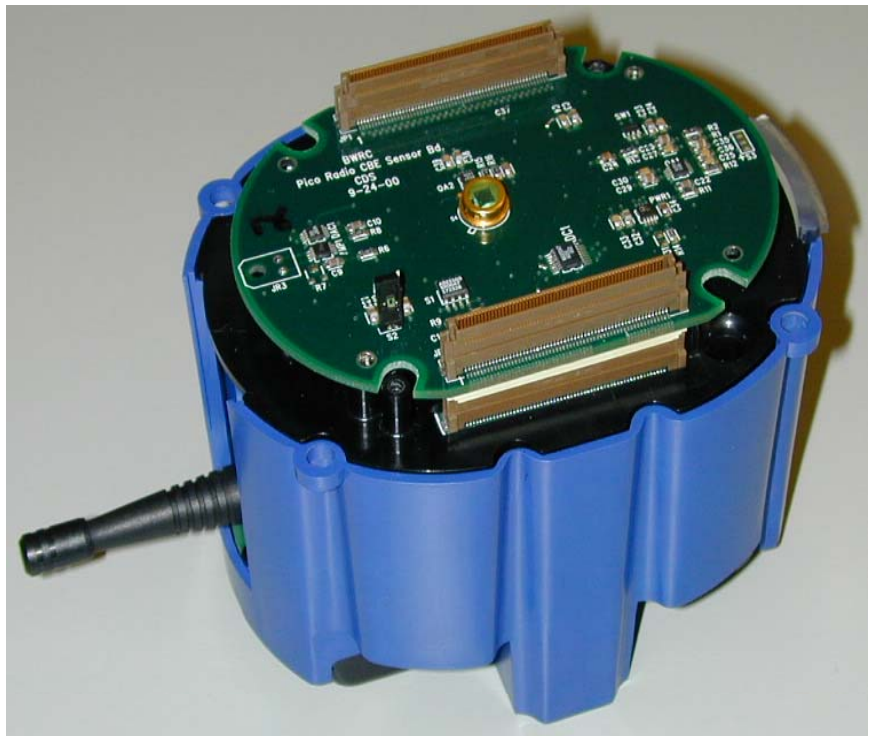


Figure 15: Injection Molded Final Product

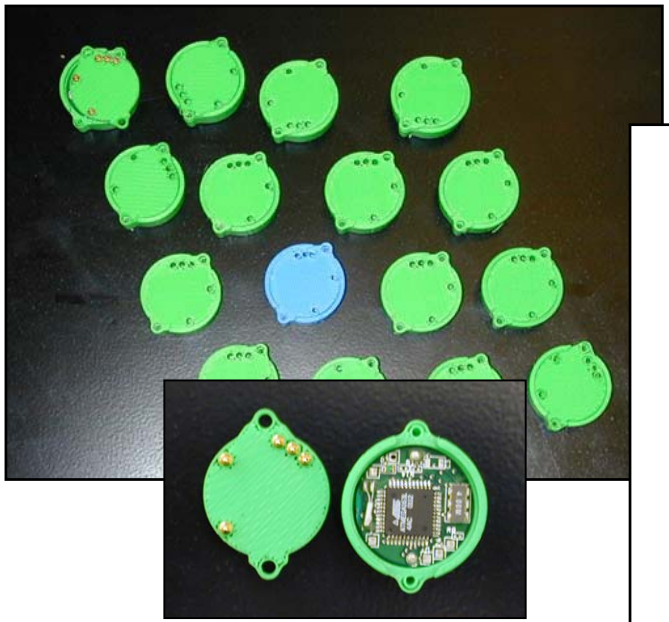
PicoRadio Project Version 3

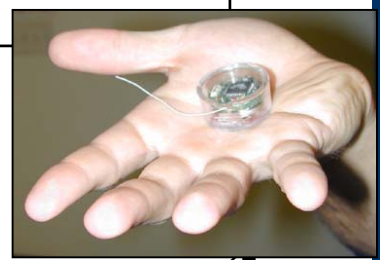
- A digital network processor chip (4mm x 4mm in size)
- An analog RF front-end chip with transmitter, receiver, amplifier and filters (1mm x 1mm in size)
- 4 FBAR resonators (MEMS devices from Agilent) (0.2 x 0.4mm each)
- Flash memory (6mm x 9mm)
- A temperature sensor
- Voltage regulator or DC/DC converter
- Super-capacitor for support of Energy Scavenging

PicoRadio Project

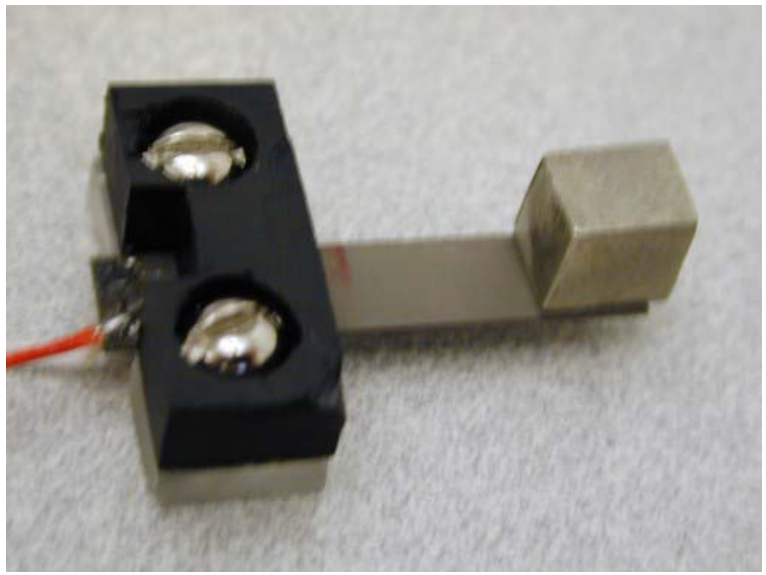
- **Summary: how PicoRadio relates to DR**
  - Over the next two years (to 2004/5) platforms will integrate the above sub-components using high-density fine pitch interconnection technology
  - CMOS radio with MEMS FBAR resonator means very low power – very cheap (10x10)
  - Will operate from Energy Scavenging (>10yr life)

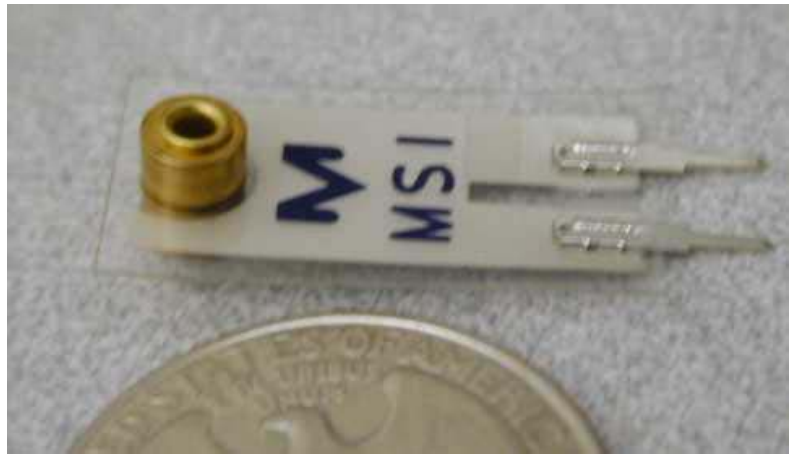
2.) Motes + TinyOS (Culler)

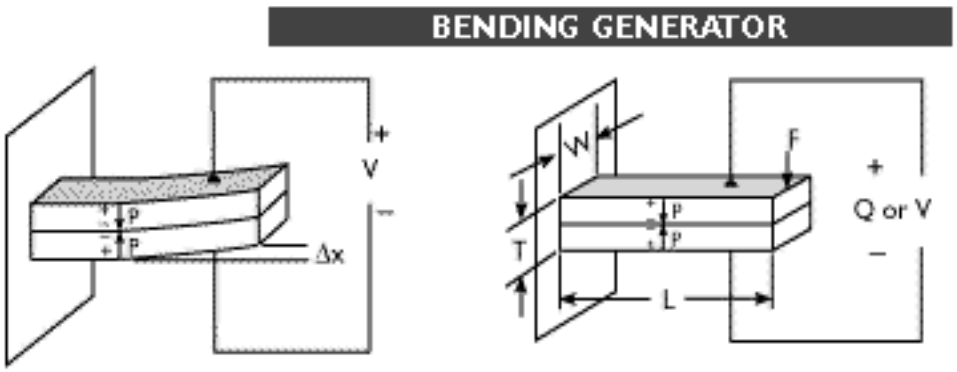




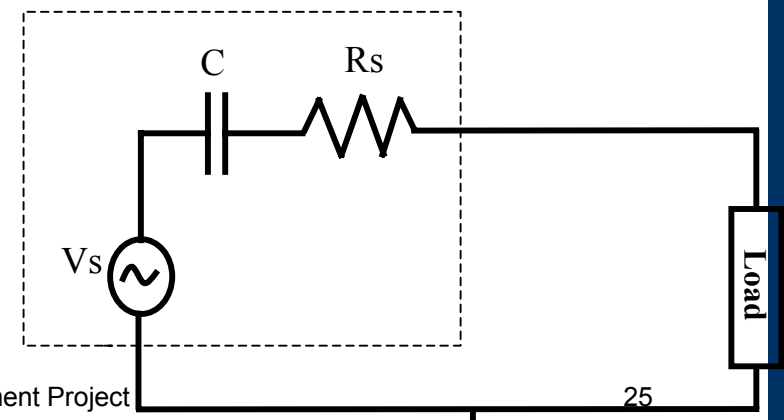
3.) Energy Scavenging with Piezoelectric Bimorphs (Wright)







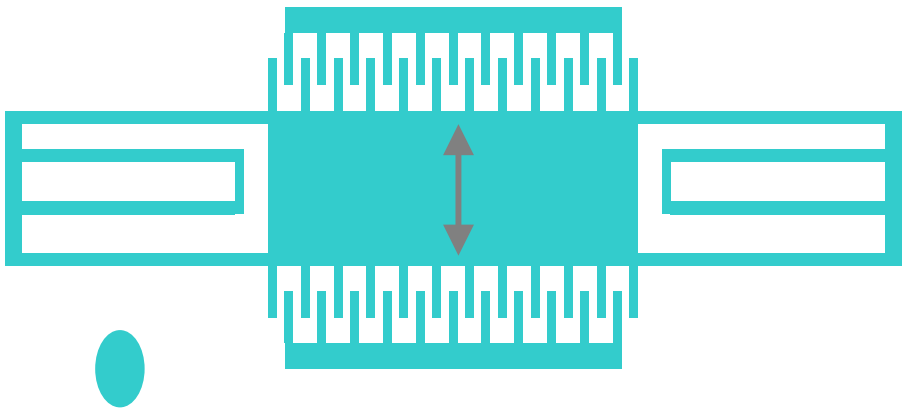
Piezoelectric generator



MEMS Capacitive Generators

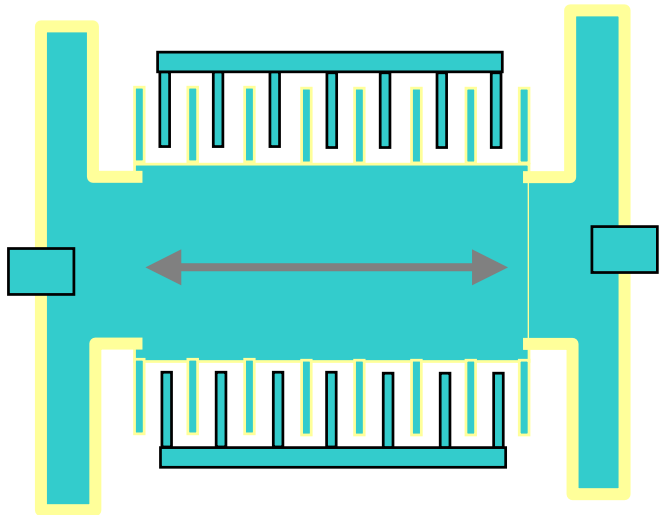
In-plane, overlap type:

Capacitance changes by changing overlap area of fingers.



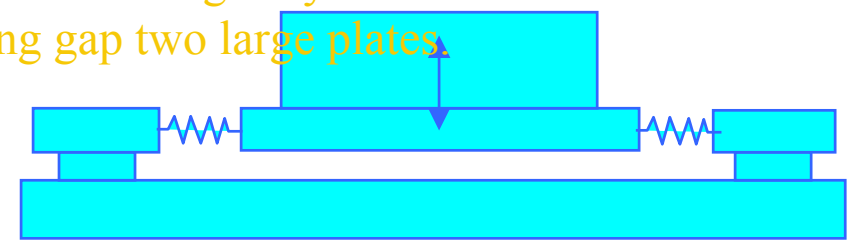
In-plane, gap closing type:

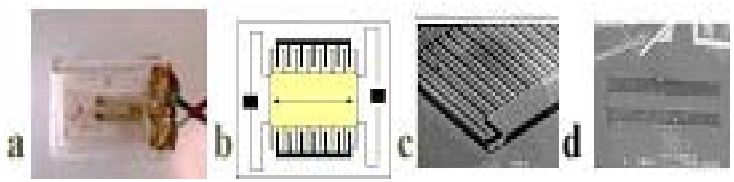
Capacitance changes by changing gap between fingers.



Out-of-plane, gap closing type:

Capacitance changes by changing gap two large plates.

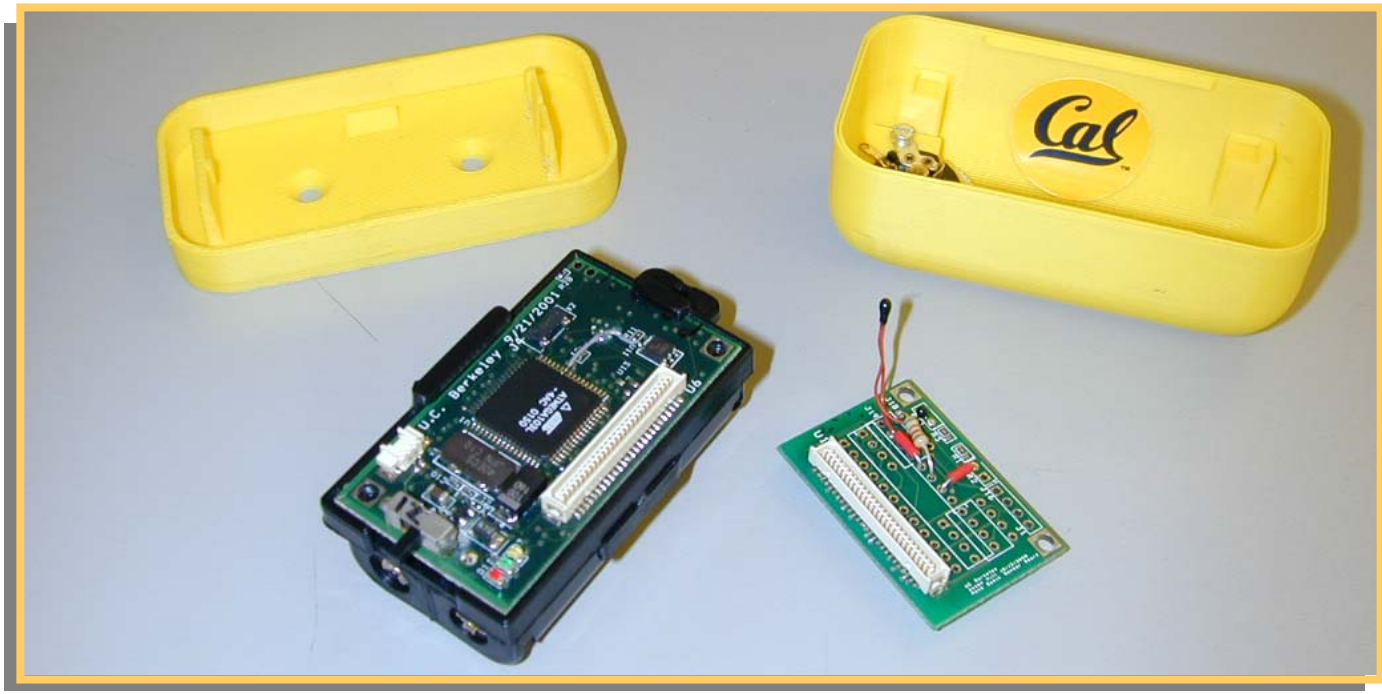




4.) BSAC Sensors (White)

- Current
- Voltage
- Temperature
- Occupancy (optional)

BSAC Motes + Sensors



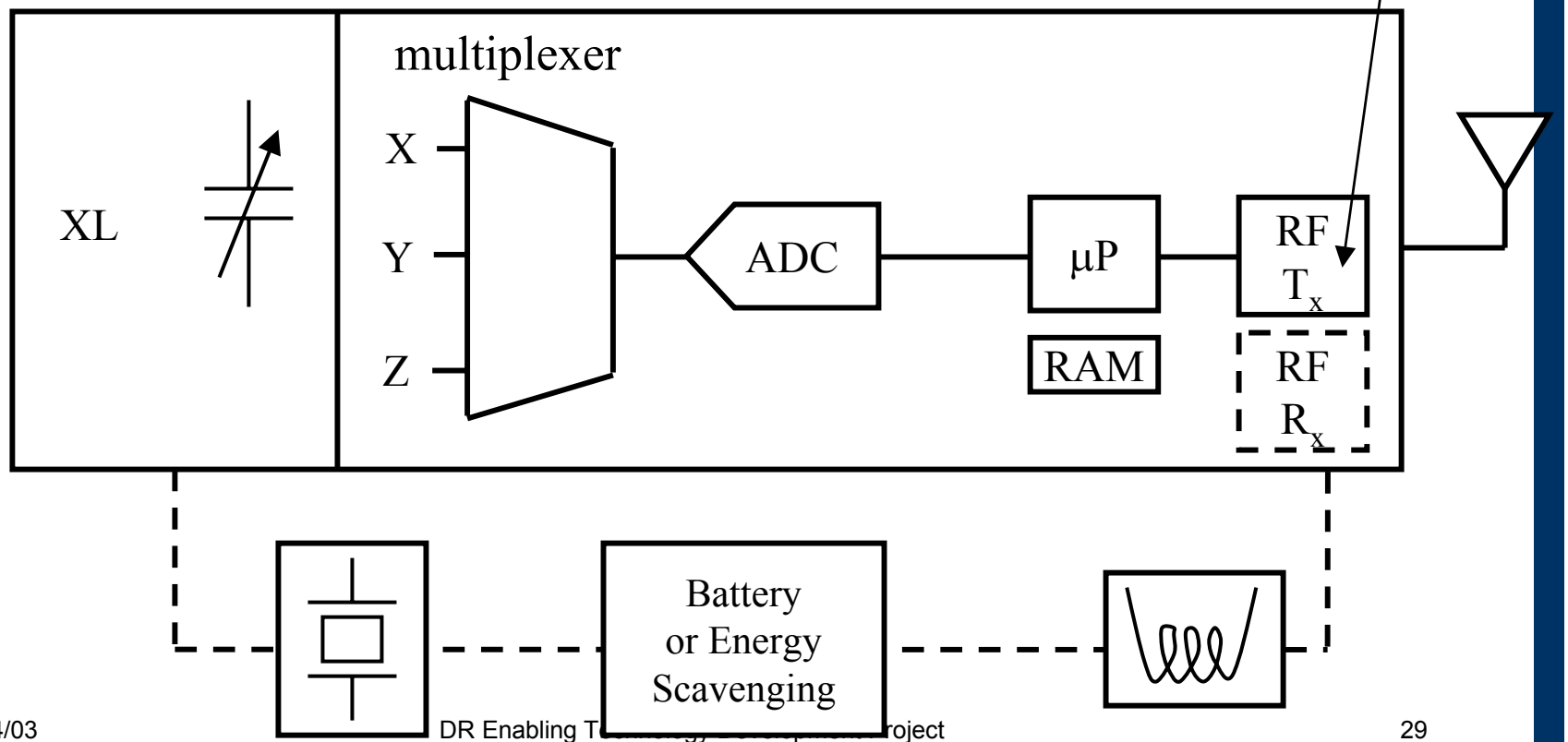
- Mica Board
- Basic Sensor Board
- 1 Degree Accuracy Thermistor
- Fused Deposition Modeling (FDM) Casing

5.) MEMS & SmartDust

MEMS chip 3-axes

CMOS - 2x2 mm

900Mhz



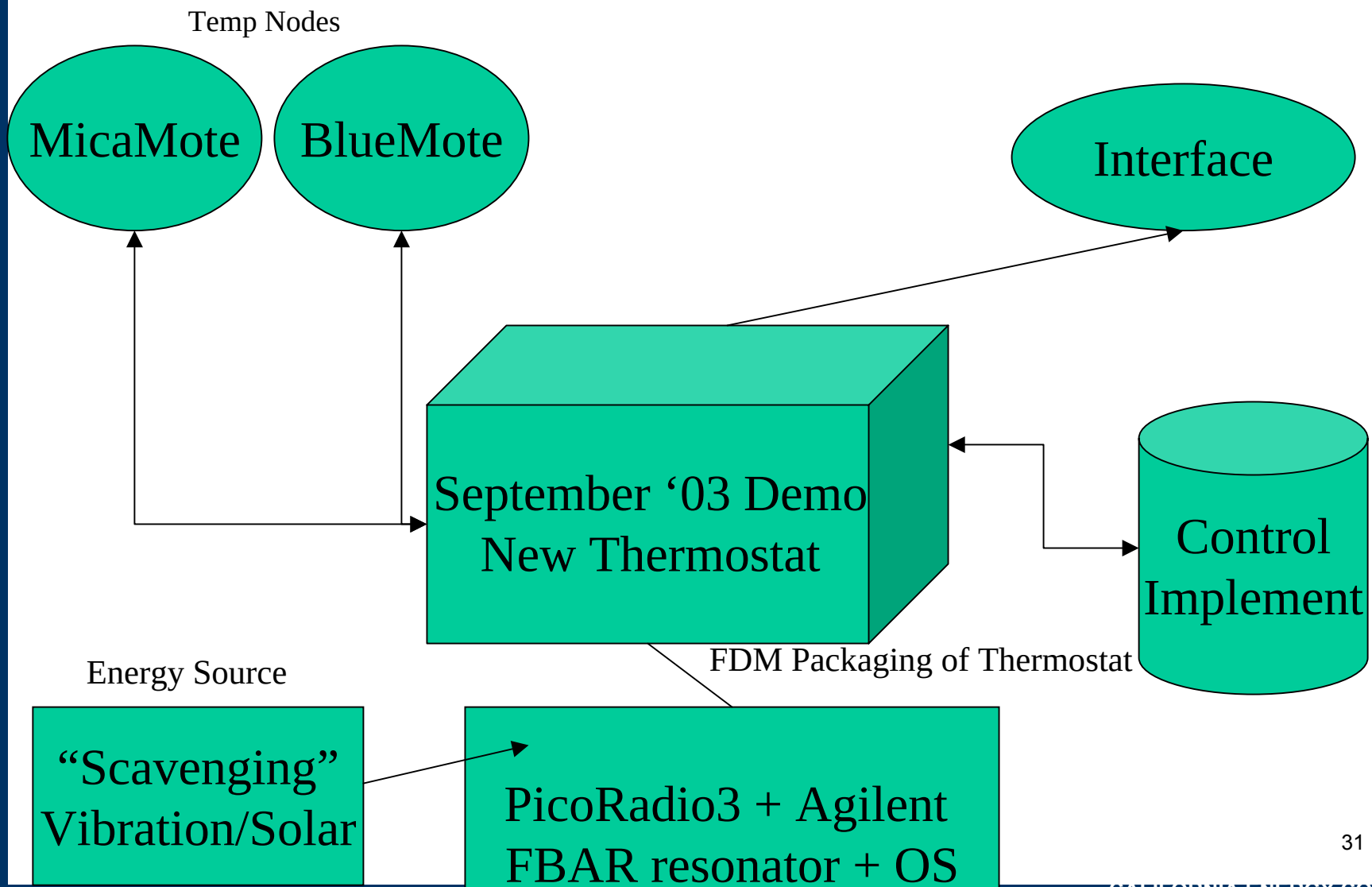
Bright Future

- **The approximate cost of semiconductor manufacturing today gives an integrated approximate cost-estimation method that**

1 sq. mm. Silicon = 10cents

- **In 2004/5 PicoRadio will therefore cost about $10, plus another $10 for the capacitor etc. By 2008, costs will reduce as research naturally evolves towards CMOS and MEMS-based systems.**

September 2003 Demonstration



COMPANION DR PROJECT

- **Large Commercial and Institutional (LC&I) DR Demonstrations and Case Studies (Mary Ann Piette, LBNL)**
  - Stake in the ground study to establish state-of-the-art DR capabilities and R&D needs
  - Send a dynamic tariff to LC&I buildings
  - Determine automatic DR capability
  - Report results in a form that will help make policy and R&D decisions possible

TECHNICAL ADVISORY COMMITTEE (TAC)

- Joe Desmond (Infotility, real-time messaging)
- Joe Hughes (EPRI/E2I, industry standards)
- Roger Levy (consultant, business processes)
- Belvin Louie (PG&E, meters)
- Don Pezzolo (consultant, communications, thermostats)
- Mary Ann Piette (LBNL, buildings, energy monitoring)

FUNDING MECHANICS

- **Research Opportunity Notices (RONs)**
  - Meters (posted 10/02)
  - Thermostats (posted 10/02)
  - System Integration (posted 6/03)
  - Network Management (posted 6/03)
  - Technology adoption (may be posted late 2003)
- **Proposal Process**

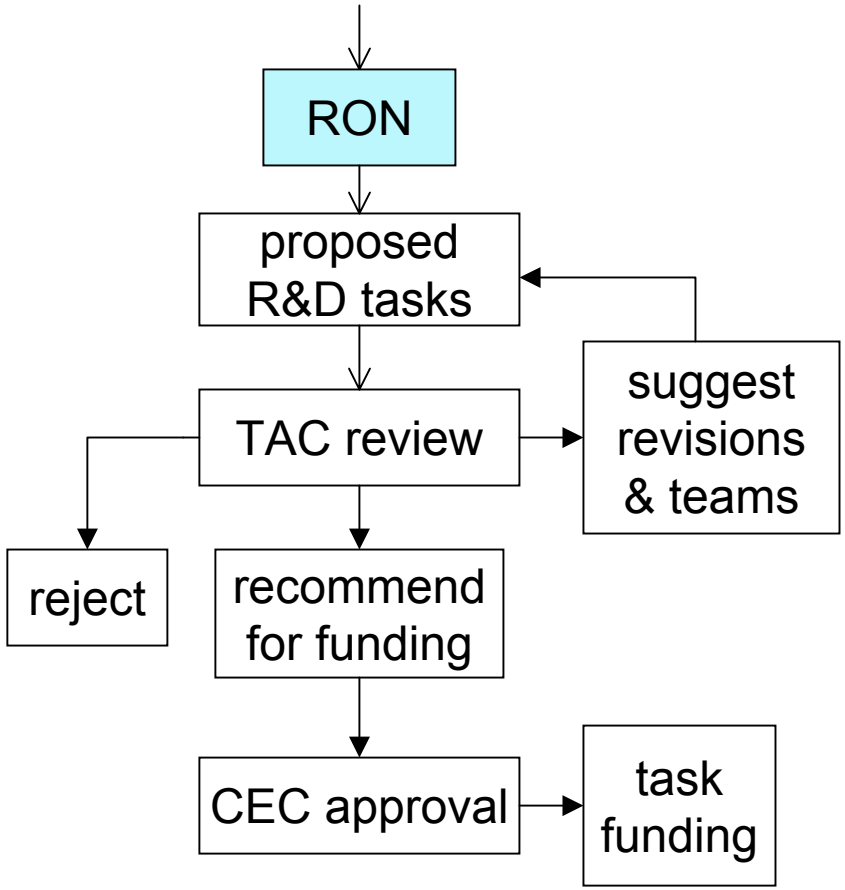
PROPOSAL TOPICS

- **Meters & Thermostats**
  - Silicon radios (e.g., LLNL microwave)
- **System Integration**
  - Complimentary to CEIDS & DOE GridWise
  - Collaborate with California utilities
- **Network Management**
  - Collaborate with industry (e.g., Cisco)

PROPOSAL STRATEGIES

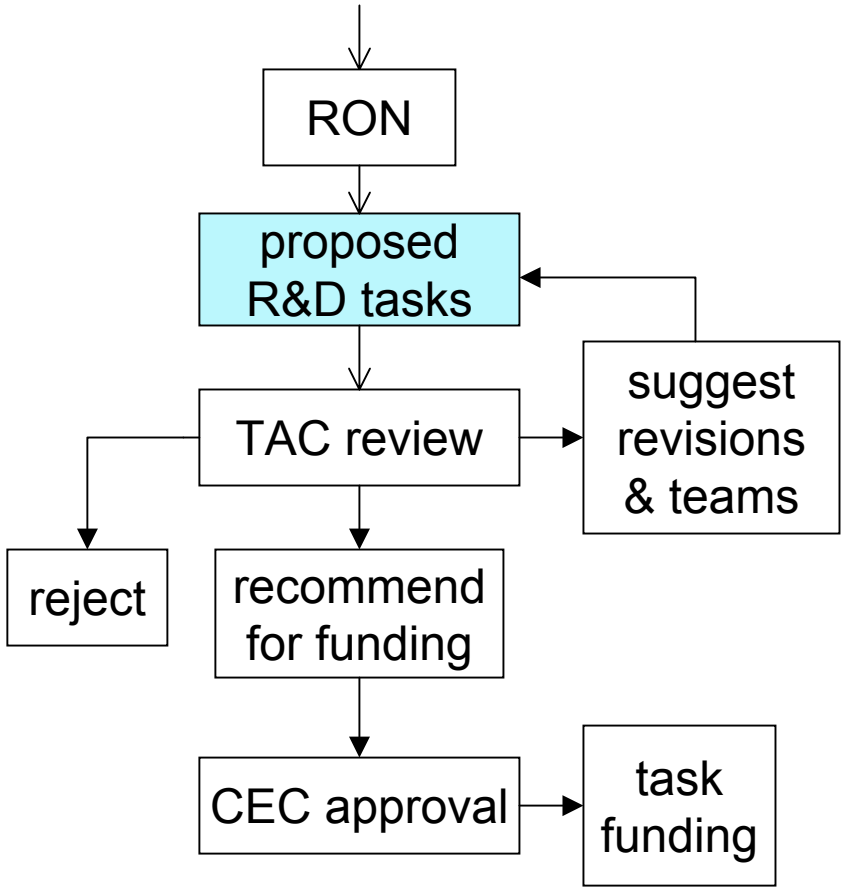
- One RON
- Part of one RON
- Combine RONs (e.g., UCB proposal)
- Combine pieces of different RONs
- Collaborate
- Leverage funding
- Start with R&D design phase (<$250 K)

RESEARCH OPPORTUNITY NOTICE (RON)



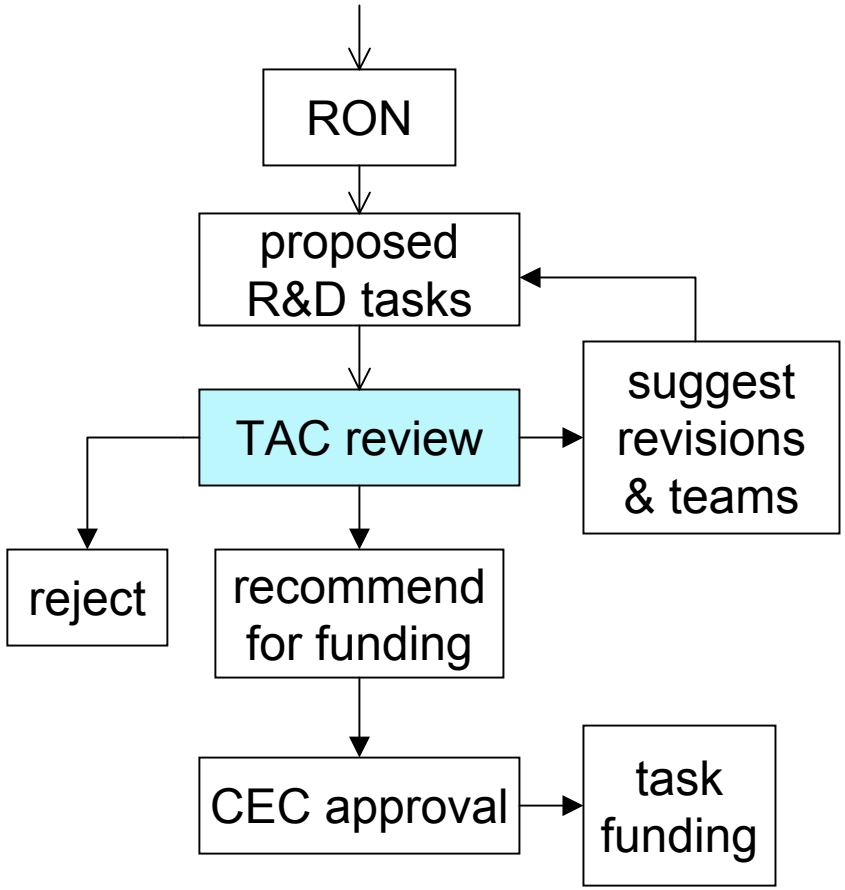
- RONs are posted at CIEE website in PDF file format and presented at semi-annual workshops
- 8-10 weeks to get through funding process from receipt of proposed tasks

PROPOSED R&D TASKS



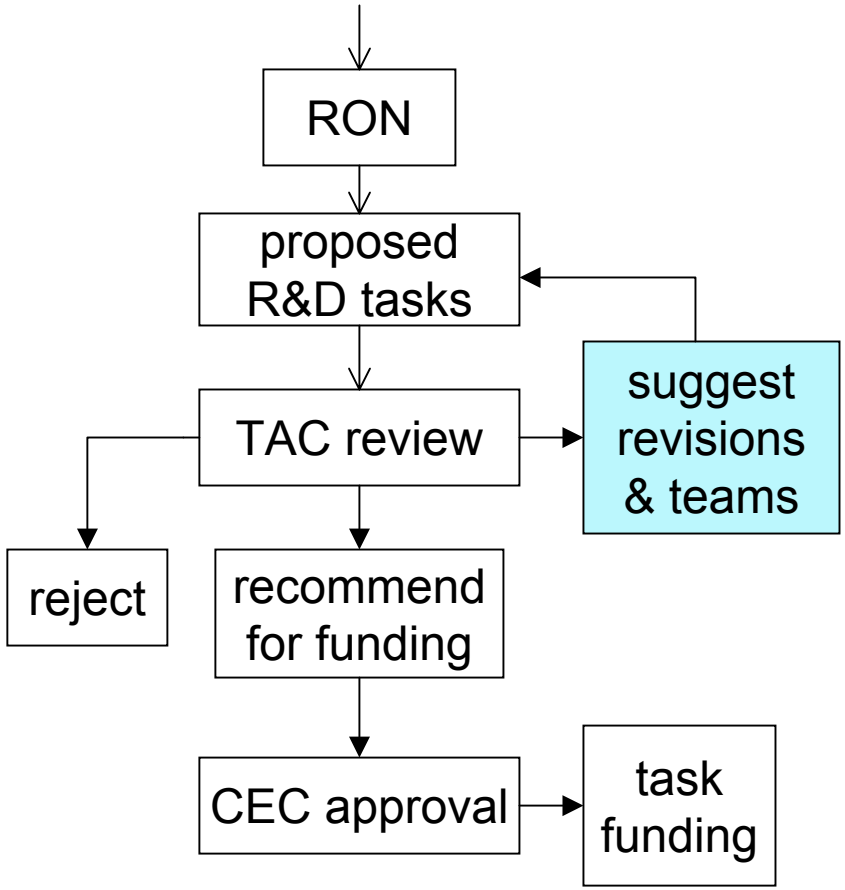
- **R&D tasks should be informal proposals**
  - < 5 written pages or
  - < 30 presentation slides
- **Discuss R&D ideas with Ron Hofmann and Gaymond Yee before submitting**

TECHNICAL ADVISORY COMMITTEE (TAC) REVIEW



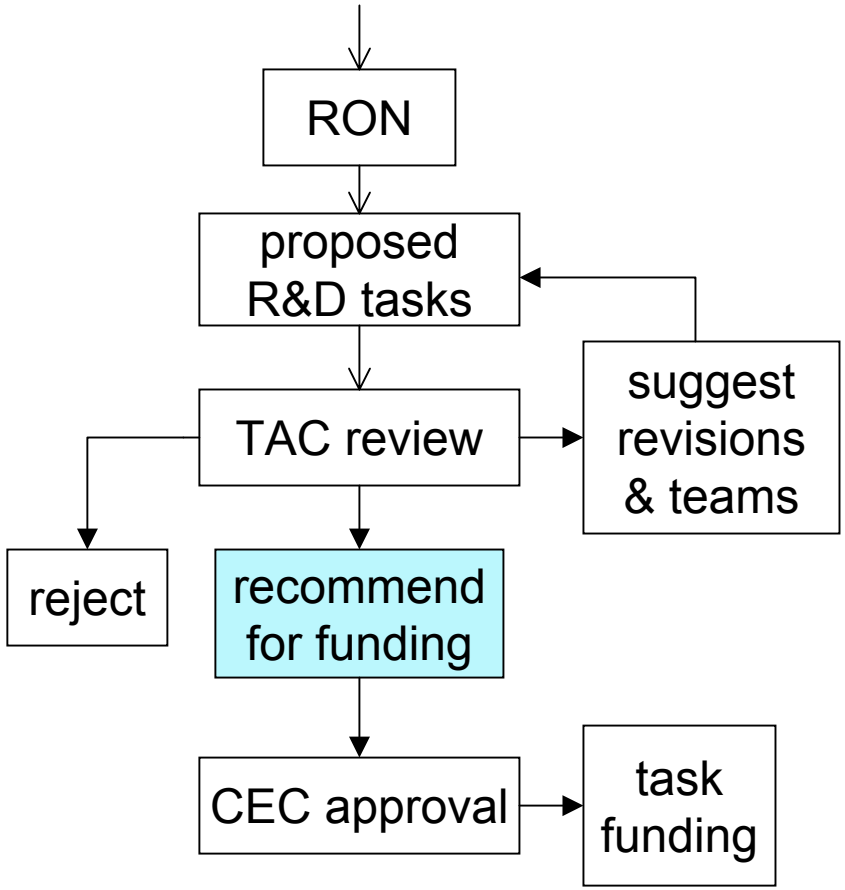
- **Separate TACs for each RON**
- **Reviewers may sit on more than one TAC**
- **Provides review**
- **3 possibilities**
  - Recommend
  - Suggest changes
  - Reject

SUGGEST REVISIONS & TEAMS



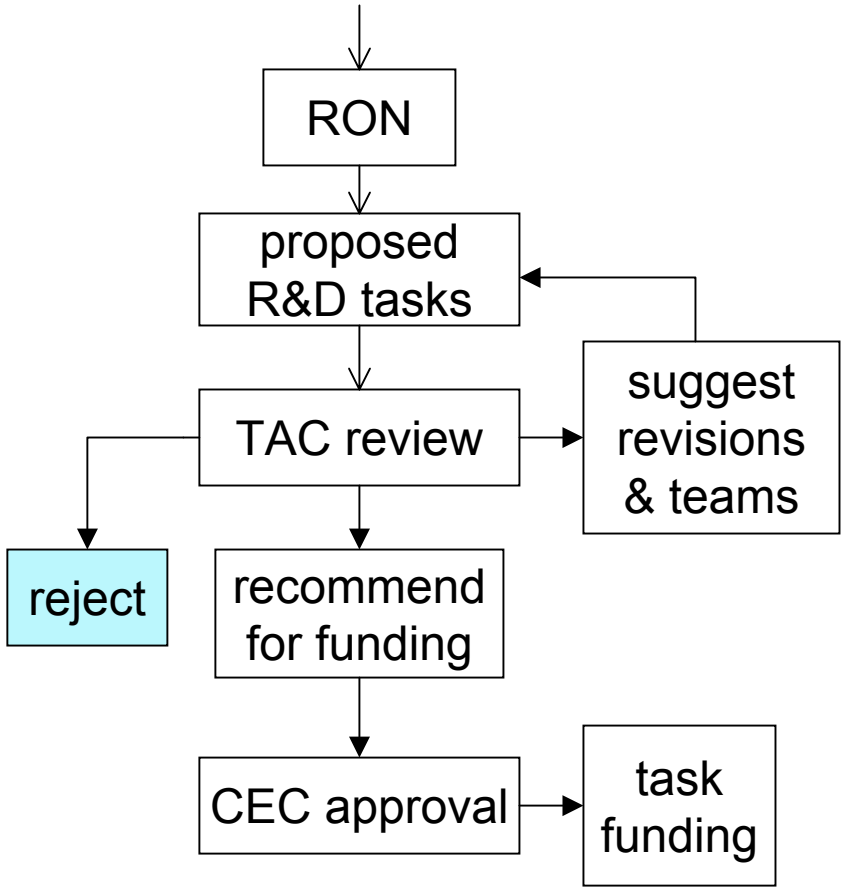
- **Key elements**
  - Multi-disciplinary
  - Collaboration
  - DR relevance
- **3-8 year timelines**
  - Medium term
  - Long term
- **Annual milestones**

RECOMMEND TASK R&D FOR FUNDING



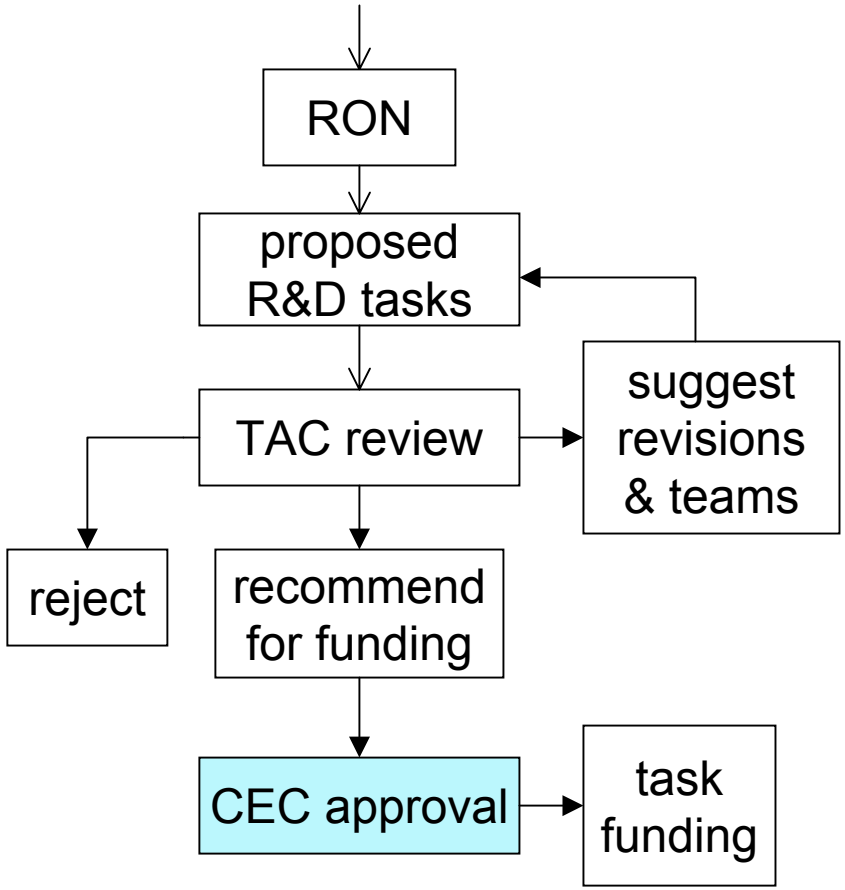
- **DR ETD Project Manager**
  - Gaymond Yee
- **DR Program Advisor**
  - Ron Hofmann
- **CEC Contract Manager**
  - Laurie ten Hope

REJECT



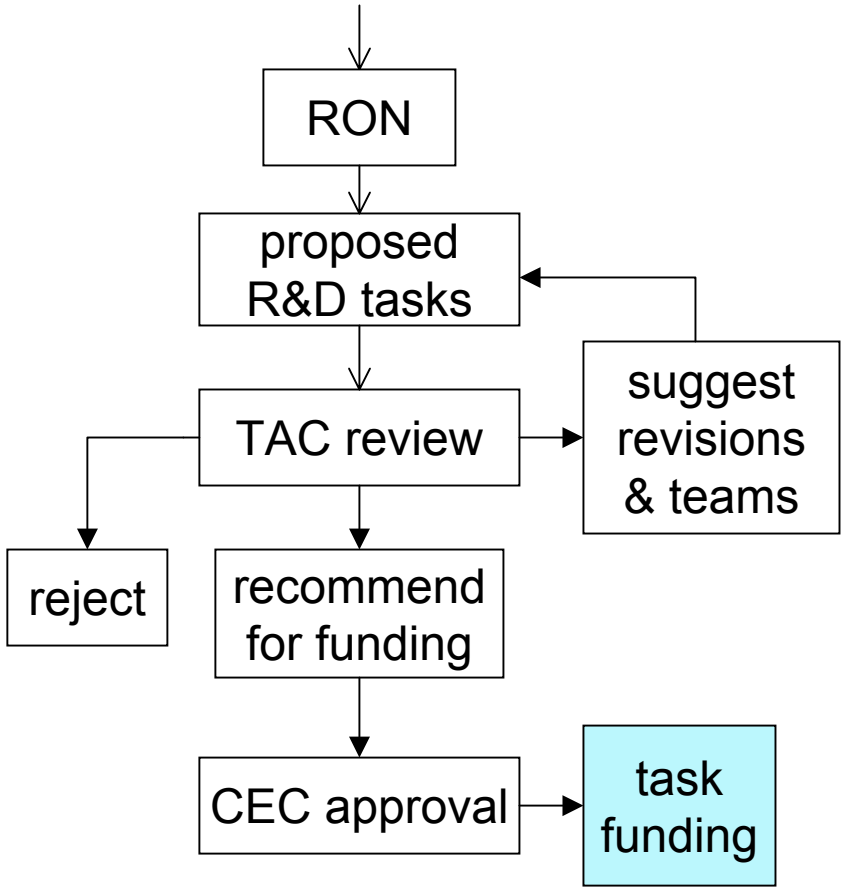
- **Doesn't address open DR ETD RONs**
- **Isn't multi-disciplinary**
- **Isn't collaborative**
- **Can resubmit new proposed R&D tasks after discussions**

CEC APPROVAL



- **Laurie ten Hope (CEC Contract Manager)**

TASK FUNDING



- **Maureen Barnato (DR ETD administrator)**
- **Formal procedures to be posted at CIEE website**
- **For UC, it's a familiar process**

DR ETD TEAM

- **Project management**
  - Gaymond Yee
- **Task administration**
  - Maureen Barnato
- **Information website**
  - http://ciee.ucop.edu/dretd/

REMAINING AGENDA

- **Roger Levy**
  - meters and prices
- **Alexandra von Meier**
  - power delivery system
- **Gaymond Yee**
  - research opportunity notices
- **Ron Hofmann**
  - Q&A and closing remarks