EPRI
Strategic Science & Technology Program

Entergy Executive Review
March 31, 2000
Palo Alto, CA

Paul M. Grant
Science Fellow

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SS&T - EPRI Board Mandate

"10% of dues received shall support long - range research and development"

EPRI BOD Action, 1984

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SS&T Program Implementation

- Total 2000 Budget = $35M ($3M External)
- 11 “Initiatives” (> $1M, 1-3 Years)
- ~40 “Projects” (< $1M, ~ 1 Year))
- ~1/3 Technical Staff Involved
- Semiannual Internal & RAC Review/Prioritization

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SS&T Program: Technology Focus

- The Electricity Paradigm
  - Generation/Storage
  - Transmission/Distribution
  - End Use
- Crosscutting Industrial/Societal Issues
- Future Watch

SS&T Initiatives (Technology Focus)

Generation/Storage

Advanced Nuclear

Advanced Coal

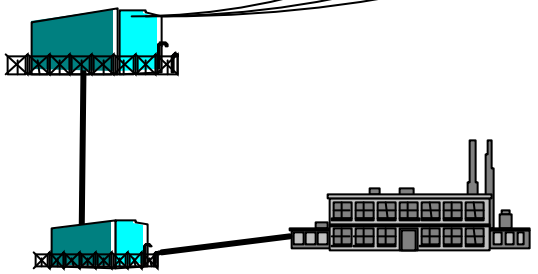
Low Pressure Turbine Performance

The Future of Power Delivery

Complex Interactive Systems/ Networks

Advanced Power Electronics

Transmission/ Distribution



End Use

Power Market Redesign

New Retail Product Design

Climate Adaptability

Paradigm Crosscutting

Materials Health

Human Performance

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SS&T Program Guide: Electricity Technology Roadmap

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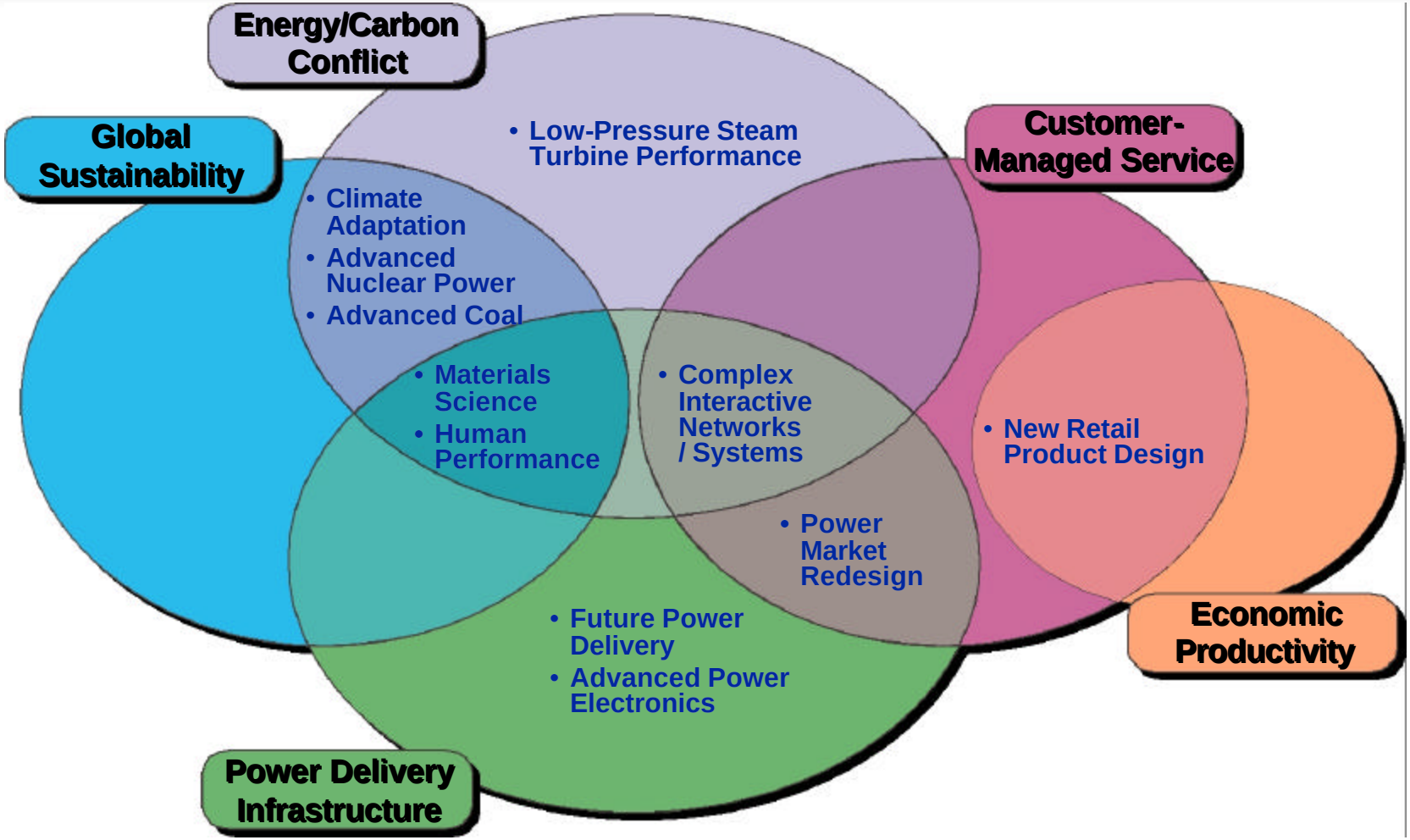
SS&T Initiatives (Roadmap Signposts)



Advanced Nuclear Power

**"The world needs more energy….
Nuclear power is environmentally safe, practical and affordable.
It is not the problem – it is one of the best solutions."**

The Need for Nuclear Power
R. Rhodes and D. Beller
Foreign Affairs, Vol. 79, No. 1
January/February 2000

- Advanced Reactor Technology
- Corrosion Research
- Advanced Information System

- 2000 Funding: $2,000,000

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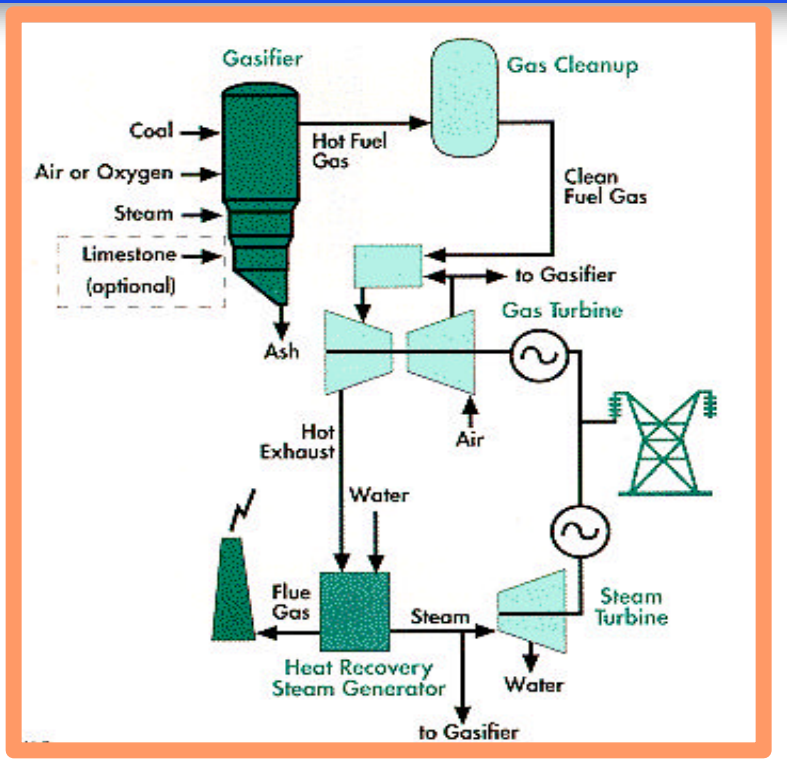
Advanced Coal

"~60% of US electricity production is derived from coal, 27% worldwide."

US DOE Energy Information Agency



- Low $N0_x$ Combustion
- Emissions Control
- Advanced Plant Design

- 2000 Funding: $1,500,000

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Low Pressure Steam Turbine

"Water, water, everywhere… but not on turbine blades!"

Anon.

- Control droplet and film formation
- Demonstrate efficiency increases on the order of 1%.
- Electric field induced film/droplet retardation
- Chemical retardation of film/droplet formation

- 2000 Funding: $850,000

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Complex Interactive Networks/Systems

"We are sick and tired of them and they had better change!"

Chicago Mayor Richard Daley on the August 1999 Blackout

- From Power Grids to Power Laws: A statistical physics model for complex T&D networks.
- Intelligent management through multi-agent computational techniques.
- Defense against catastrophic grid failures.

2000 Funding:
$6,390,000

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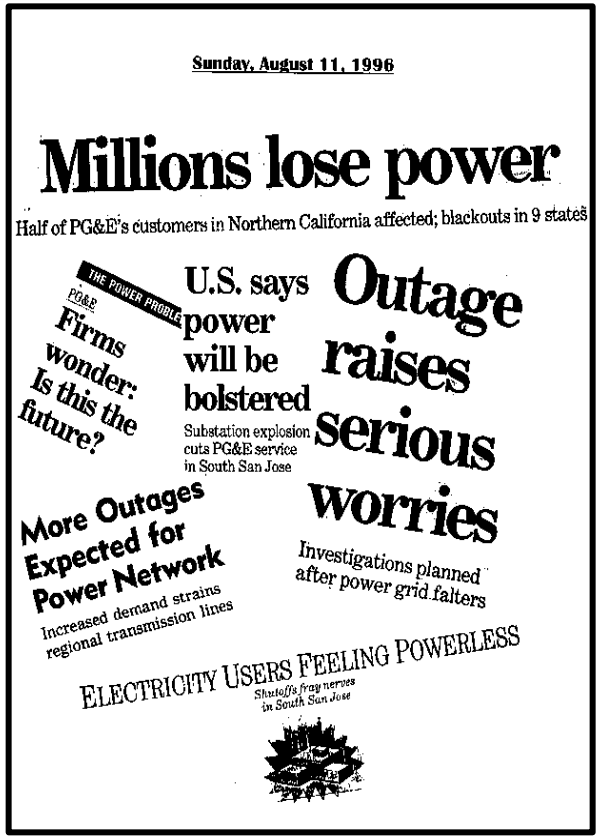
Complex Interactive Networks/Systems

The Reason for this Initiative:

"Those who do not remember the past are condemned to repeat it."

George Santayana

- **Two faults in Oregon (500 kV & 230 kV) led to…**
  - **…tripping of generators at McNary dam**
  - **…500 MW oscillations**
  - **…separation of the Pacific Intertie at the California-Oregon border**
  - **…blackouts in 13 states/provinces**
- **Studies show with proper "intelligent controls," all would have been prevented by shedding 0.4% of load for 30 minutes!**



Sunday, August 11, 1996

Millions lose power

Half of PG&E's customers in Northern California affected; blackouts in 9 states

THE POWER PROBLE

PG&E Firms wonder: Is this the future?

U.S. says power will be bolstered

Substation explosion cuts PG&E service in South San Jose

Outage raises serious worries

More Outages Expected for Power Network

Increased demand strains regional transmission lines

Investigations planned after power grid falters

ELECTRICITY USERS FEELING POWERLESS

Shutoffs fray nerves in South San Jose

August 10, 1996

Complex Interactive Networks/Systems

"This band of brothers…"

Henry V

- US DoD Co-funded
- Cal Tech, MIT, UCLA, UI, UCSB, CMU, RPI, Cornell, UCB, GWU, WSU, UW, Harvard, U Mass, U Boston, ASU, ISU, VT, ComEd, TVA

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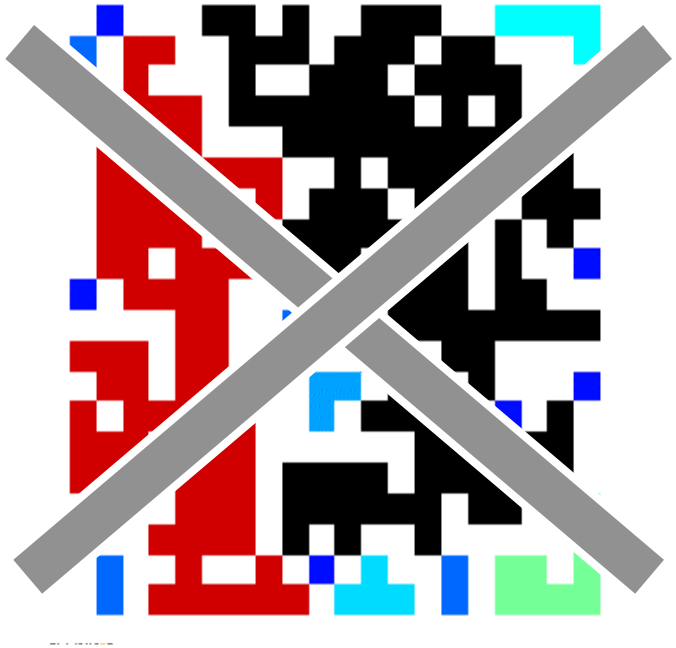
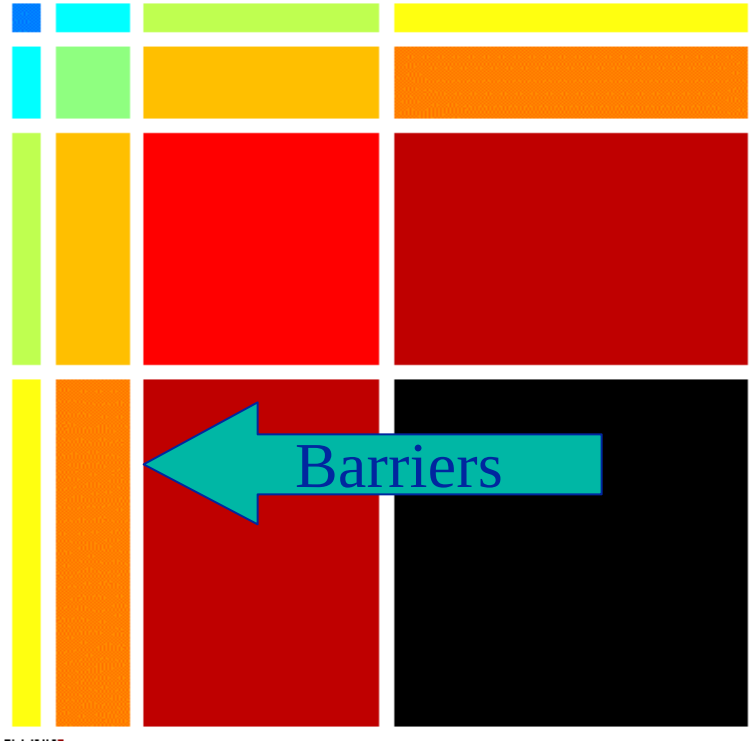
Complex Interactive Networks/Systems

Failure Propagation on Grid

Percolation



Designed System



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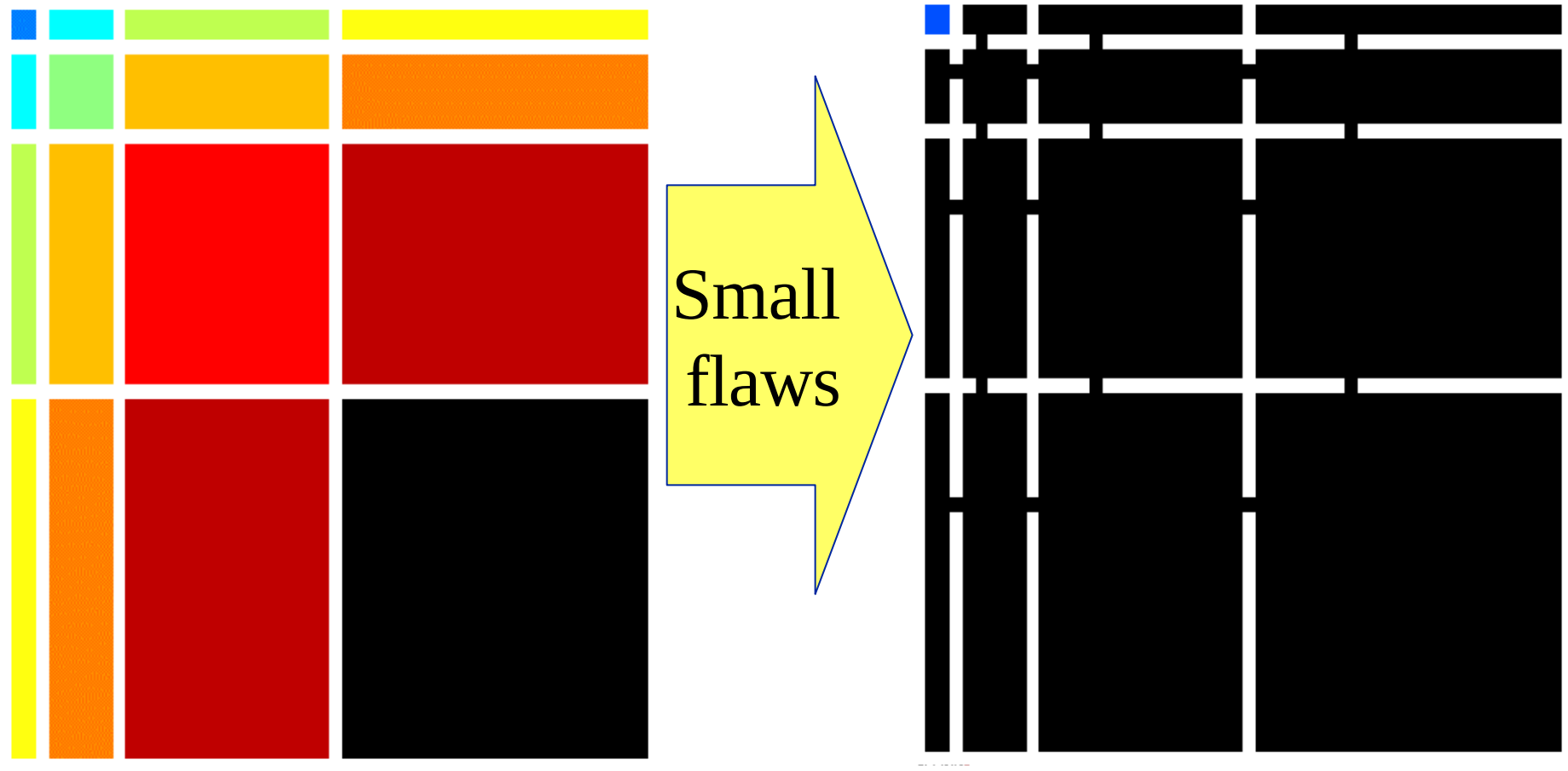
Complex Interactive Networks/Systems

Failure Propagation on Grid – Barrier Breakdown



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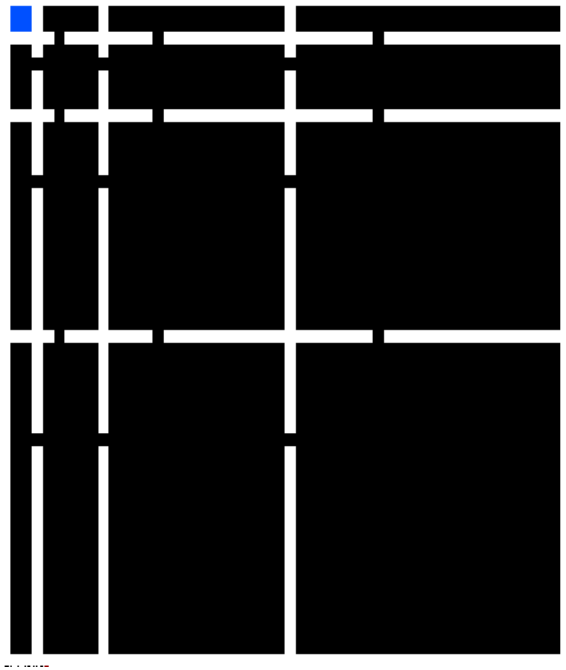
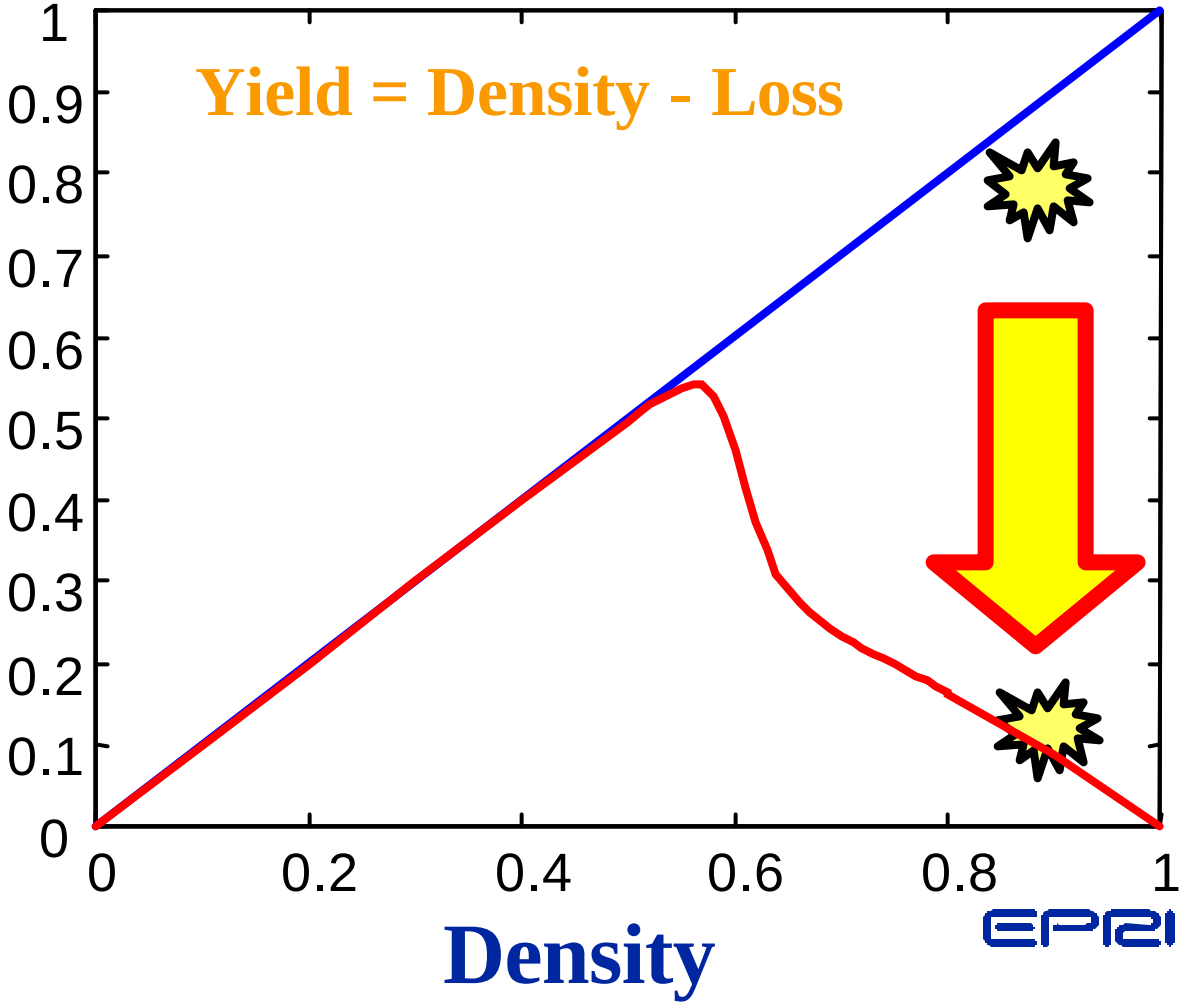
Complex Interactive Networks/Systems

Failure Propagation on Grid – Topology & Probability



Yield



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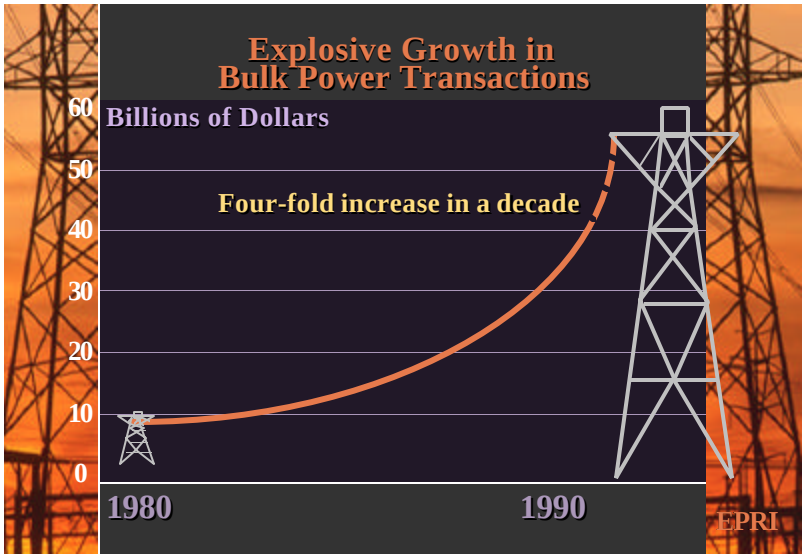
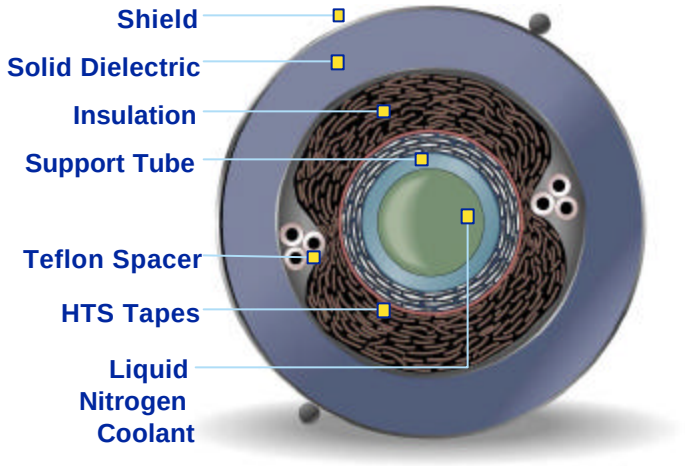
Future of Power Delivery

Increasingly Stressed T&D System





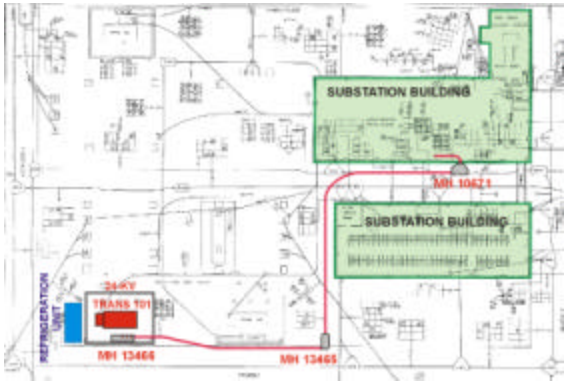
- Maximize utilization of energy corridors
  - Superconducting cables
  - Advanced superconducting wire
- Improve T&D asset performance and lifetime
  - FACTS & Energy storage

2000 Funding:
$3,220,000

Future of Power Delivery

DECO Demo

- Detroit Edison, Pirelli, EPRI, DOE, ASC, Linde
- 120 m, 3 phase, 27 kV, 3000 A
- Switch on 1Q01
- Triple power underground power delivery



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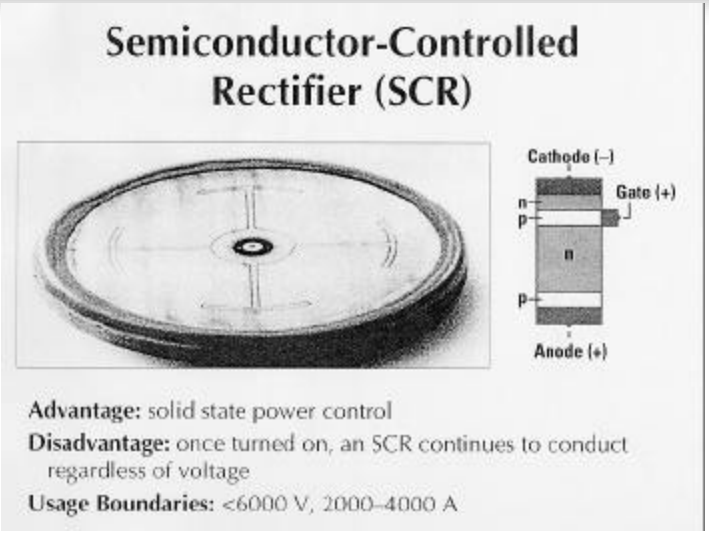
Advanced Power Electronics

"The continued development of silicon based electronics will encounter a "brick wall of physics" by 2006."

Semiconductor Industry Association Roadmap



- Advanced Silicon
  - Advanced MOS Turn-off Thyristors
  - Design and test prototype devices
- Beyond Silicon
  - "Wide Bandgap" Materials (SiC, GaN)
  - Design and test prototype devices
- Coordinated with DARPA complementary program

2000 Funding:
$2,830,000

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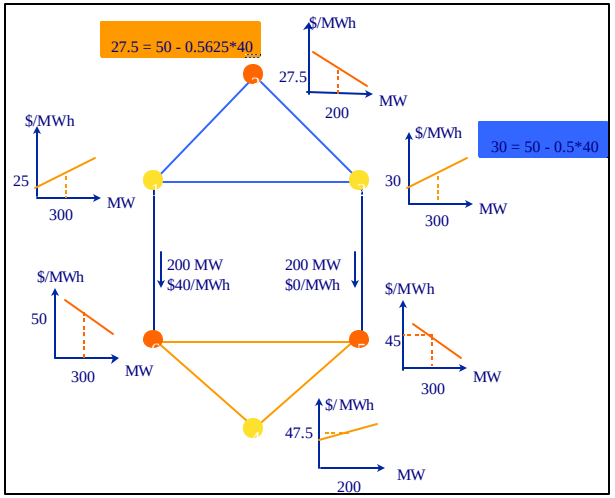
End Use

Power Market Redesign

"Experience in wholesale electric markets…suggest that increase reliance on competition could bring significant tangible benefits to all electricity consumers."

Comprehensive Electricity Competition Bill (Murkowski Bill)



- Restructuring of energy markets is evolving.
- Develop theoretical basis
- Simulate, perform market experiments
- Develop, evaluate pricing approaches

2000 Funding: $750,000

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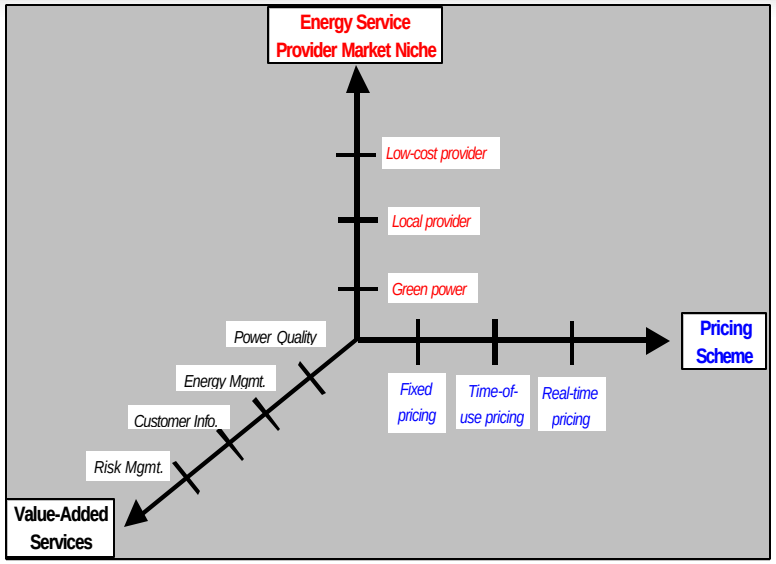
New Retail Product Design

"To increase sales, we must uncover applications for our products our customers have not yet themselves realized."

Thomas J. Watson, Founder of IBM



- Product designs that bundle commodity energy with value-added services.
- Model price/load/competitor response combining traditional engineering simulation techniques with econometric methods.

2000 Funding:
$1,000,000

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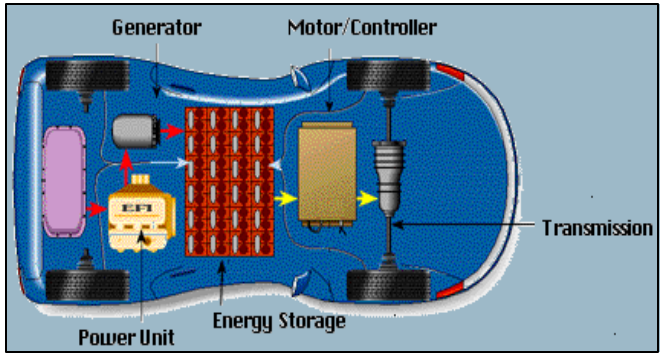
End Use (Project)

Grid-Connected Hybrid Electric Vehicles

"60% of vehicle travel miles could be supported by a 40 mile range battery and a supplemental prime mover."

EPRI Study



- Accelerate GCHEV commercialization to develop market.
- Technical/economic/market analyses for GCHEV buses and delivery vans and commuter vehicles.
- Lobby for GCHEV support on federal/state level.

2000 Funding:
$350,000

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Adaptation

Hurricane "Mitch," 1998

10,000 feared dead and missing in Nicaragua and Honduras

- Identify Adaptation Opportunities
  - Regional Climate Modeling
  - Ecosystem Adaptation
  - Health Effects Adaptation
  - California Analysis
- Include Adaptation in Integrated Assessments

2000 Funding:
$1,000,000

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Materials Health

"Materials Science is the unifying discipline underlying all modern technology."

Materials Research Society

- Material damage mechanisms and advanced materials.
- Key areas:
  - condition assessment, repair, remaining life assessment (CARLA)
  - coal science
  - advanced materials, biomimesis
  - corrosion assessment & control
  - corrosion control using biological systems

2000 Funding:
$4,660,000

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Human Performance

"Human error played a major role in bringing about the TMI incident."

Nuclear Fears
PBS Frontline, 1998

- Emphasis on organizational and management issues contributing to human error.
- HP management database and analysis
- Automated HP analysis tools

- 2000 Funding: $1,000,000

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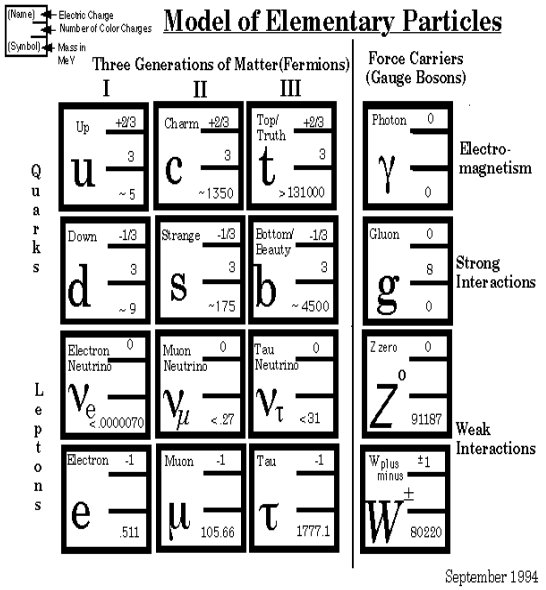
SS&T - Future Watch

OutPost on the Endless Frontier

by Paul M. Grant
electricwindow.com
& by request



- "Good" Science
  - **High T_c**
- "Bad" Science
  - **Cold Fusion**

2000 Funding:
$0

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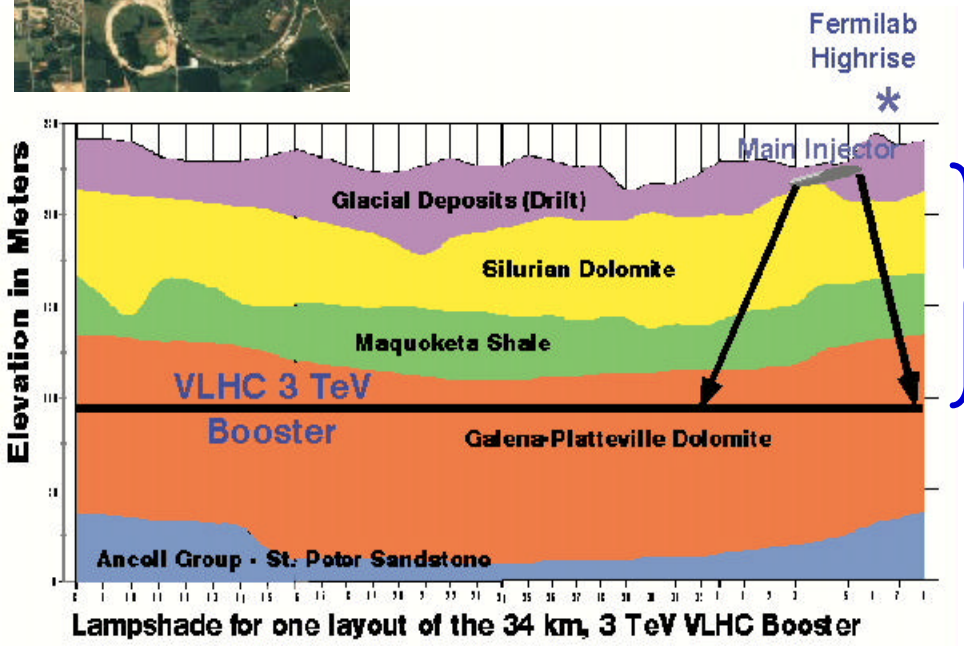
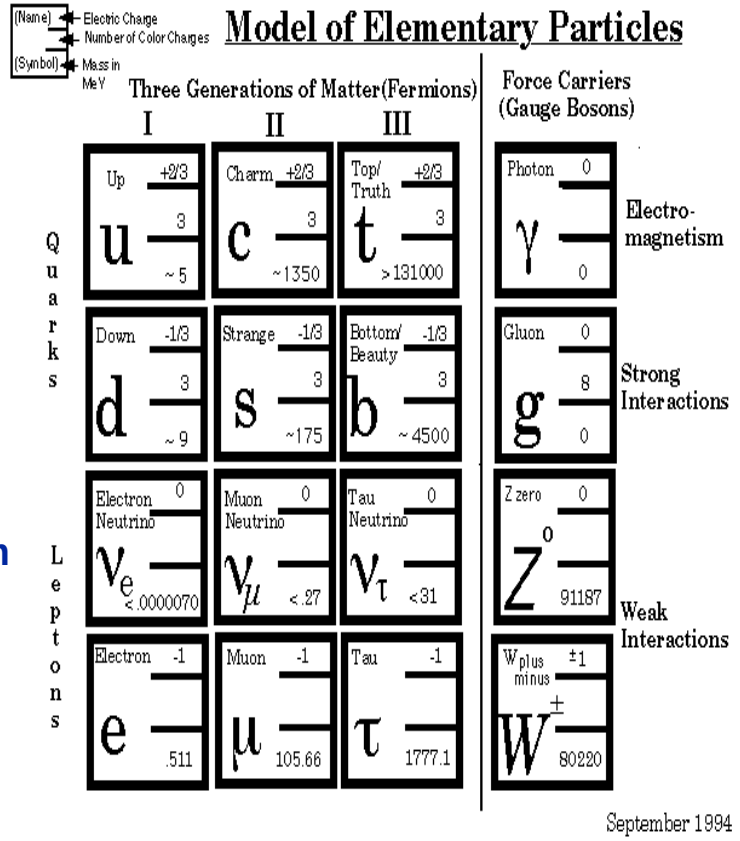
"Good" Science

Future Hadron Colliders

Fermilab's Tevatron





"Good" Science

Advanced Underground Energy Corridors

- "Out of sight, out of mind"
  - **High T_C dc cables**
  - **Gas/liquid transport**
  - **Communication**
  - **Parcel Delivery**
- Near perfect adaptation
  - **Weather**
  - **Intrusion**

Cost:
$400/m

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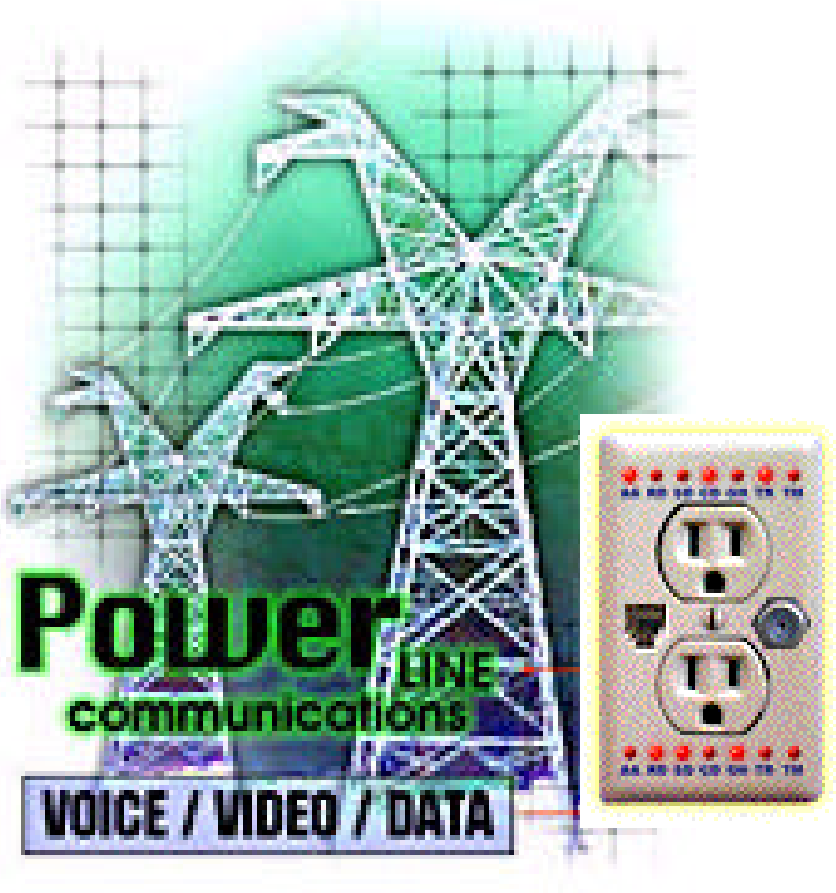
Future Watch

“Bad” Science

Media Fusion Corporation
www.mediafusioncorp.net

- 2.5 Gbit/sec on T/D Lines
  - **1000x DSL**
  - **Skips around transformers**
  - **Sell your IBM, Lucent & MCI**
- “Fugetabawtit”
  - **OutPost 11**



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Future Watch

"Bad" Science

Black Light Power
www.blacklightpower.com

New form of hydrogen power provokes scepticism

- New H "Ground State"
  - **Excess Heat from water**
  - **New hydrogen chemistry**
  - **Sell your PGE, NiMo & Entergy**
- "Fugetabawtit"
  - **Nature, vol 404, 16 March 2000, p. 218.**

"…threatened several prominent physicists with possible legal action…"

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