EPRI
Strategic Science & Technology Program

EPRI TDC Meeting

September 27, 2000

Charleston, NC

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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Charleston TDC Agenda for SS&T

- Defining SS&T Program Content
  - Sources of Input
  - Integration and Prioritization

- Member Advisory Role
  - Currently RAC SS&T Subcommittee
  - Should this be extended…broadened?

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SS&T History: 1985 – 1994
Pre-Progressive Flexibility

- Exploratory Research & Applied Science
- ~ $50M Annually
- VP Director, “Oversight” by ERAS Council
- Administered by “Executive Scientist” Program Managers
- Project Management by Technical Staff
- ~ 100 Projects

Materials	Sensors	Mathematics
Superconductivity	Power Electronics	Robotics
Conducting Polymers	Insulators	Energy Issues
Environment	Controls	Rotating Machinery

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SS&T History: 1995 - 1997
Progressive Flexibility

- Strategic Research & Development (SR&D)
- ~ $40M Annually (50/50 Group/Core)
- Four sub-Directors, “Oversight” by SR&D Council
- “Core” Project Management by “Executive Scientist” Program Managers
- “Group” Project Management by Technical Staff
- 17 “Core Vectors”

Déjà vu all over again

Materials	Sensors	Mathematics
Superconductivity	Power Electronics	Robotics
Conducting Polymers	Insulators	Energy Issues
Environment	Controls	Rotating Machinery

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SS&T History: 1995 - 1997
Open Target Menu

- Strategic Science & Technology (SS&T)
- ~ $35M Annually ($3M External)
- Director -> CEO (now VP S&TD), RAC Oversight
- Project Management by Sector Technical Staff
- 11 “Initiatives,” ~40 “Projects”

Materials Health	Advanced Nuclear	Advanced Coal
Human Performance	Power Electronics	Future Power Delivery
Power Markets	CIN/S	New Retail Products
Adaptation	LP Turbines	

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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

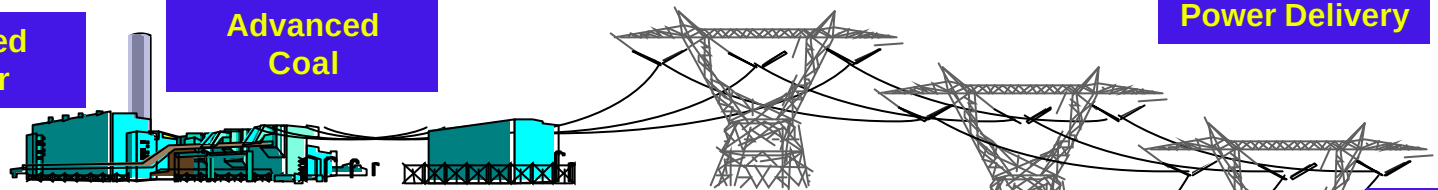
- The Electricity Paradigm
  - Generation/Storage
  - Transmission/Distribution
  - End Use
- Crosscutting Industrial/Societal Issues
- Future Watch

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

Climate Adaptability

Paradigm Crosscutting

Materials Health

Human Performance

End Use

Power Market Redesign

New Retail Product Design

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SS&T Program Guide: Electricity Technology Roadmap

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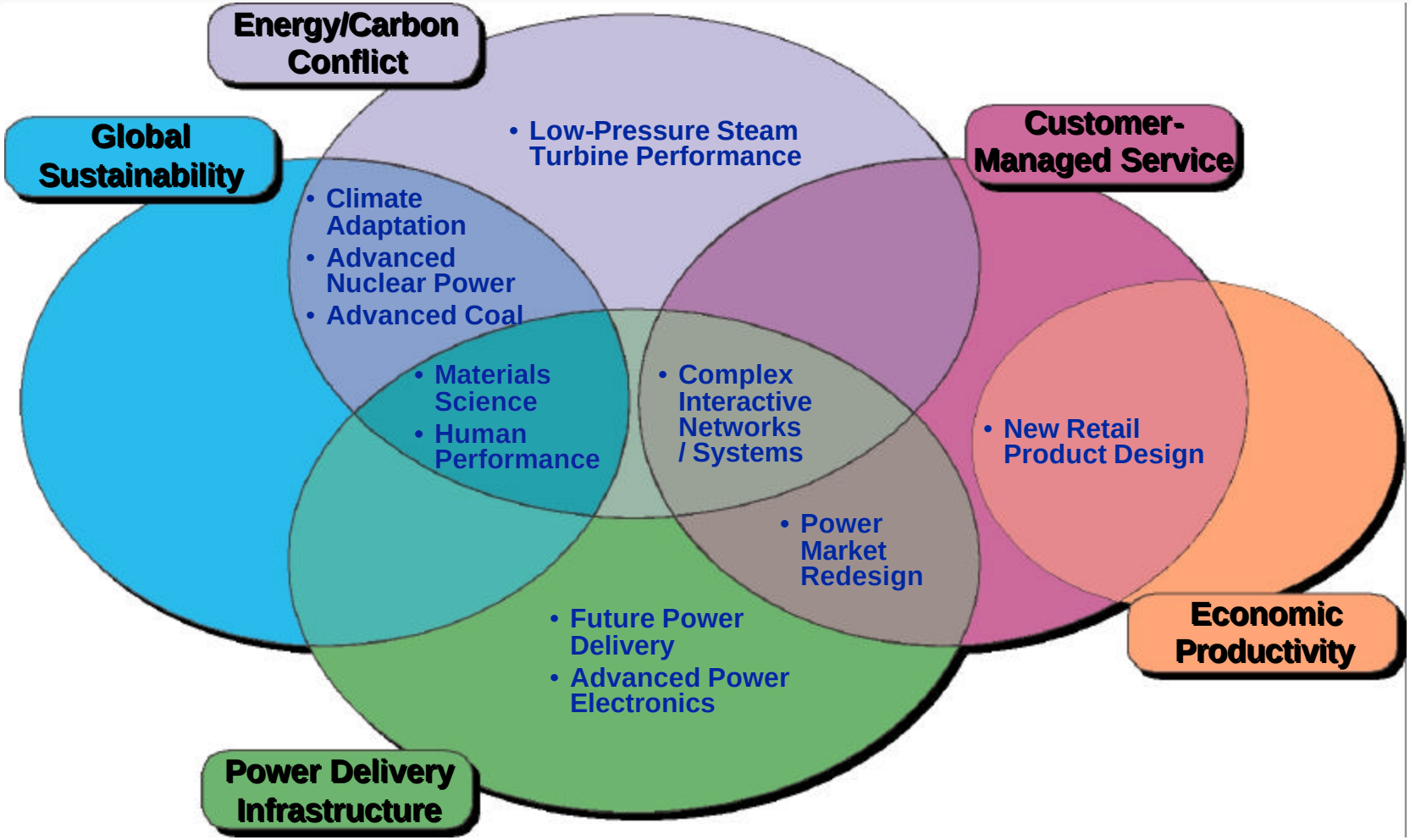
SS&T Initiatives (Roadmap Signposts)



Sure Could've Used Help

CIN/S & Power Markets

- Initially took top-down approach, engaging all-academic teams to dress power grid/market models with their favorite theoretical suit-of clothes.
- Needed more "member intelligence agency" input to assess their current experience in the "new world" of power marketing and transmission control.
- Monitor ISO activity for empirical deployment on which to base abstract modeling.
- Much better now and two of SS&T's premier initiatives, attracting significant public and policy attention.

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Did OK By Ourselves

Superconductivity & Power Electronics

- Deep and long-term EPRI core staff competency and program commitment.
  - Engaged key industrial, DOE, DARPA and academic partners
  - Novel IP and equity arrangements have yielded an exclusive EPRI sc cable patent and $3.5M (so far!) in stock sales (AMSC)
  - Effectively lobbied for increased Congressional funding
  - High visibility in scientific journals, professional society meetings, and news media
- Ran “road-shows” past selected utility members
  - Critically sifted feedback from studies and member comments
  - Sought out suitable demonstration sites…found Detroit Edison and AEP Ynez

DTE sc cable demo will be the 2001 “crown jewel” of EPRI SS&T

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The Future of SS&T

Warning!
Totally Speculative
as of 9/27/00

- 2001 Funding, $28M ($3M External)
- Content and Structure
  - "X"% Sector-driven, possibly target-marketed, perhaps separate TC pool
  - "X/4"% "Internal R&D," discretionary and opportunistic, perhaps marketed at CEO level
- Member Involvement
  - Sector SS&T: Sector/BU/ST&D Advisory Board
  - Internal R&D: RAC & BOD Accountable

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SS&T Program Appendix

- Distinguished Alumni of ER/AS, SR&D, and SS&T
- 1999-2001 Initiative Summary
- Future Watch Activities

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Distinguished Alumni: I

- The Boiler Tube Failure Book
- The Turbine Steam Path Damage Book
- 8 years of phase transition zone (PTZ) work on stress corrosion cracking and corrosion fatigue in turbines
- 8 years of volatility work on impurities, salts, oxides and other compounds in steam and water
- Innovative condensate polishing methods (radial flow, off-site regeneration)
- CQIM and NO_x/LOI Predictor software
- Utilization of flame scanner signals in commercial coal plant optimization codes.
- Copper corrosion, transport, and deposition understanding in cycle chemistry.

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Distinguished Alumni: II

- Improved weld repair techniques.
- Small punch test for fracture toughness.
- High temperature materials degradation in combustion turbines.
- Nuclear Regulatory Commission design certification for the passive AP-600 reactor design.
- Information mgm't. and construction modeling technologies for advanced nuclear plants.
- Use of Raman spectroscopy for in-situ assessment of inter-granular stress corrosion cracking (IGSCC).
- Understanding of Hg sorption in processing effluents from coal plants
  - dependence on flue gas NO_x concentration
  - viable sorption model

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Distinguished Alumni: III

- UCA ("Universal Communications Architecture") security project
  - results became part of national IEEE specification (TR1550 - UCA, Version 2)
  - results being used in Grid Operations & Reliability target
  - results being used in EPRI Information Security Initiative
- UCA Gas & Water Project results being used by targets to develop cross-industry UCA for utilities providing integrated gas, water, electricity services.
- Power Delivery Reliability Initiative
  - Funded seminal work @ Univ. of Iowa on system reliability
  - Led to identification and use of physical stability limits software used as core analysis tool for the PRA in the initiative.

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SS&T Initiative Summay

- By Paradigm
- By Cross-cutting

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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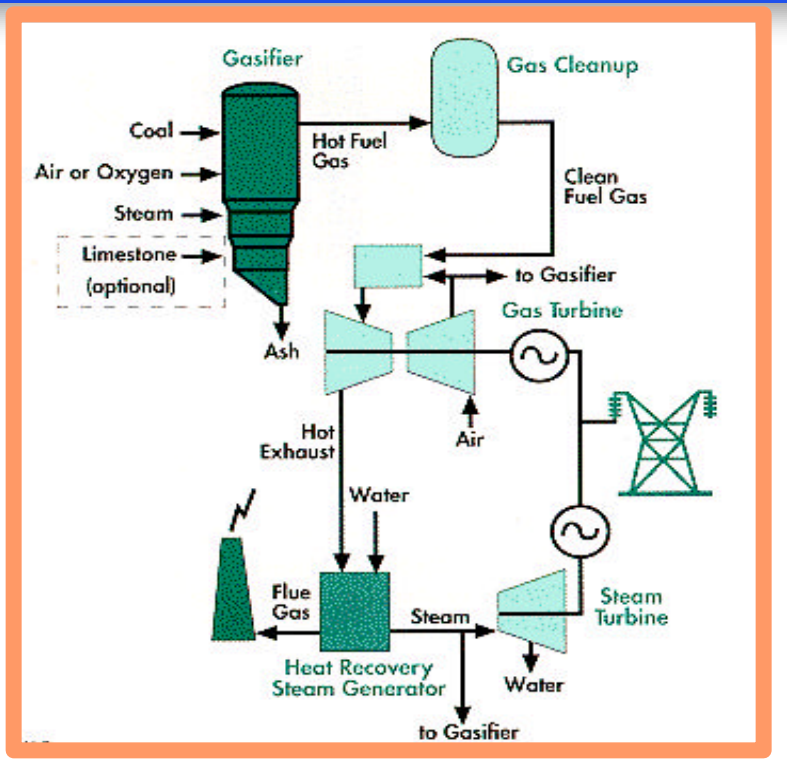
Advanced Coal

"~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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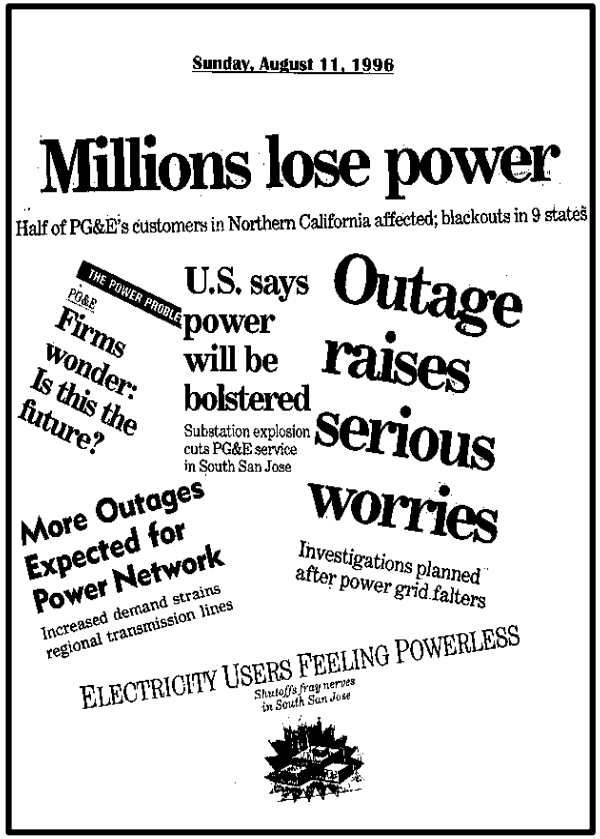
Complex Interactive Networks/Systems

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

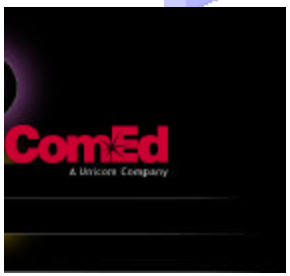
August 10, 1996

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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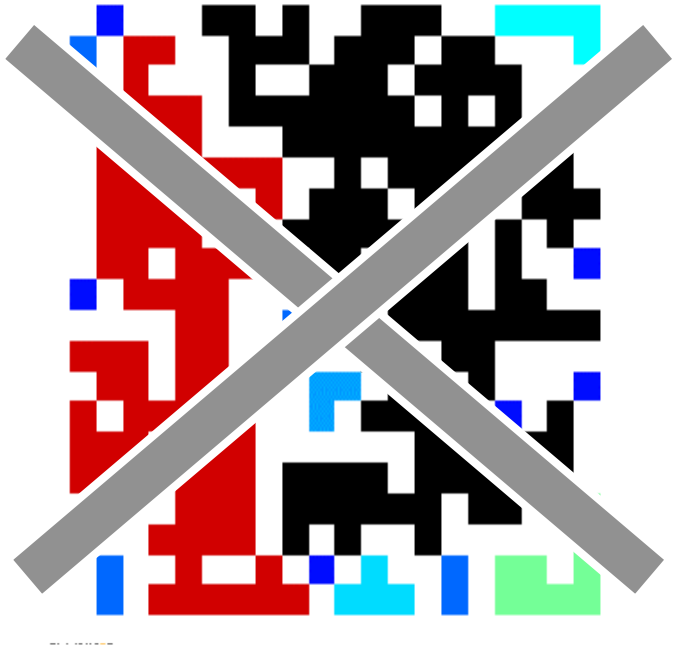
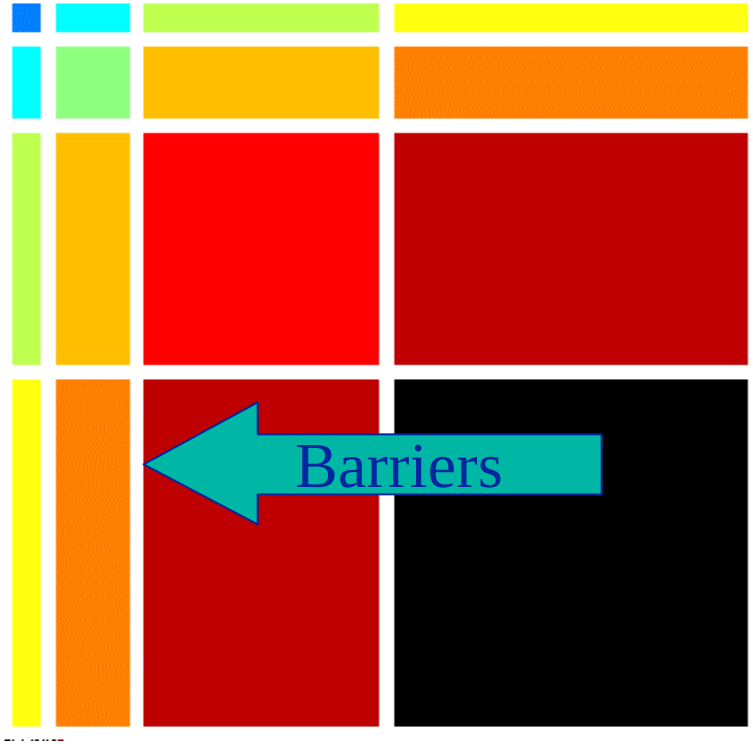
Complex Interactive Networks/Systems

Failure Propagation on Grid

Percolation



Designed System



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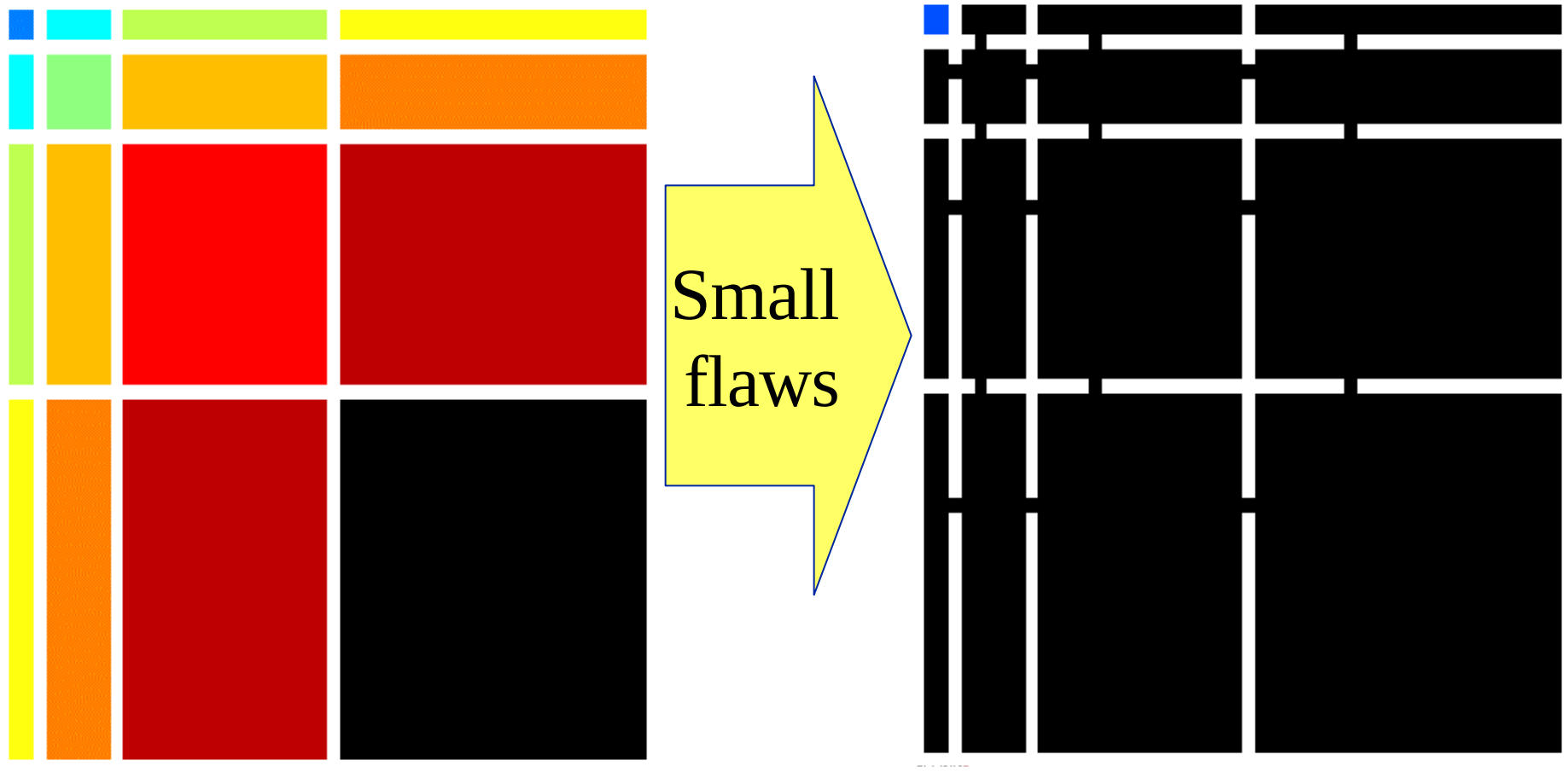
Complex Interactive Networks/Systems

Failure Propagation on Grid – Barrier Breakdown



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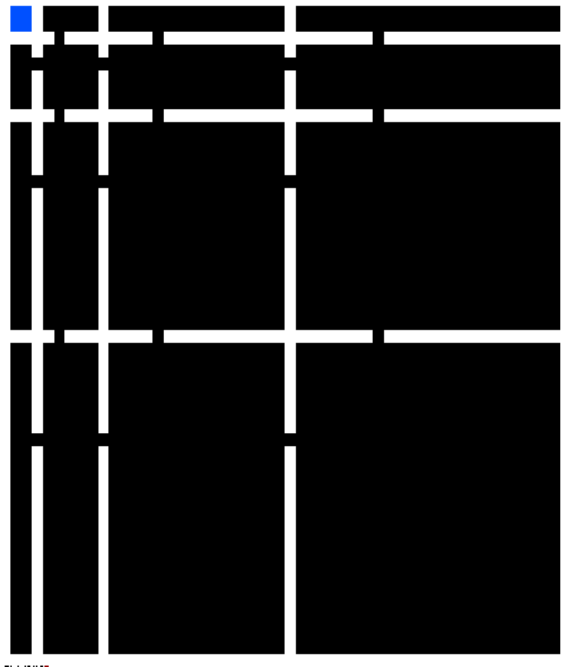
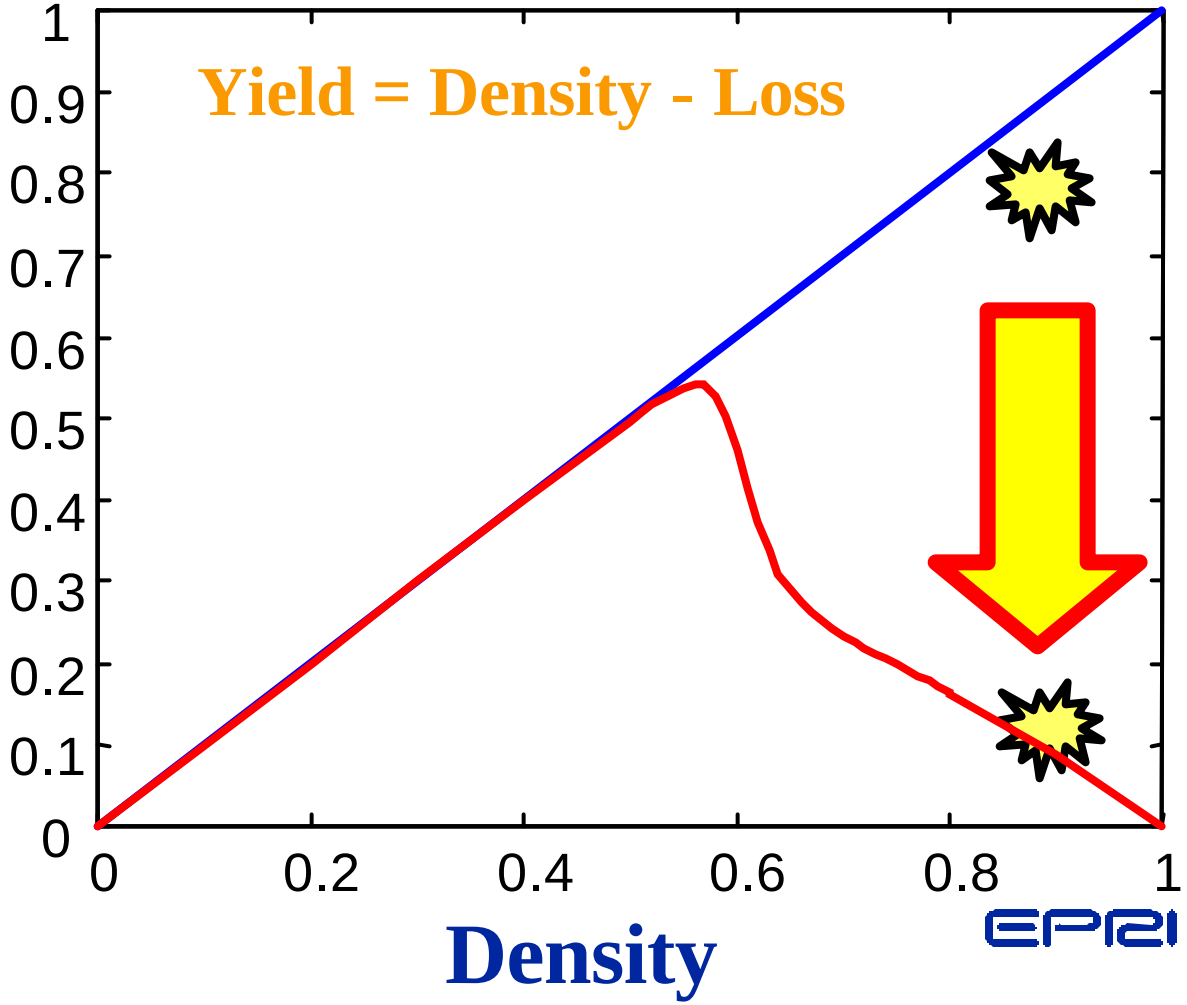
Complex Interactive Networks/Systems

Failure Propagation on Grid – Topology & Probability

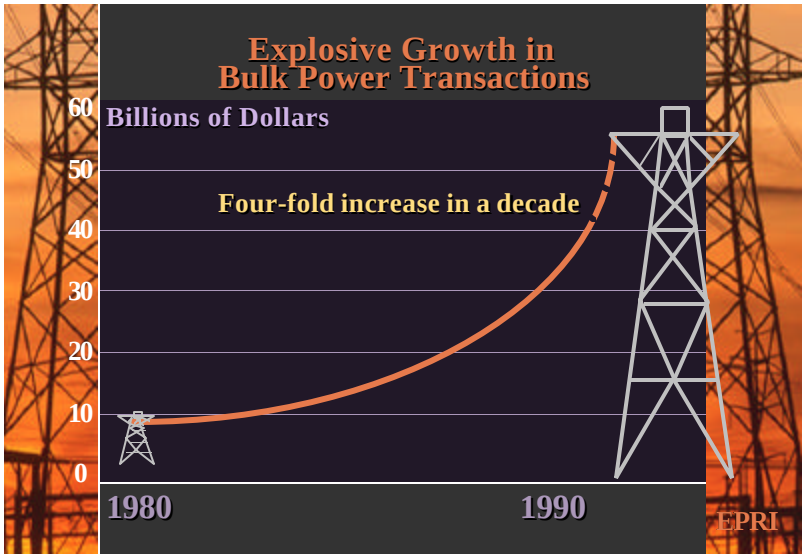


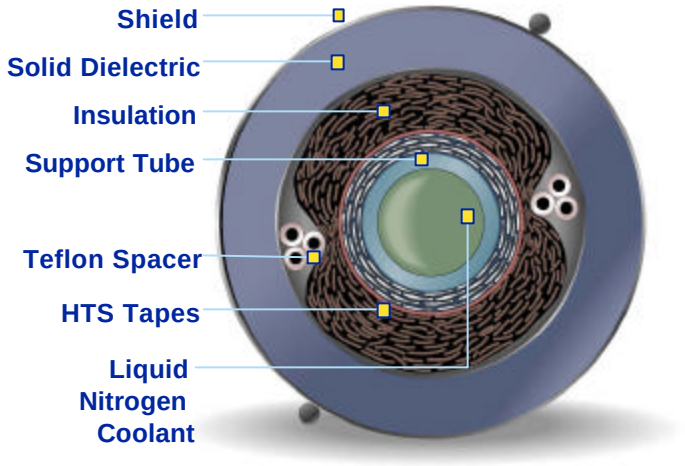
Yield



Future of Power Delivery

Increasingly Stressed T&D System





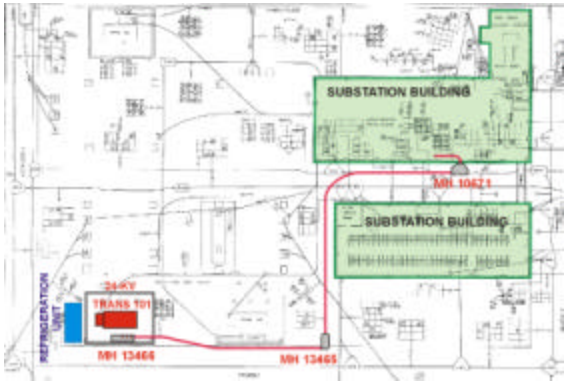
- Maximize utilization of energy corridors
  - Superconducting cables
  - Advanced superconducting wire
- Improve T&D asset performance and lifetime
  - FACTS & Energy storage

2000 Funding:
$3,220,000

Future of Power Delivery

DECO Demo

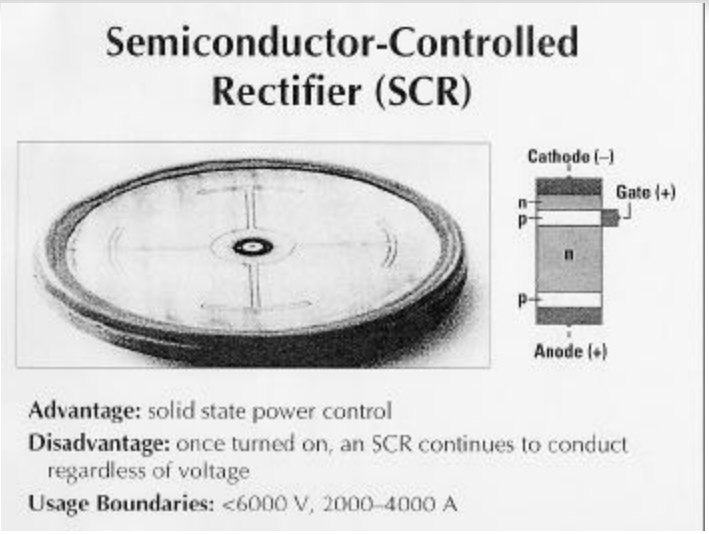
- Detroit Edison, Pirelli, EPRI, DOE, ASC, Linde
- 120 m, 3 phase, 27 kV, 3000 A
- Switch on 1Q01
- Triple power underground power delivery



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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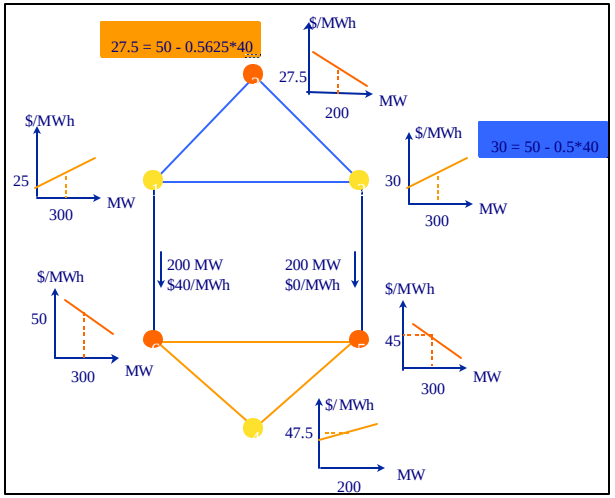
End Use

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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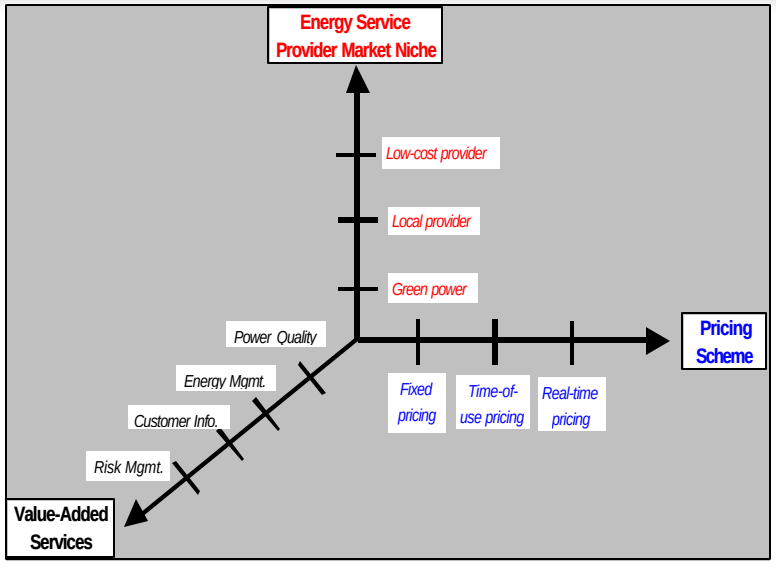
New Retail Product Design

"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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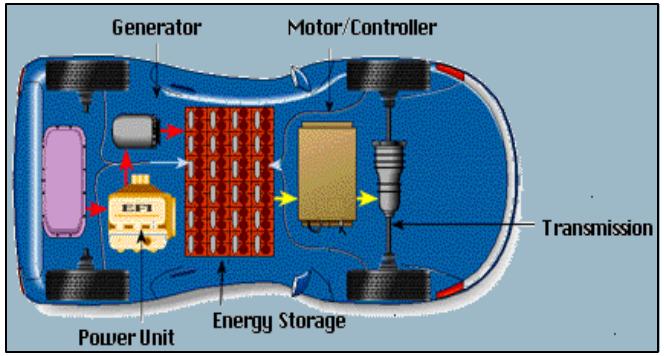
End Use (Project)

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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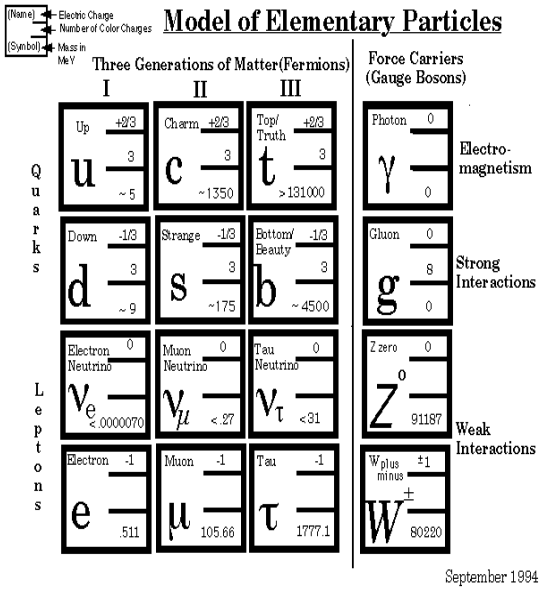
SS&T - Future Watch

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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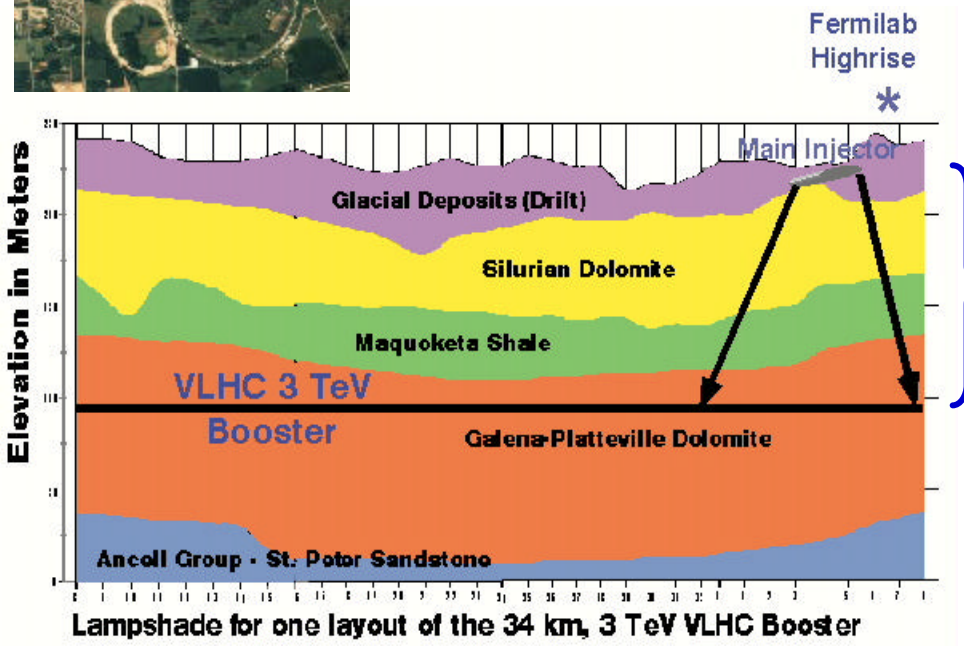
Future Watch

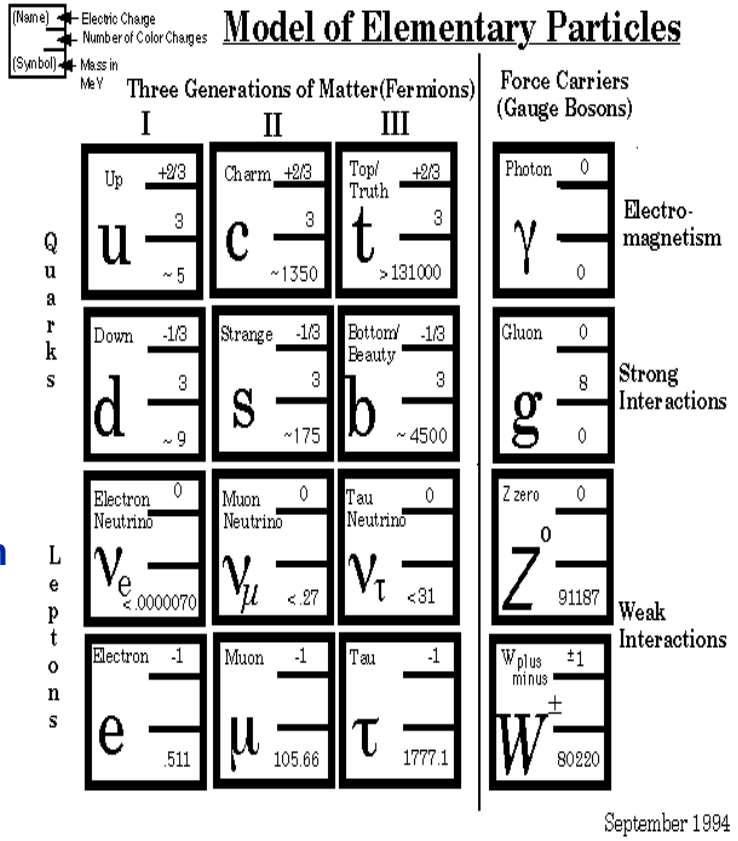
"Good" Science

Future Hadron Colliders

Fermilab's Tevatron



Lampshade for one layout of the 34 km, 3 TeV VLHC Booster



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Future Watch

"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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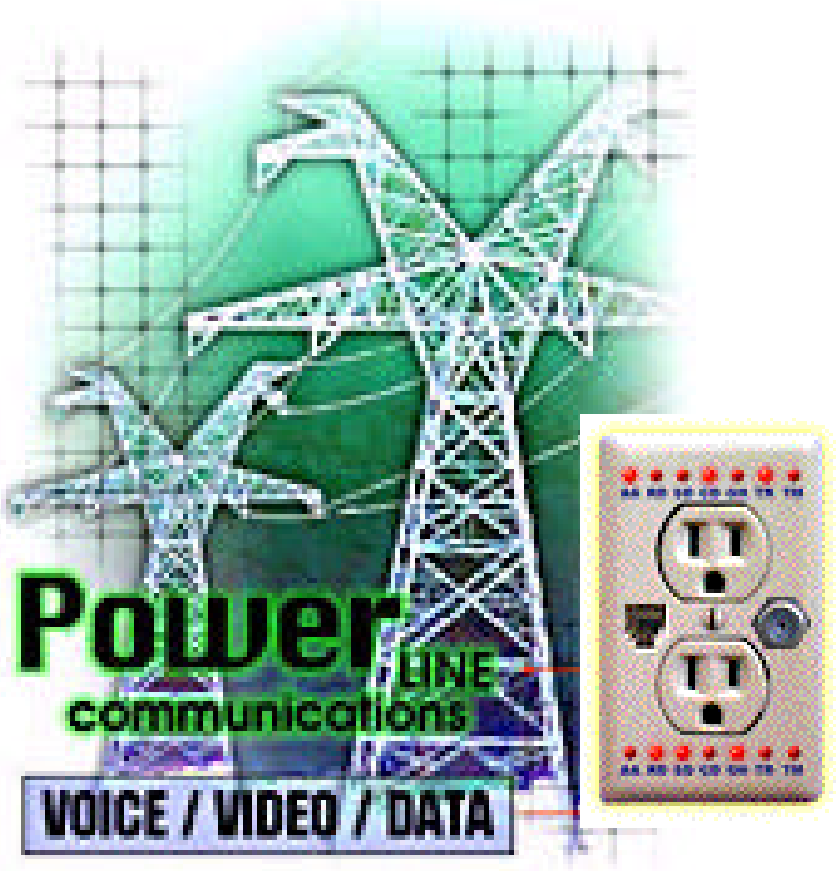
Future Watch

"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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