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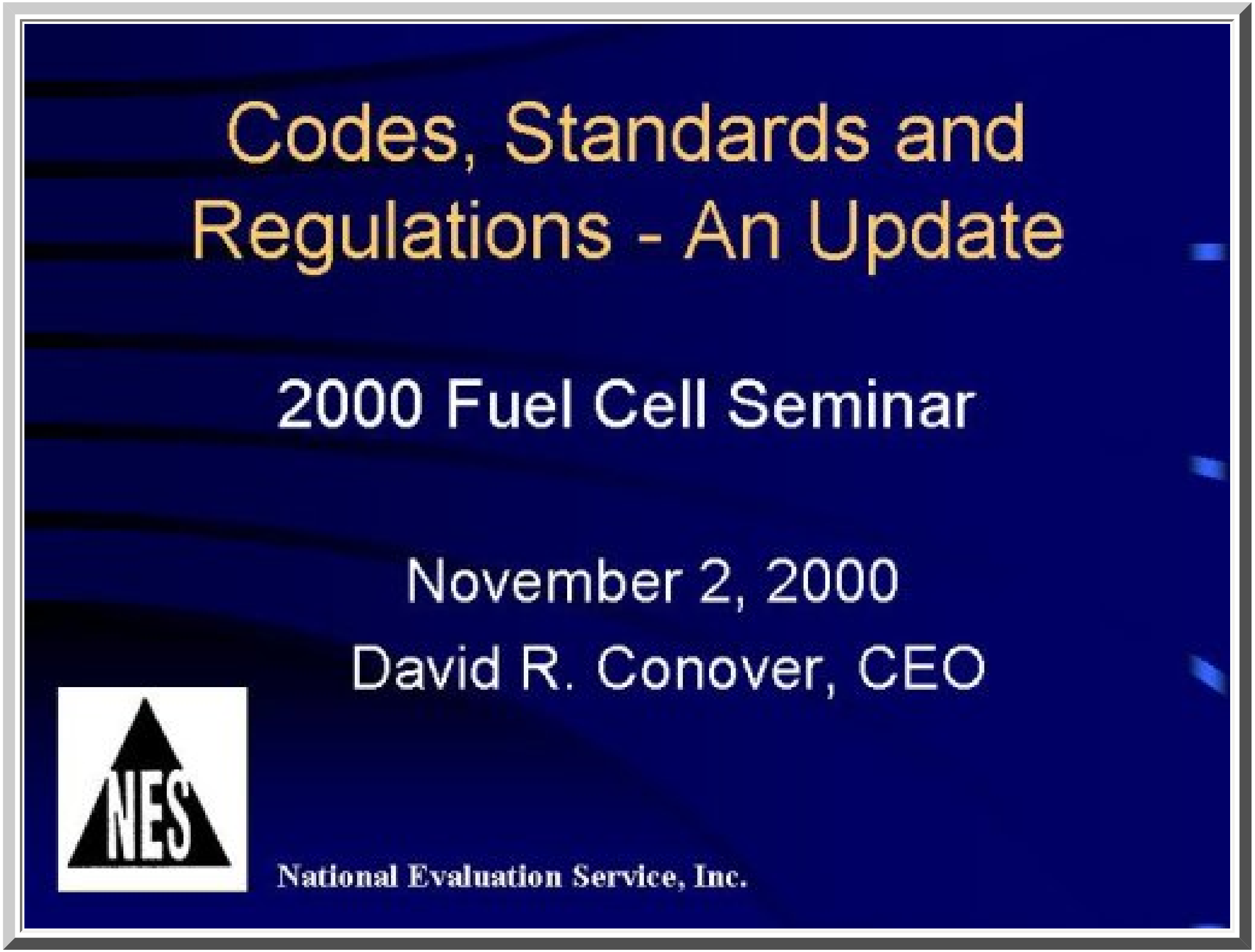
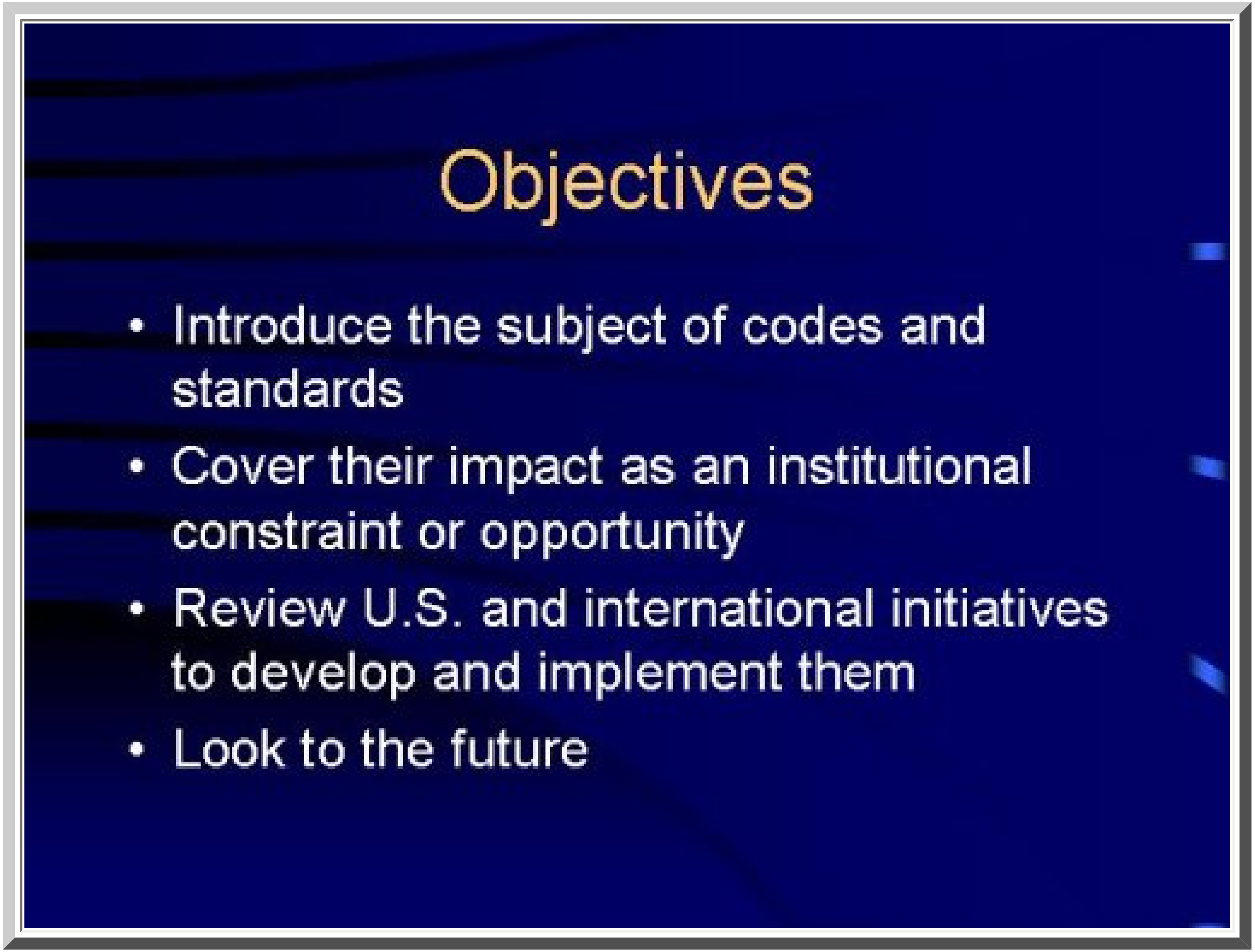


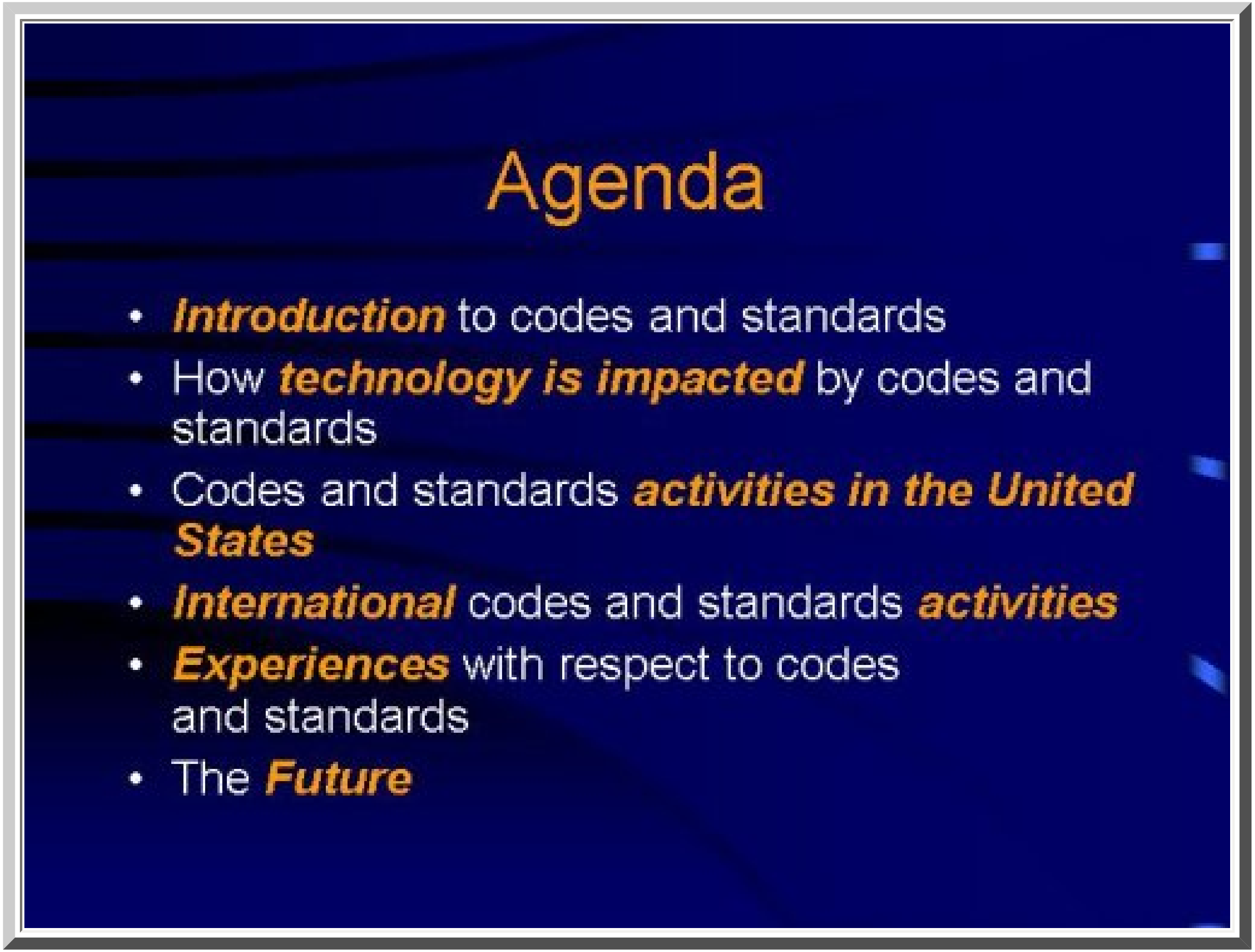
Kudos

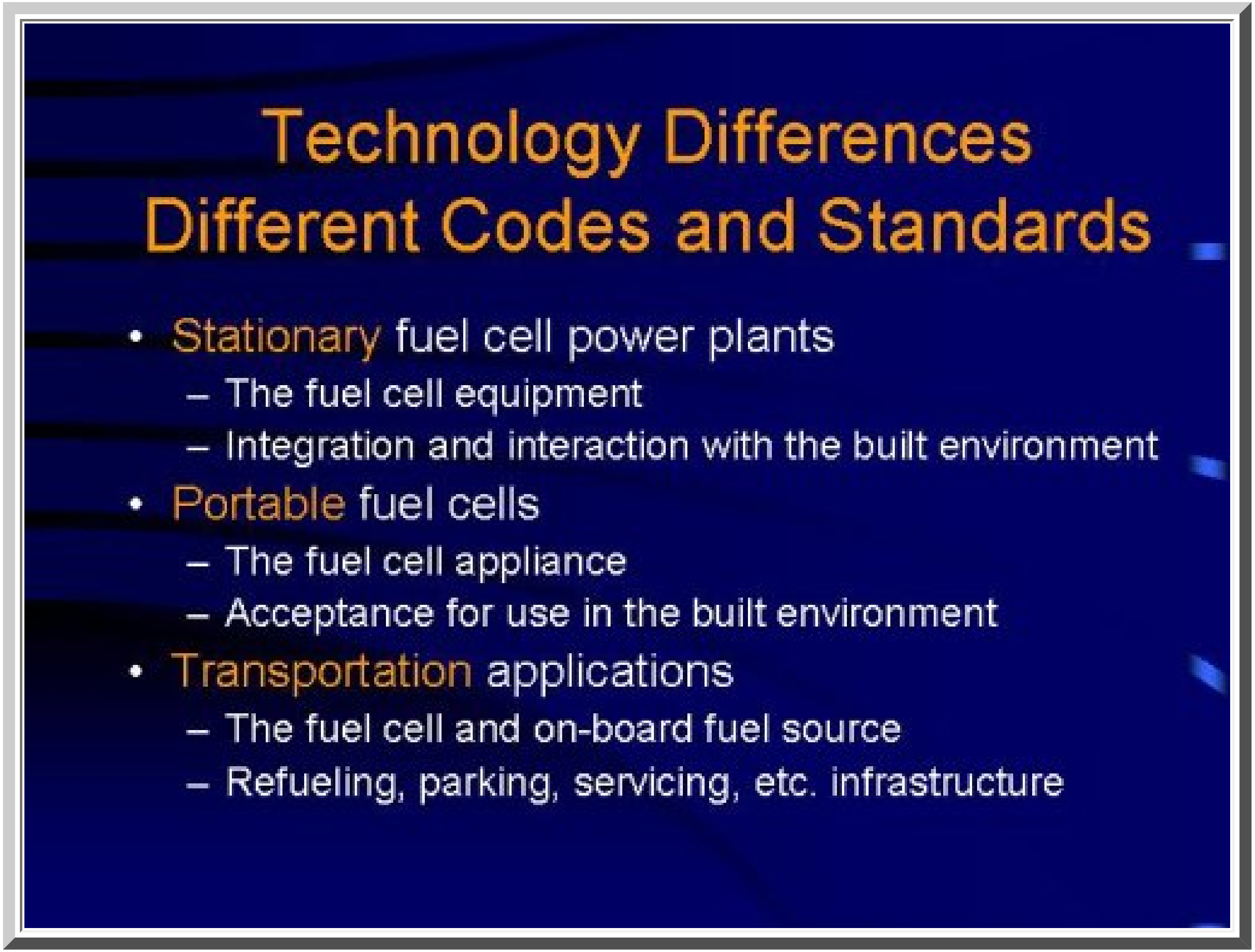
Jeff Allen - Allen Engineering
Rich Bielen - NFPA
Anne-Marie Borbely - PNNL
Dick DeBlasio - NREL
Bettina Drehman - Ballard
George Earle - Plug Power
Ron Fiskum - US DOE
Harry Jones - UL
Jeff Grant - Ballard

Steve Kazubski - CSA
Bruce Kinzey - PNNL
Brenon Knaggs - Ballard
Tony Leo - ERC
Darren Meyers - BOCA
Karen Miller - NHA
Glenn Scheffler - ONSI
Todd Strothers - CSA
Bob Wichert - USFCC

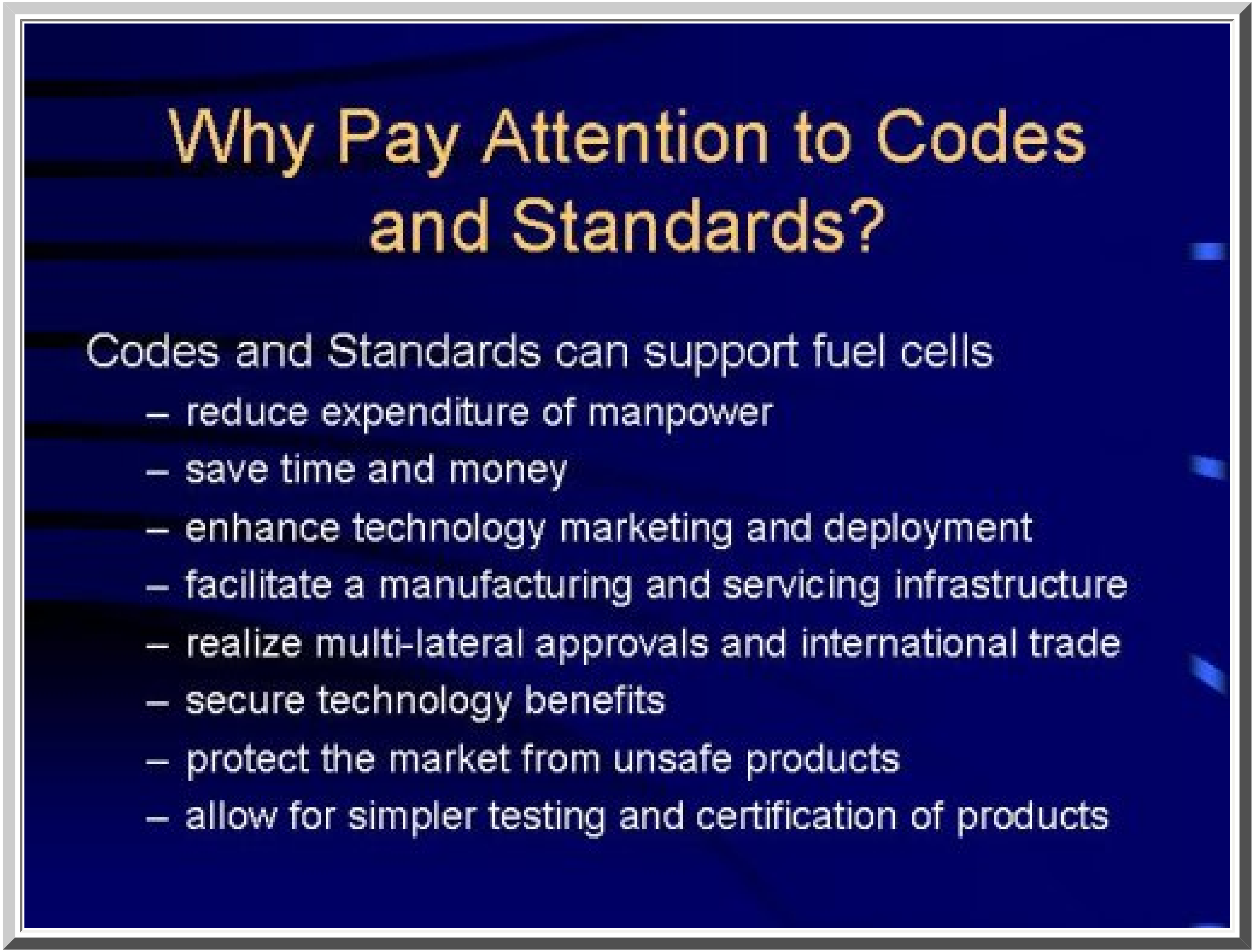

Goal
A better understanding of codes and standards, their impact on fuel cell technology development and deployment, and a commitment for the industry to work together with those who develop, adopt and implement them


Objectives
• Introduce the subject of codes and standards
• Cover their impact as an institutional constraint or opportunity
• Review U.S. and international initiatives to develop and implement them
• Look to the future


Agenda
• Introduction to codes and standards
• How technology is impacted by codes and standards
• Codes and standards activities in the United States
• International codes and standards activities
• Experiences with respect to codes and standards
• The Future


Technology Differences
Different Codes and Standards
• Stationary fuel cell power plants
– The fuel cell equipment
– Integration and interaction with the built environment
• Portable fuel cells
– The fuel cell appliance
– Acceptance for use in the built environment
• Transportation applications
– The fuel cell and on-board fuel source
– Refueling, parking, servicing, etc. infrastructure

Codes and Standards, Slide 7

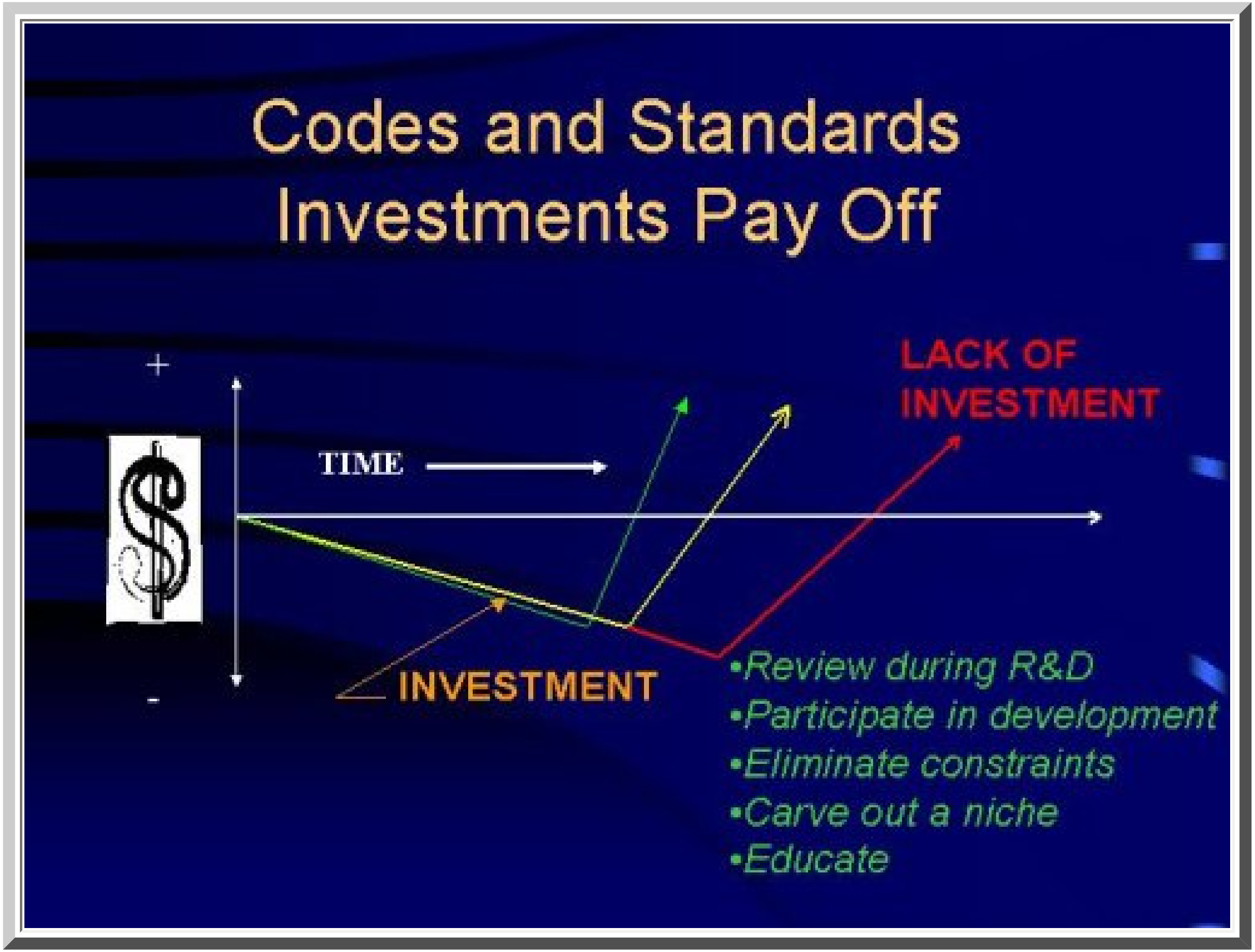


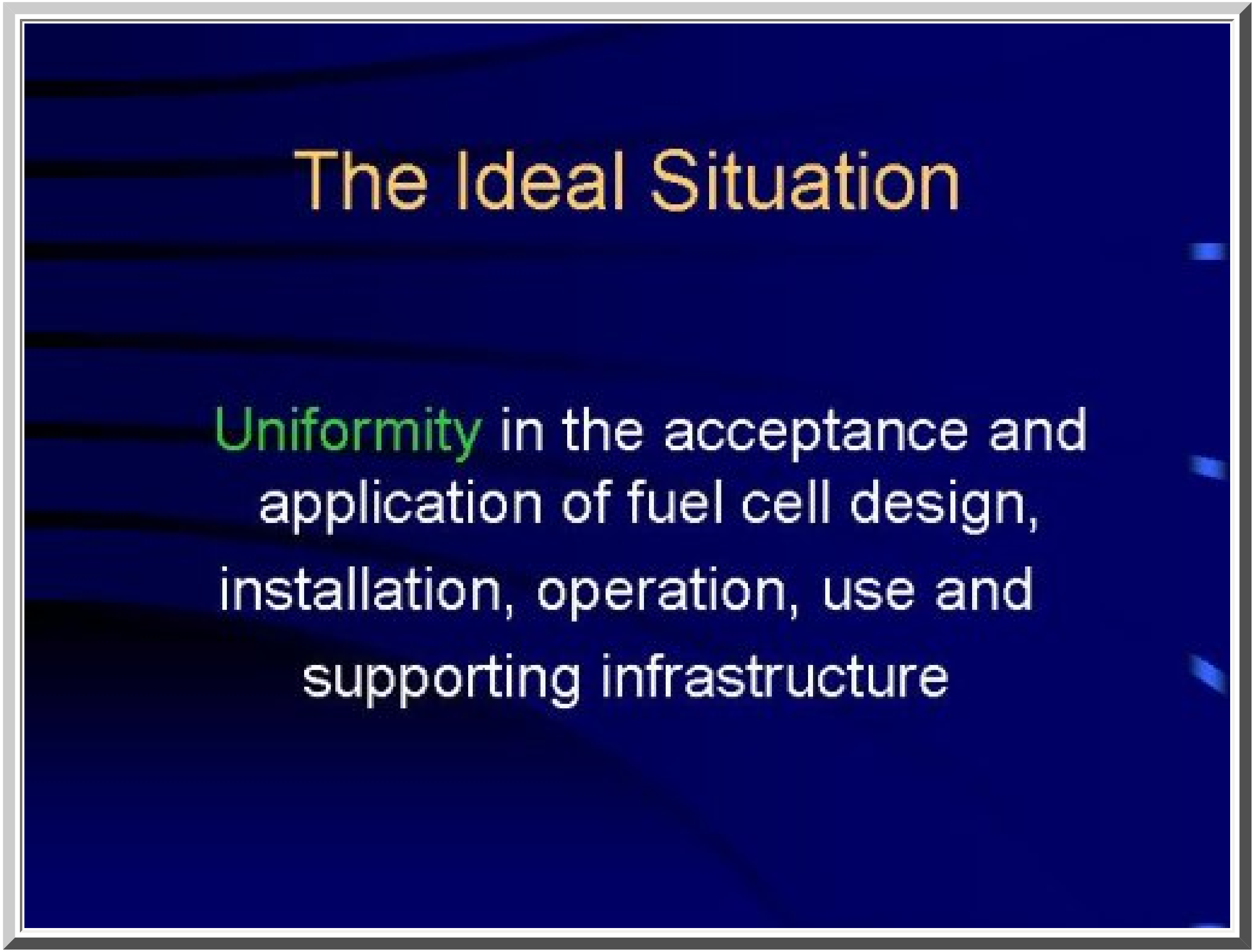

What are Codes and Standards?
• Documents that establish a basis for "technical communication"
• Provisions for assessing technology safety and performance
• The basis for "Building Construction Regulations" or other rules addressing public health and life-safety


DANGER
CONSTRUCTION AREA
What are Building Construction Regulations?
• Legally adopted provisions to protect public health, life-safety and welfare
• Criteria that govern the design of buildings and associated technology
• Criteria that must be satisfied to secure approval for installation and use of building technology
• Criteria that form the basis for acceptance of technology

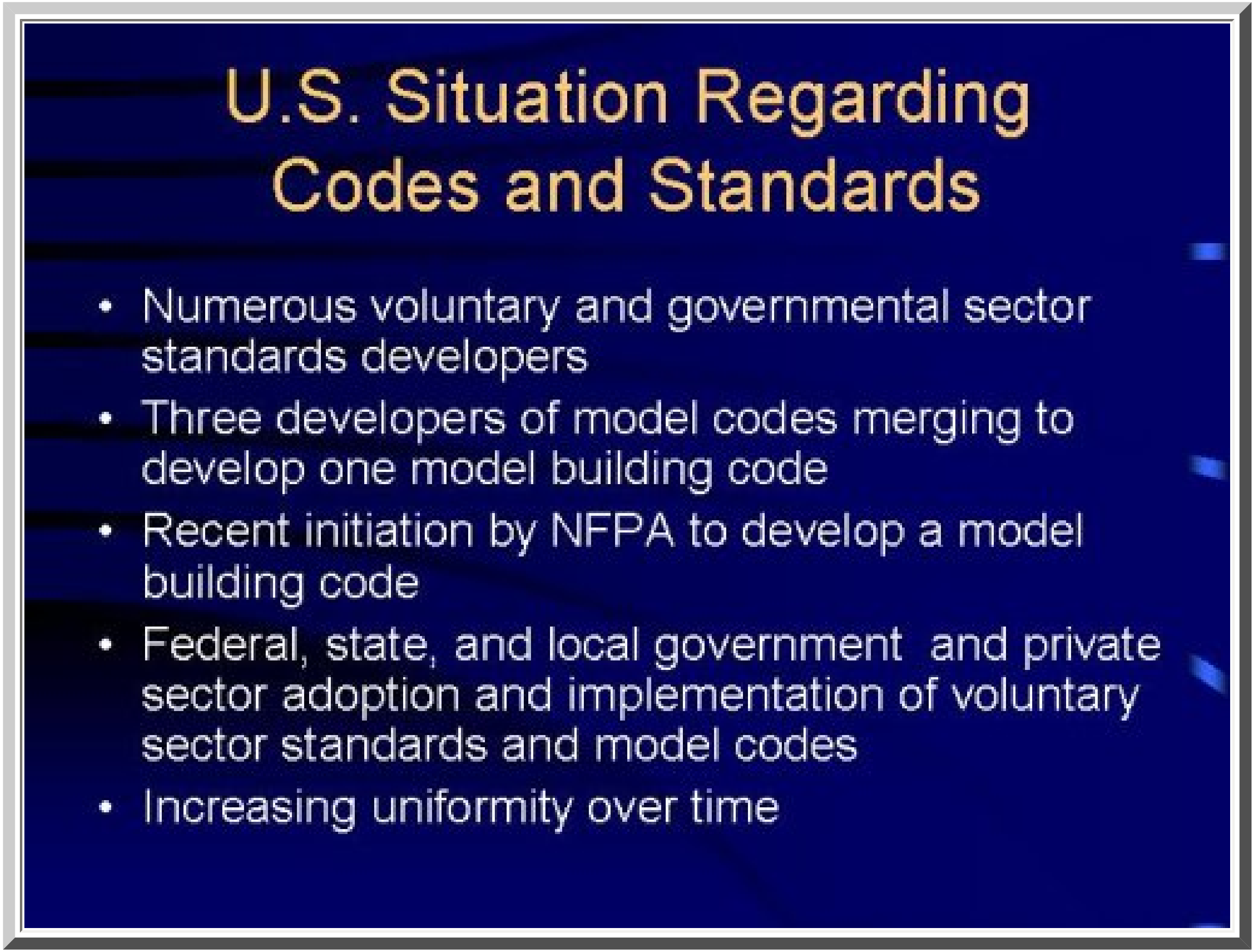

What do Building Regulations Cover?
• Stationary fuel cell power plant design and installation
• Portable fuel cell use
• Supporting infrastructure for vehicular applications of fuel cells
• Technology performance and safety
• Installation and integration with the built environment
• Operation, maintenance and use of the technology and the buildings served

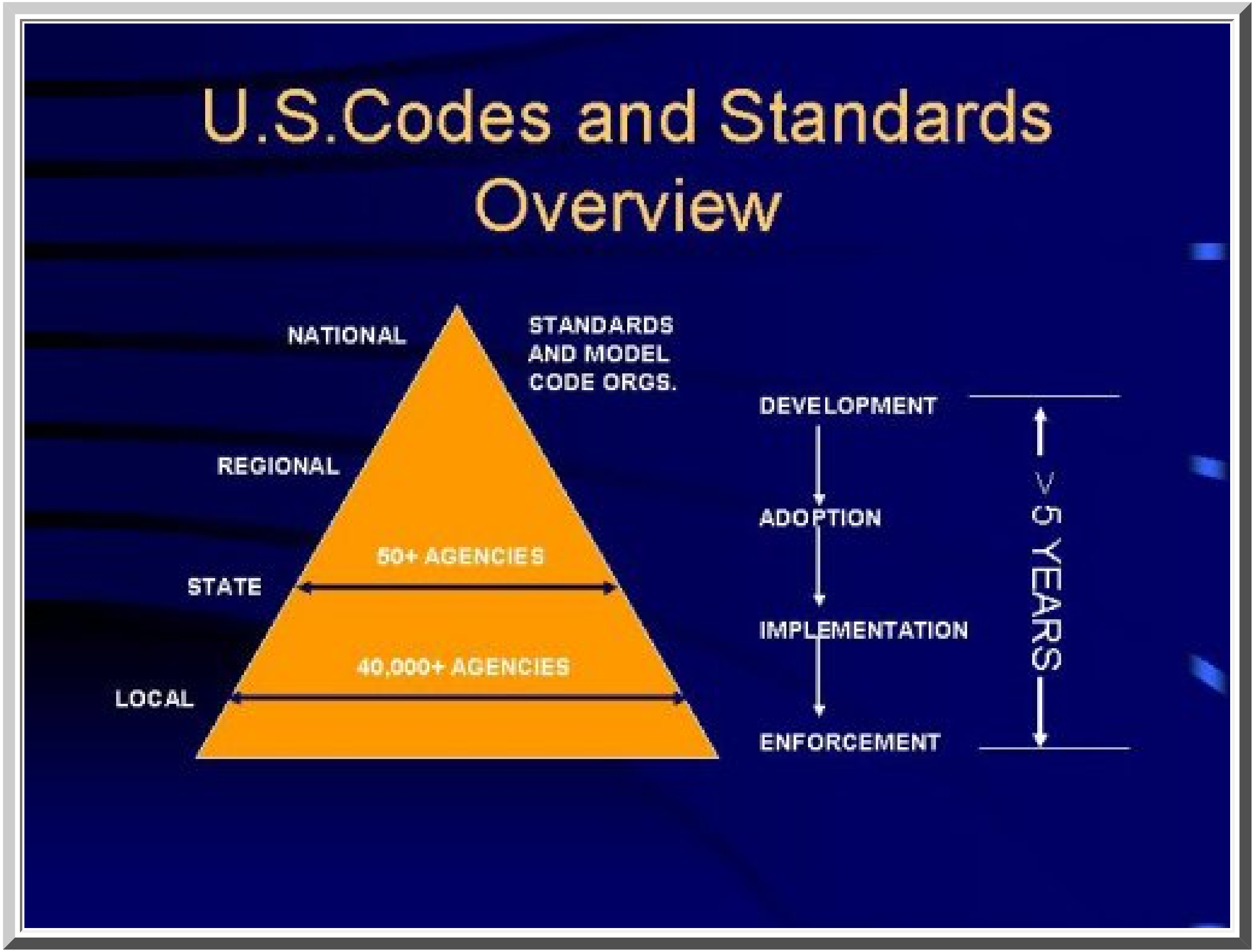

Building Construction Regulations can be a Constraint
• They typically lag technology development and deployment
• Those doing R&D are not generally aware of them and their potential impact
• They directly affect technology design, application and acceptance
• Financial resources of technology developers are targeted to other activities


Codes and Standards
Investments Pay Off
+
-
TIME
LACK OF
INVESTMENT
INVESTMENT
•Review during R&D
•Participate in development
•Eliminate constraints
•Carve out a niche
•Educate


The Ideal Situation
Uniformity in the acceptance and application of fuel cell design, installation, operation, use and supporting infrastructure

Codes and Standards, Slide 14




U.S.Codes and Standards Overview
NATIONAL
STANDARDS AND MODEL CODE ORGS.
REGIONAL
50+ AGENCIES
STATE
40,000+ AGENCIES
LOCAL
DEVELOPMENT
ADOPTION
IMPLEMENTATION
ENFORCEMENT
> 5 YEARS

Development of Codes and Standards

- Occurs in public and private sectors
- Opportunity for participation by all interested and affected parties
- Varying processes, time-frames, and scope of subjects covered
- Published and available for adoption and use

Adoption of Codes and Standards

- Legislative or Regulatory action = A
- Mandatory or through incentives = B
- Varying levels of government = C
- Varying agencies and entities =D
  - $A \times B \times C \times D = [\infty - 1]$

Codes and Standards, Slide 18


Enforcement of Codes and Standards
• Ensuring that what is adopted is satisfied
• Numerous agencies at different levels of government or in the private sector
– Utility
– State or local government
– Insurance
• Mandatory, voluntary or through incentives

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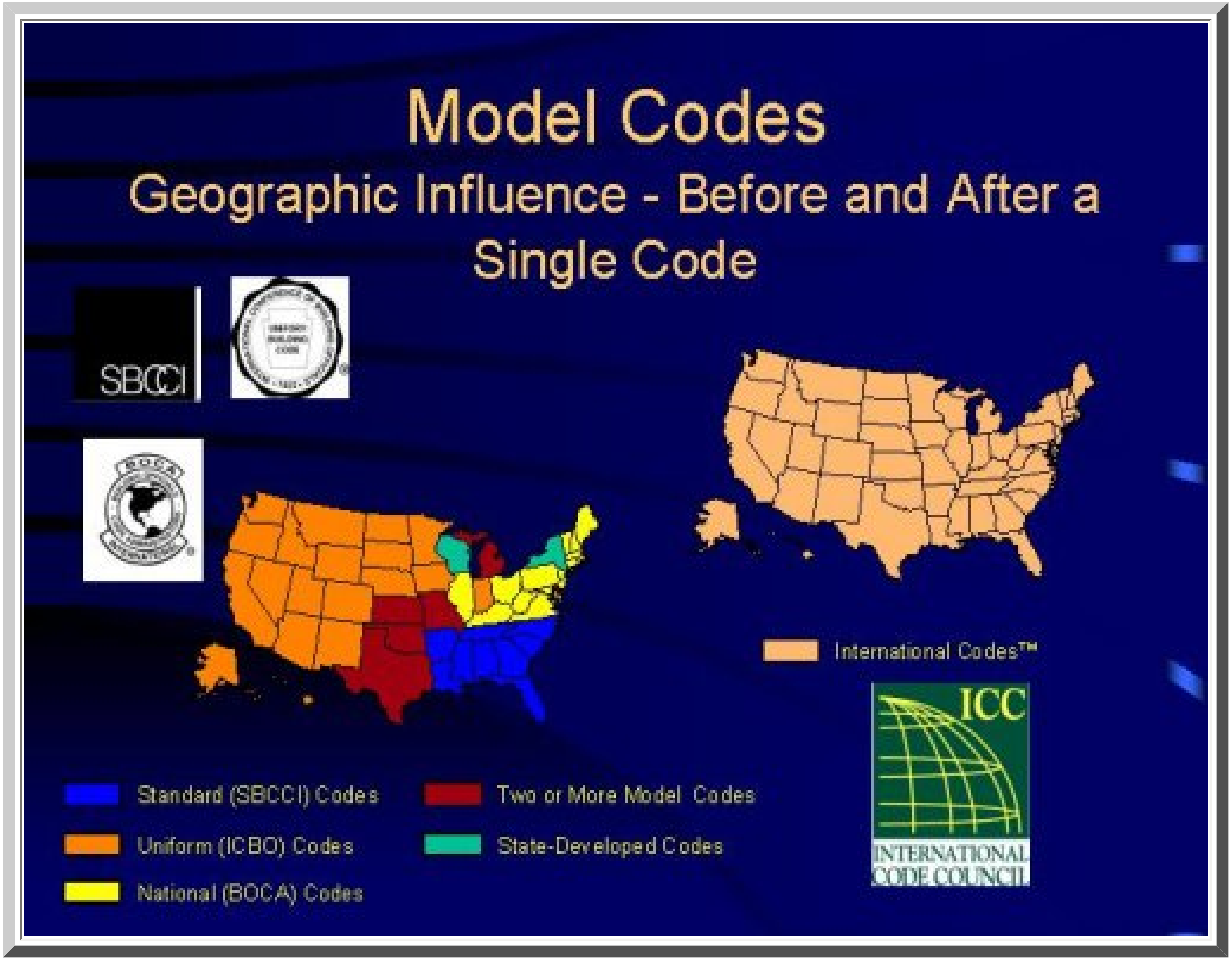
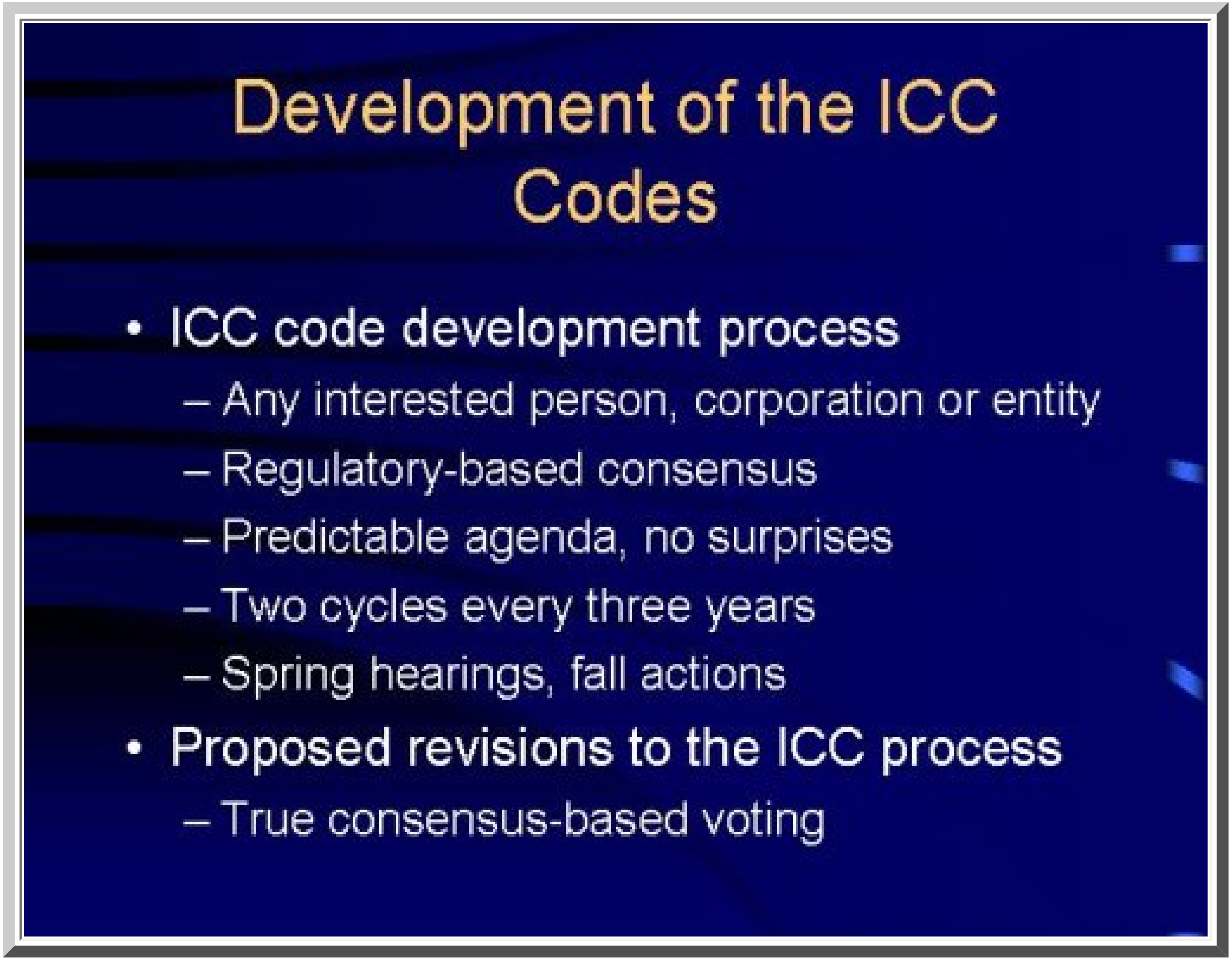

Model Codes
Geographic Influence - Before and After a Single Code
SBCCI
International Codes™
ICC
INTERNATIONAL CODE COUNCIL
Standard (SBCCI) Codes
Two or More Model Codes
Uniform (ICBO) Codes
State-Developed Codes
National (BOCA) Codes

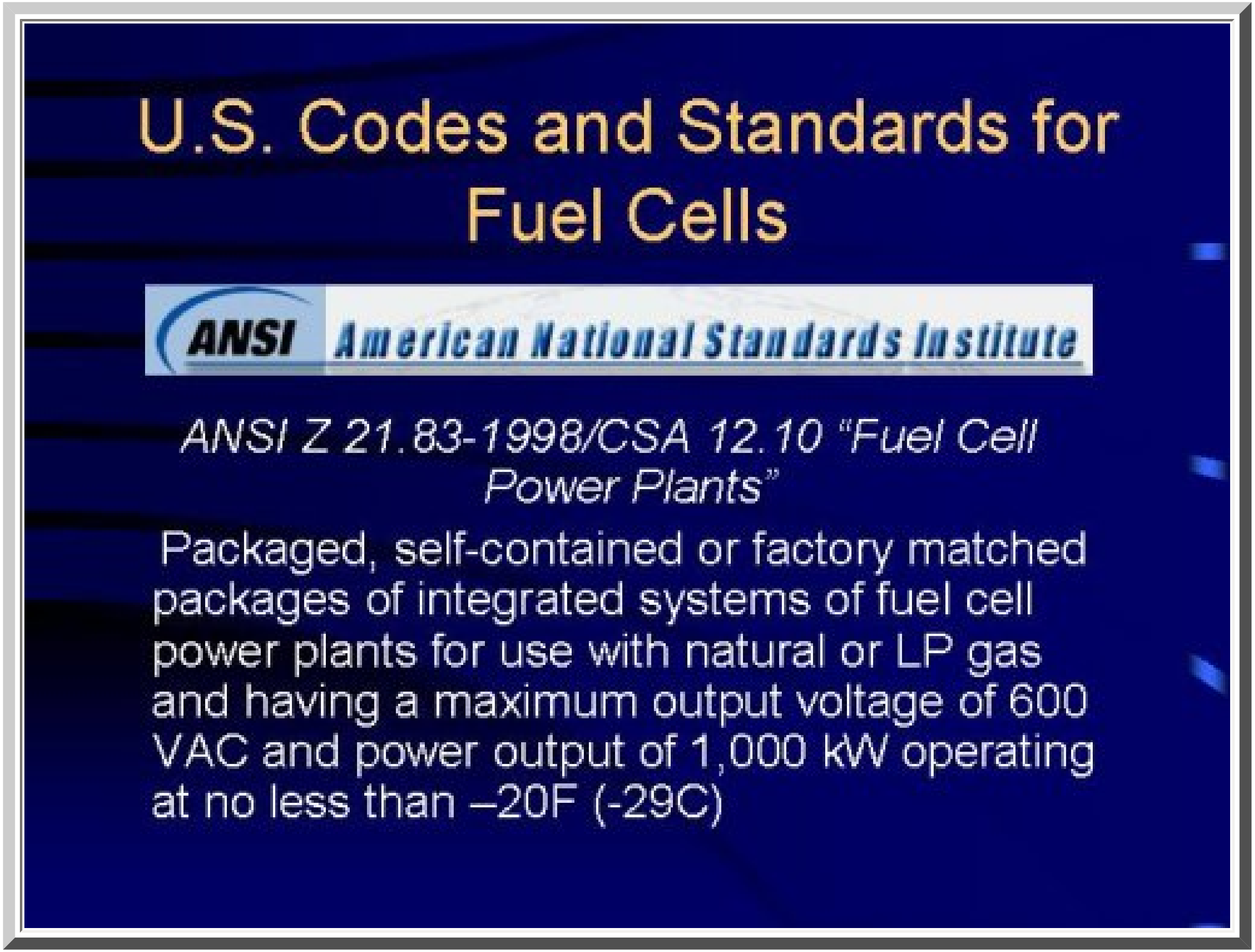

Development of the ICC Codes
• ICC code development process
– Any interested person, corporation or entity
– Regulatory-based consensus
– Predictable agenda, no surprises
– Two cycles every three years
– Spring hearings, fall actions
• Proposed revisions to the ICC process
– True consensus-based voting

U.S. Codes and Standards for Fuel Cells

INTERNATIONAL CODE COUNCIL®

2000 *International Mechanical Code*

"924.1 General. Stationary fuel cell power plants having a power output not exceeding 1,000 kW, shall be tested in accordance with ANSI Z21.83 and shall be installed in accordance with the manufacturer's installation instructions."


U.S. Codes and Standards for Fuel Cells
ANSI American National Standards Institute
ANSI Z 21.83-1998/CSA 12.10 "Fuel Cell Power Plants"
Packaged, self-contained or factory matched packages of integrated systems of fuel cell power plants for use with natural or LP gas and having a maximum output voltage of 600 VAC and power output of 1,000 kW operating at no less than –20F (-29C)

U.S. Codes and Standards for Fuel Cells

ANSI American National Standards Institute

- **ANSI Z 21.83-1998/CSA 12.10 "Fuel Cell Power Plants"**
  - *Construction*
    - Materials
    - General construction and assembly
    - Enclosures and associated construction
    - Air/fluid handling and moving equipment
    - Electrical equipment and wiring

- Protection of service personnel
- Safety circuit analysis
- Instructions and marking Heaters and vessels
- Piping systems
- Drain, venting, and ventilation exhaust systems
- Automatic ignition systems and gas-air control
- Flame safeguards
- Fuel gas controls and equipment

U.S. Codes and Standards for Fuel Cells

ANSI American National Standards Institute

- **ANSI Z 21.83-1998/CSA 12.10 "Fuel Cell Power Plants"**
  - ***Performance***
    - ultimate strength
    - allowable leakage
    - protection
    - emissions
    - burner operation
    - automatic ignition
- exhaust gas and surface and component temperatures
- electrical tests
- rain and wind tests
- adhesion/legibility of markings

U.S. Codes and Standards for Fuel Cells

NFPA 853 "Standard for the Installation of Stationary Fuel Cell Power Plants"

Design, construction, and installation of stationary (non-portable) fuel cell power plants with a gross electrical generation that exceeds 50 kW; including:

(1) A singular prepackaged, self-contained power plant unit

(2) Any combination of prepackaged, self-contained power plant units

(3) Power plant units comprised of two or more factory matched modular components intended to be assembled in the field and

(4) Engineered and field-constructed power plants that employ fuel cells

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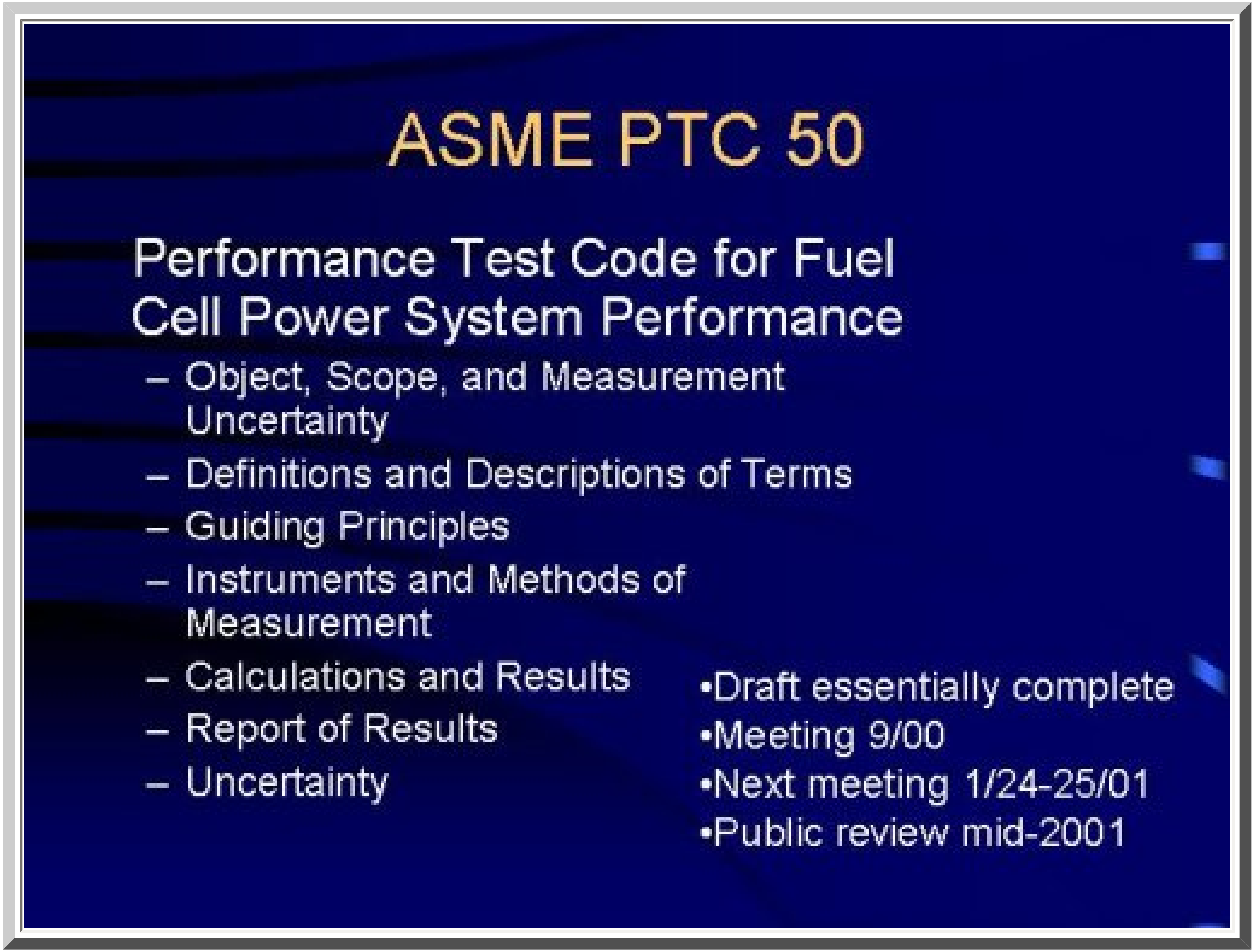
NFPA 70 and 110

- NFPA 70 adopted by reference in the US model building codes

> NFPA 70, the *National Electrical Code®*, provides "practical safeguarding of persons and property from hazards arising from the use of electricity."

- NFPA 110 presently only allows rotating equipment to satisfy the emergency power equipment requirement. The equivalency clause may allow fuel cells to be used for emergency and standby power if acceptable to the authority having jurisdiction


ASME PTC 50
Performance Test Code for Fuel Cell Power System Performance
– Object, Scope, and Measurement Uncertainty
– Definitions and Descriptions of Terms
– Guiding Principles
– Instruments and Methods of Measurement
– Calculations and Results
– Report of Results
– Uncertainty
•Draft essentially complete
•Meeting 9/00
•Next meeting 1/24-25/01
•Public review mid-2001

ASME PTC 50

Performance Test Code for Fuel Cell Power System Performance

- Object, Scope, and Measurement Uncertainty
- Definitions and Descriptions of Terms
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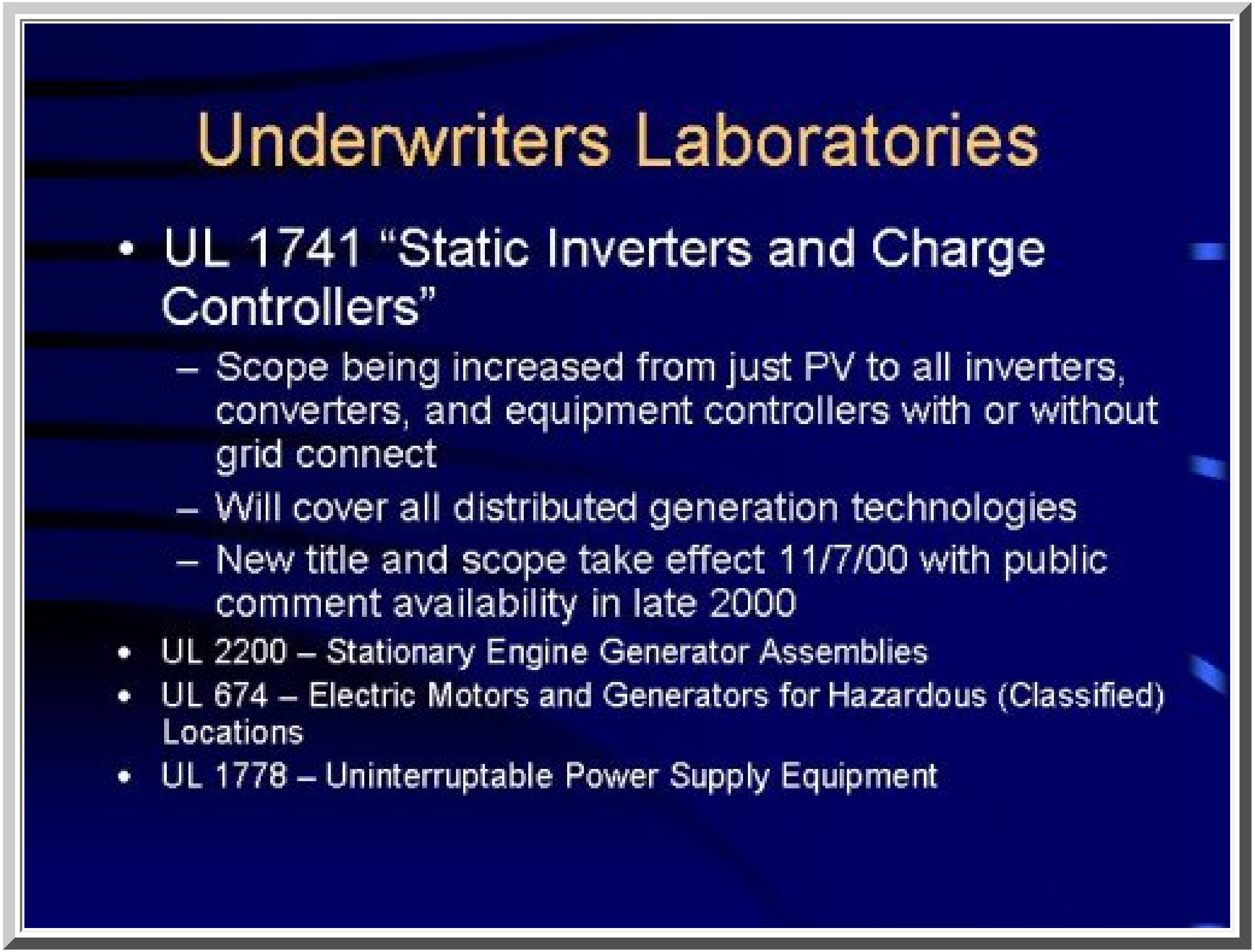
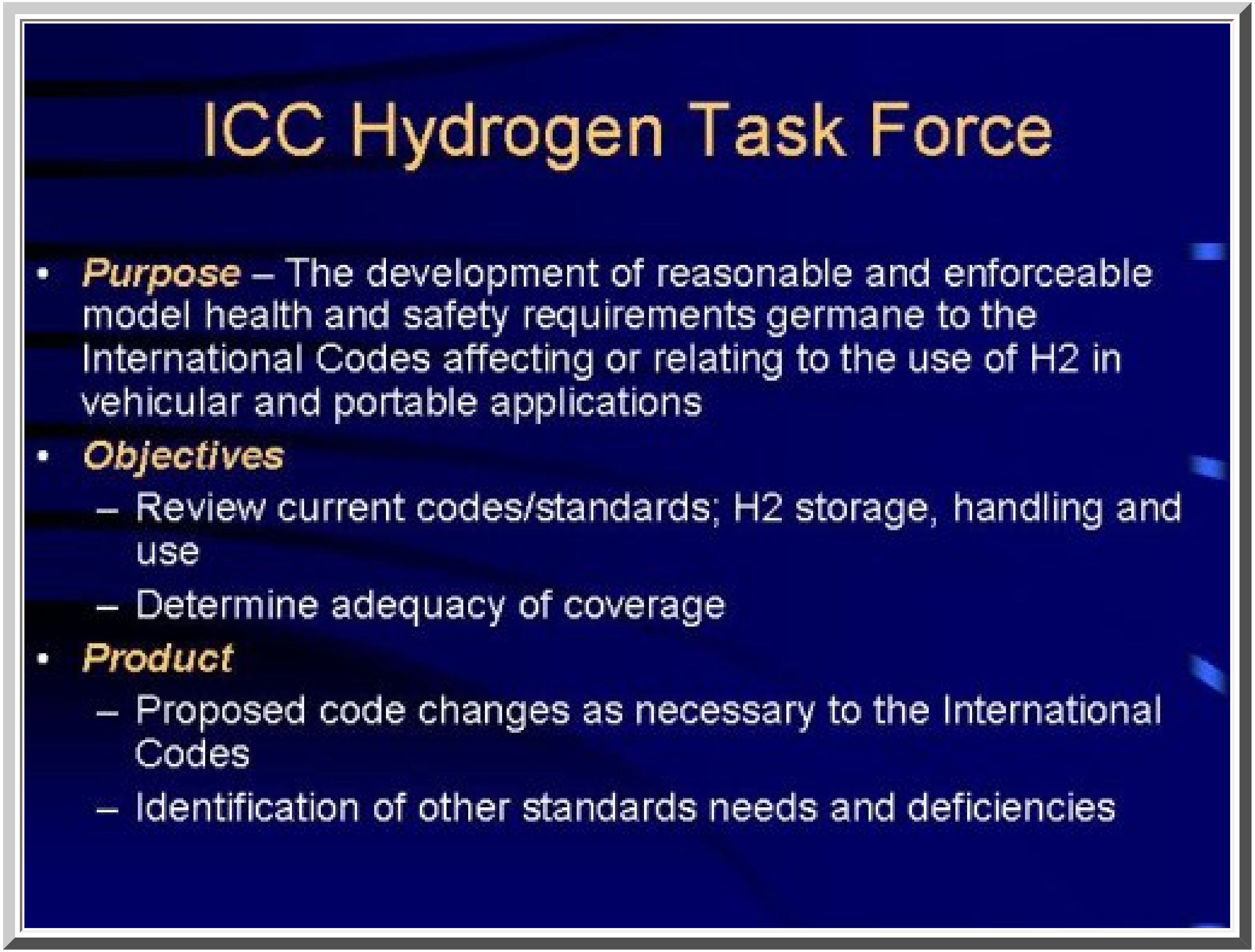
IEEE Interconnection Standard P1547

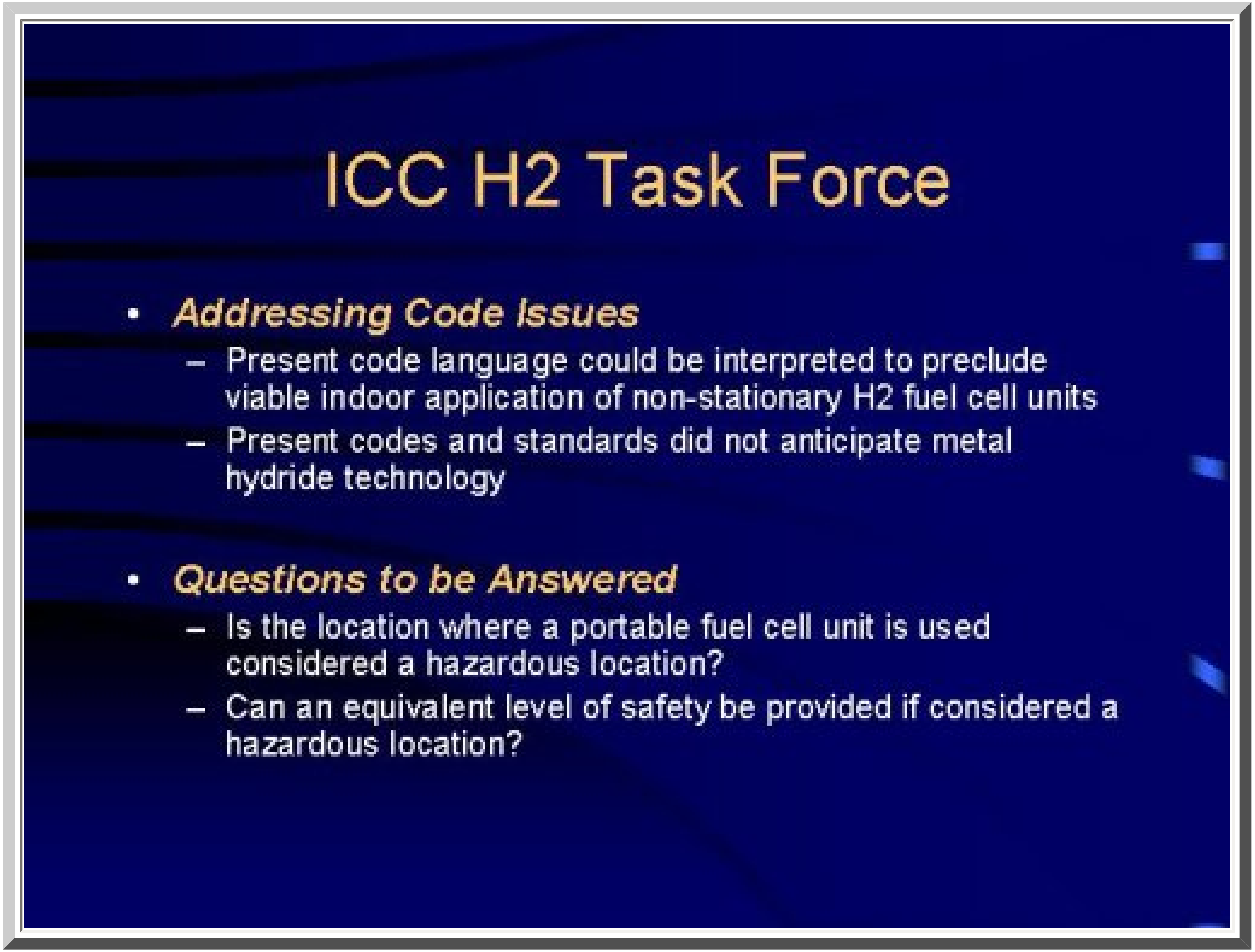
- Being developed by IEEE Standards Coordinating Committee (SCC) 21
- SCC 21 responsible for standards development in areas of
  - Fuel Cells
  - Photovoltaics
  - Distributed Generation
  - Energy Storage
- Reports directly to IEEE Standards Board

IEEE Interconnection Standard P1547

- ***Title:*** Standard for Interconnecting Distributed Resources with Electric Power Systems
- ***Purpose:*** Provide a uniform standard for interconnection of distributed resources with electric power systems, and requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection
- Development completed in 2001
- Adoption and use to follow


Underwriters Laboratories
• UL 1741 "Static Inverters and Charge Controllers"
– Scope being increased from just PV to all inverters, converters, and equipment controllers with or without grid connect
– Will cover all distributed generation technologies
– New title and scope take effect 11/7/00 with public comment availability in late 2000
• UL 2200 – Stationary Engine Generator Assemblies
• UL 674 – Electric Motors and Generators for Hazardous (Classified) Locations
• UL 1778 – Uninterruptable Power Supply Equipment


ICC Hydrogen Task Force
• Purpose – The development of reasonable and enforceable model health and safety requirements germane to the International Codes affecting or relating to the use of H2 in vehicular and portable applications
• Objectives
– Review current codes/standards; H2 storage, handling and use
– Determine adequacy of coverage
• Product
– Proposed code changes as necessary to the International Codes
– Identification of other standards needs and deficiencies


ICC H2 Task Force
• Addressing Code Issues
– Present code language could be interpreted to preclude viable indoor application of non-stationary H2 fuel cell units
– Present codes and standards did not anticipate metal hydride technology
• Questions to be Answered
– Is the location where a portable fuel cell unit is used considered a hazardous location?
– Can an equivalent level of safety be provided if considered a hazardous location?

ICC H2 Task Force

Recommendation - Permit the use and storage of H2 powered portable fuel cell units in non-hazardous locations when H2 detection and control systems are provided by the fuel cell unit *(similar to the concept outlined in IBC 908.3 and IRC 2210.7.2)*

National Hydrogen Association

- Codes and Standards Workshop 11/00 in DC
- Host ISO 197 Working Groups 3/01 in DC
- Leadership role in ISO TC 197 activities on Hydrogen

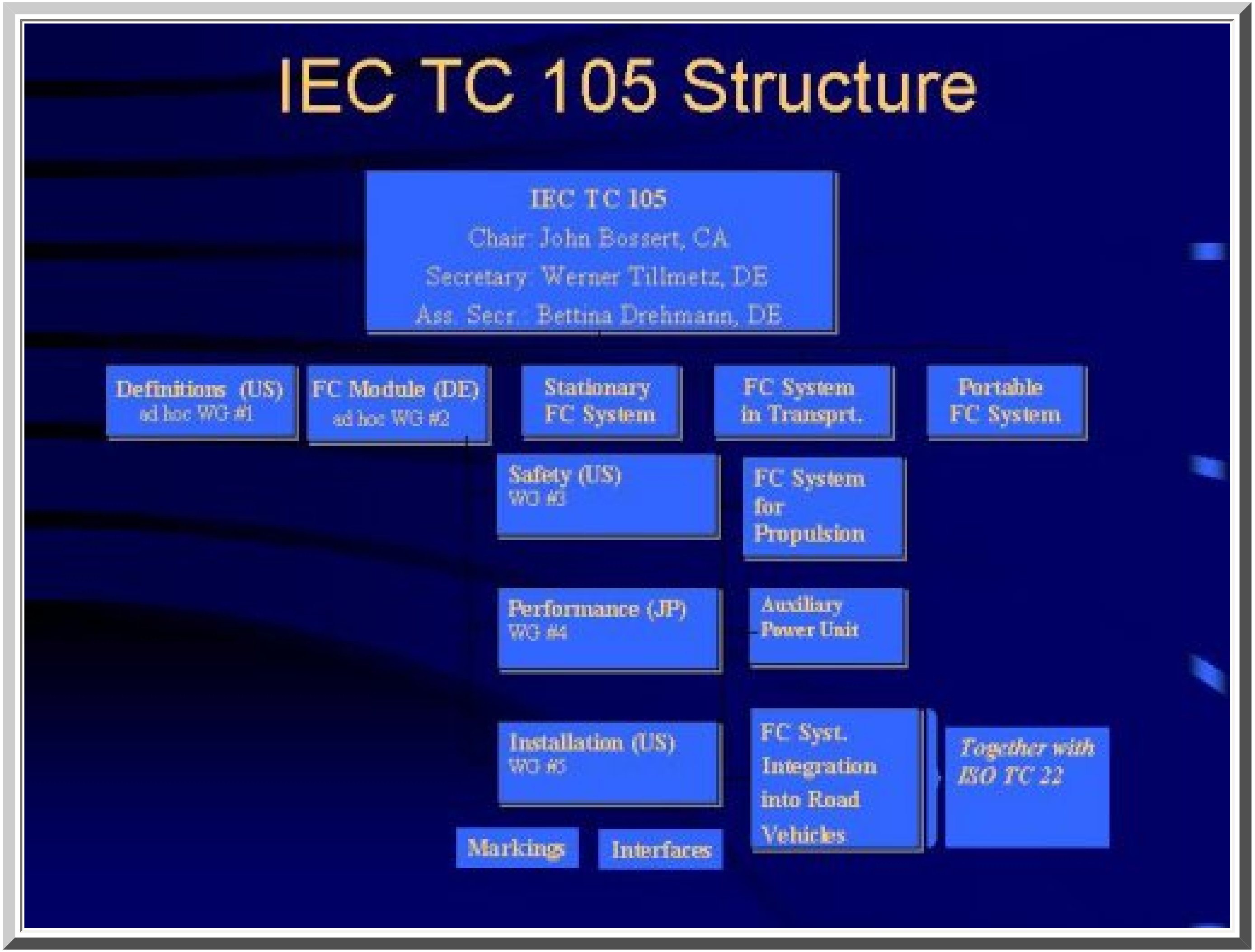

ISO TC 197 on
Hydrogen Technologies
• Developing international safety standards required to disseminate H2 technologies worldwide
• Scope – Standardization in the field of systems and devices for the production, storage, transport, measurement and use of hydrogen

ISO TC 197 on Hydrogen Technologies

- Plenary meeting September 00 in Munich
  - Working Group meetings
  - Instructed the ISO Central Secretariat to record 197's request to establish formal liaison with the following technical committees:
    - ISO/TC 58/SC 3 Gas cylinder design
    - ISO/TC 220 Cryogenic vessels
    - IEC/TC 105 Fuel cell technologies
    - ISO/TC 22/SC 21 Electric road vehicles
- 2001 Plenary meeting in October in Paris

International Efforts
IEC TC 105

- ***Scope*** - To prepare international standards regarding fuel cell technologies for all fuel cell applications such as stationary, transportation, and portable power generation systems
- ***Membership*** - CA, CN, FR, DE, IT, JP, NL, CH, GB, and US


IEC TC 105 Structure
IEC TC 105
Chair: John Bossert, CA
Secretary: Werner Tillmetz, DE
Ass. Secr.: Bettina Drehmann, DE
Definitions (US)
ad hoc WG #1
FC Module (DE)
ad hoc WG #2
Stationary FC System
FC System in Transprt.
Portable FC System
Safety (US)
WG #3
FC System for Propulsion
Performance (JP)
WG #4
Auxiliary Power Unit
Installation (US)
WG #5
FC Syst. Integration into Road Vehicles
Together with ISO TC 22
Markings
Interfaces

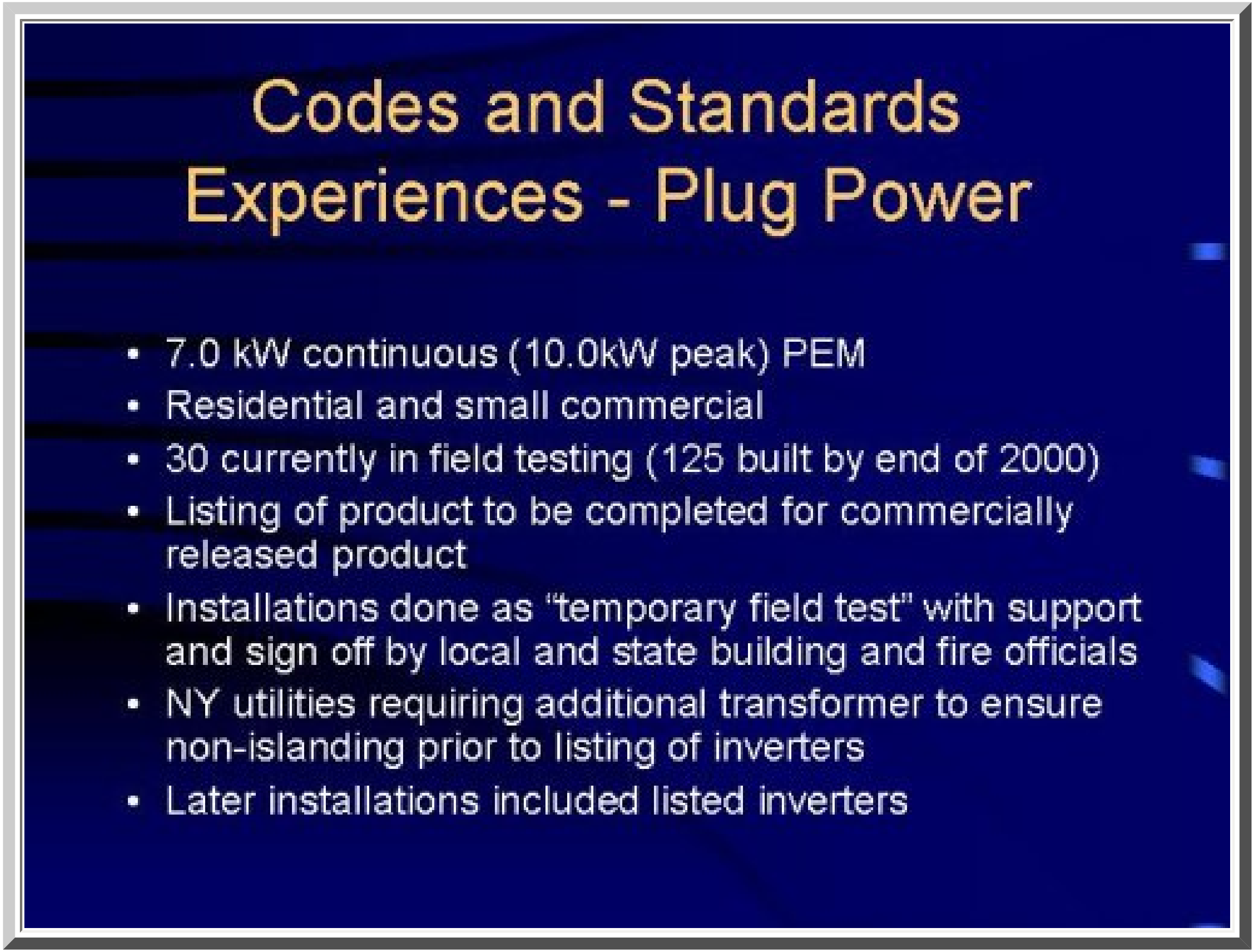
IEC TC 105

First Meeting February 23 and 24, 2000

- Overview of IEC processes
- Activities in other countries
- Strategic Policy Statement
- Program of work
- Cooperation with other ISO and IEC activities
  - ISO/TC 22 SC 21 (Electric Road Vehicles) - formal liaison
  - The Society of Automotive Engineers (SAE) - co-operation
  - IEC/TC 31 (Electric Apparatus in Explosive Atmospheres) - co-operation
  - ISO/TC 197 (Hydrogen Technologies) - discussions underway

Codes and Standards in Other Countries

- ***Canada***
  - Joint standard with United States (ANSI Z21.82/CSA 12.10)
- ***Japan***
  - Japan Standards Association - Technical Reports
    - Glossary of terms for fuel cell power systems
    - Test methods for PAFC performance
    - Test methods for environment and maintenance of PAFC
    - Marking of fuel cell power
- ***United Kingdom***
  - "CE" marking will be needed to facilitate to acceptance

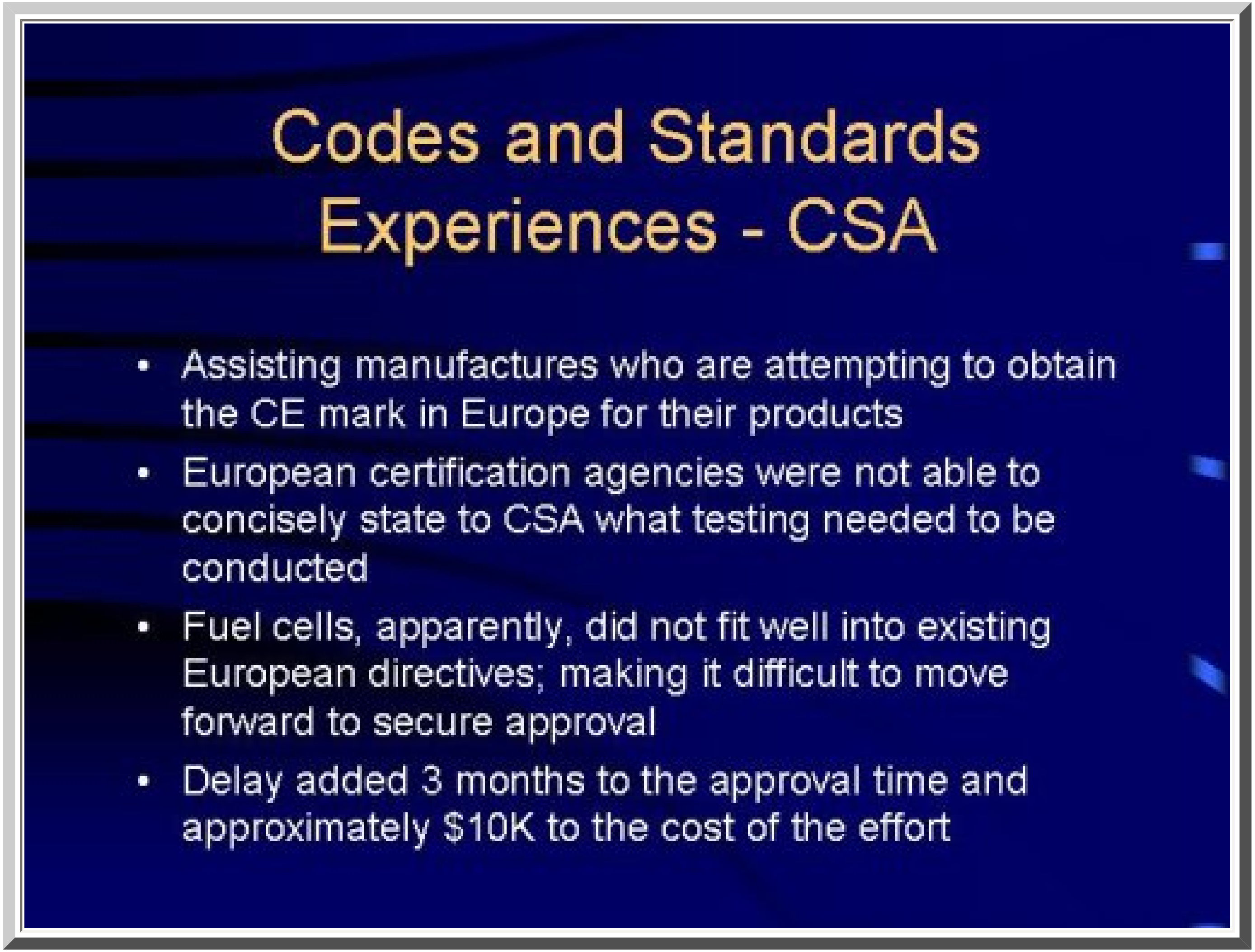

Codes and Standards
Experiences - Plug Power
• 7.0 kW continuous (10.0kW peak) PEM
• Residential and small commercial
• 30 currently in field testing (125 built by end of 2000)
• Listing of product to be completed for commercially released product
• Installations done as "temporary field test" with support and sign off by local and state building and fire officials
• NY utilities requiring additional transformer to ensure non-islanding prior to listing of inverters
• Later installations included listed inverters

Codes and Standards Experiences - IFC (ONSI)

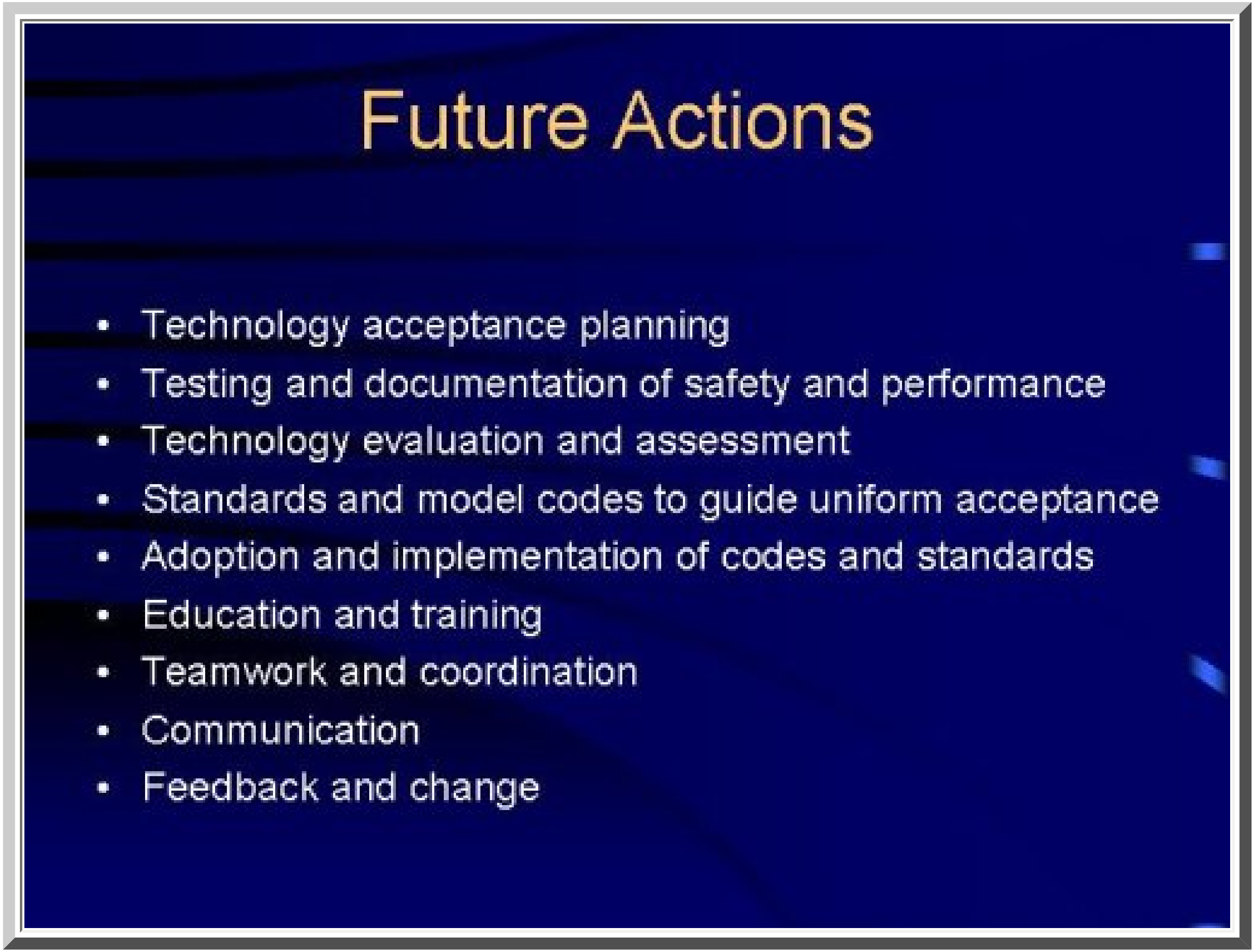
- 200 kW Phosphoric Acid
- Commercial (hospital, airport, bank computers, etc.)
- Tested and listed to ANSI Z21.83 by CSA
- Enhancing indoor installation guidance
- Biggest C&S deficiency at this time is the lack of an interconnect standard
  - IEEE 1547 is needed to facilitate "type testing" and eliminate custom, non-standard in-field tests and addition of redundant external protections and breakers to satisfy the local utility


Codes and Standards Experiences
Allen Engineering Company
– Developing a fuel cell power plant design since 1997 and recognized the importance of codes and standards compliance and potential for design impact
– Consideration of codes and standards early in the design development phase has contributed to an improved product design
– Codes and standards have impacted virtually every aspect of their designs to various degrees
• Pressurization
• Ventilation
• Enclosure layout
• System sizing

Codes and Standards, Slide 48




Summary
• Building construction regulations will affect fuel cell development and deployment
• Investments to develop and implement codes and standards are being made in individual countries and at the international level
• One globally acceptable product design, application and installation should be the goal
• There are likely to be continued inter- and intra-country variations in both technical requirements and administrative approval processes


Future Actions
• Technology acceptance planning
• Testing and documentation of safety and performance
• Technology evaluation and assessment
• Standards and model codes to guide uniform acceptance
• Adoption and implementation of codes and standards
• Education and training
• Teamwork and coordination
• Communication
• Feedback and change

The Result

One universal set of criteria that everyone involved can agree on and uniformly design to, adopt, implement and enforce

- Minimal constraints on RD&D
- Less costly technology deployment
- Uniformity
- Free trade
- Public health, life safety and welfare protection
- Timely realization of technology benefits


Contacts
National Evaluation Service
www.nateval.org
Pacific Northwest National Laboratory
www.pnl.gov/fuelcells