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CARIBBEAN CLEAN ENERGY PROGRAM (CARCEP)

The Grid Codes
Supporting Clean/Renewable Energy Policy Initiatives

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Hala N. Ballouz,
B.Sc., M.Sc. EE TAMU , P.E.
President , Electric Power Engineers, Inc.

Overview

- **Grid Code for Renewable Generation Integration**
- **Significance of Grid Code for Stakeholders**
- **Renewable Code Components**
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  - Data, Planning & Operation
- **Identifying the Requirements**
- **Holistic Approach**
  - Code + Studies, Programs and Services
  - Intelligent (Smart) Grid Examples
- **Testing and Compliance Checks**
- **Standing Committee and Working Groups**
- **Conclusion**

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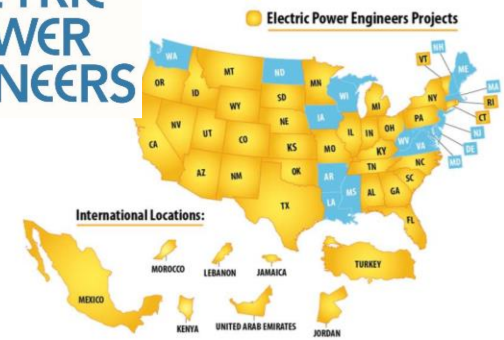
Background

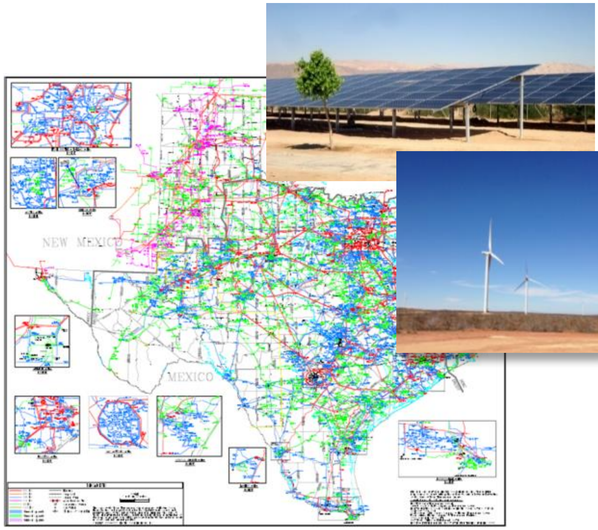
Hala N. Ballouz, P.E.

-Electric Power Engineers, President
-25+ years experience in T&D Consulting
-GridNext. Director, TREIA

ELECTRIC POWER ENGINEERS



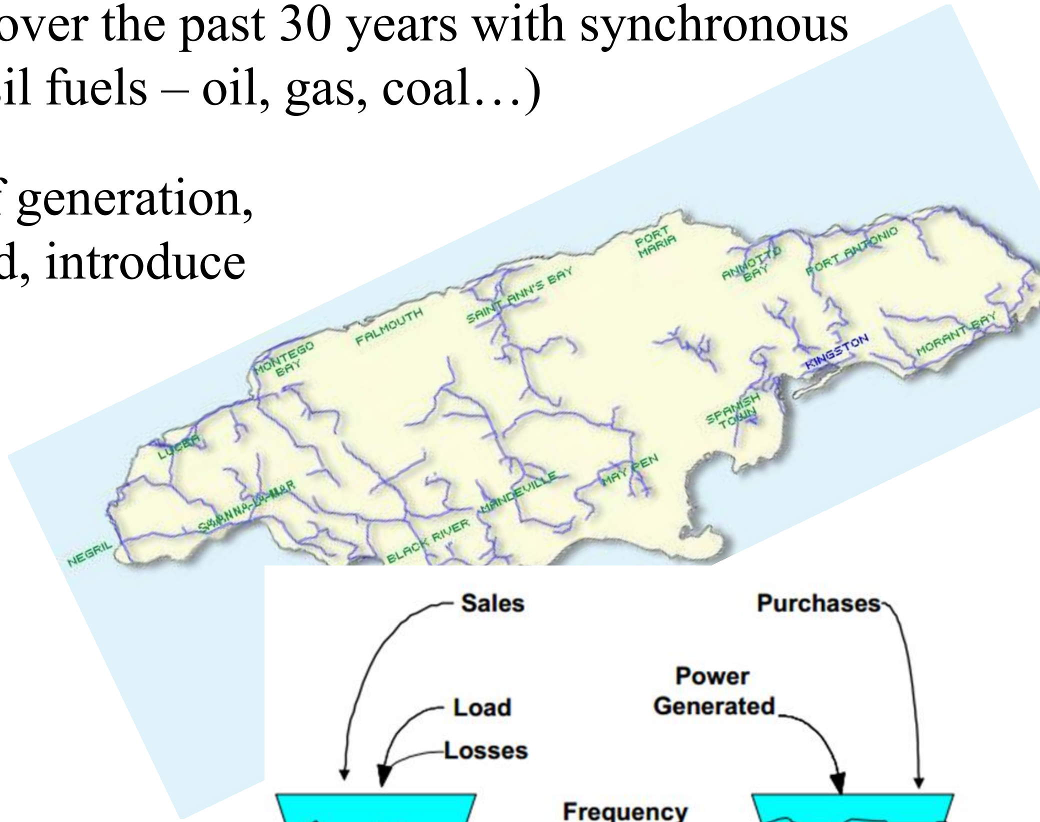
- Advisor on renewable energy integration
- Supporting de-bundling of energy markets, grid code & study and energy market analysis
- Clients include independent resource developers, electric T & D utilities, energy traders



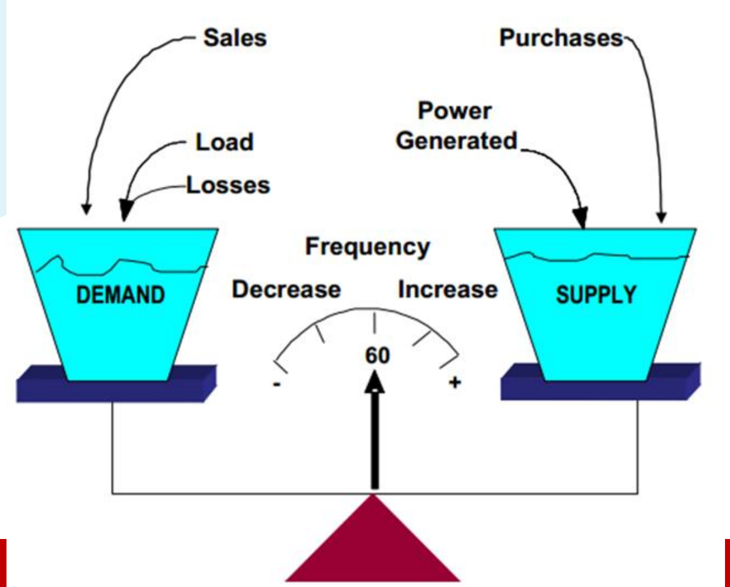
Grid Code for Renewable Generation Integration

- Grid Codes have been developed over the past 30 years with synchronous machines in mind (traditional fossil fuels – oil, gas, coal…)

- New technology and new types of generation, such as inverter type PV and Wind, introduce new challenges on the grid
  - Non-synchronous machines
  - Intermittent resources



Study and lessons learned from experience in operating wind and solar PV have resulted in the development of set of codes to integrate Wind and PV on grids



Significance of Renewable Generation Grid Code for Stakeholders

TECHNICAL

- Grid reliability & protection
- Flexibility in operating the system
- Enabling the grid to accommodate more capacity
- Standardization of System Impact Studies & Data
- Planning & Operation Requirements

COMMERCIAL

- Standardization for Evaluation of project bids
- Standardization of agreements for connection
- Bid comparison made easier and more accurate
- Certainty for development and financing Renewable projects

Stakeholders

- Planners
- Operators
- Consumers
- Generation Developers
- Technology Developer
- Financers

Renewable Code Components - I
Technical Requirements

- Frequency & Active Power Support
- Voltage & Reactive Power Support
- Harmonics
- Voltage Flicker
- Ramp Rate
- Islanding

Frequency Ride through

Automatic Voltage Control

Voltage/Fault Ride Through

Reactive Support

Renewable Code Components - II
Data, Operation & Planning

OPERATION

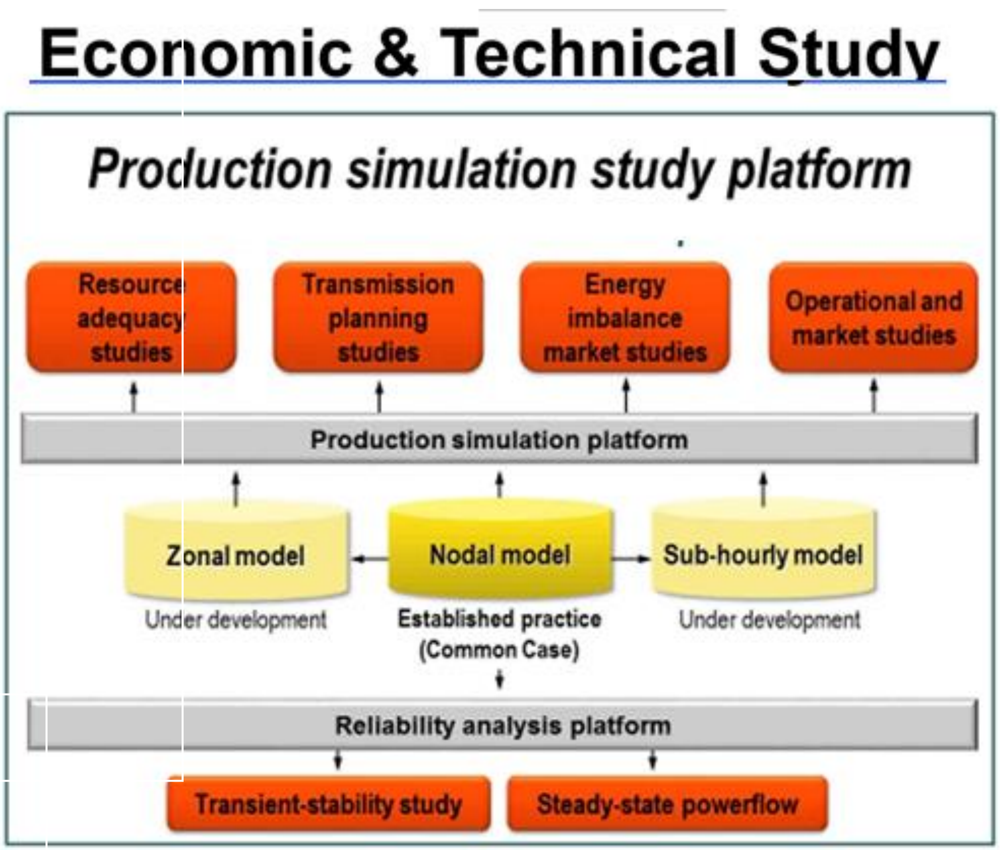
- Forecasting
- Constraint economic dispatch
- Testing and commissioning
- Compliance monitoring
- SCADA

PLANNING

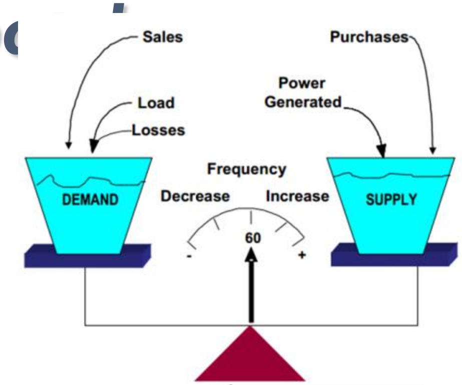
- Grid Impact Studies
- Grid support services (reactive, energy storage, etc…)
- Allocation of costs

DATA

- Data collection standardization
- Compliance records

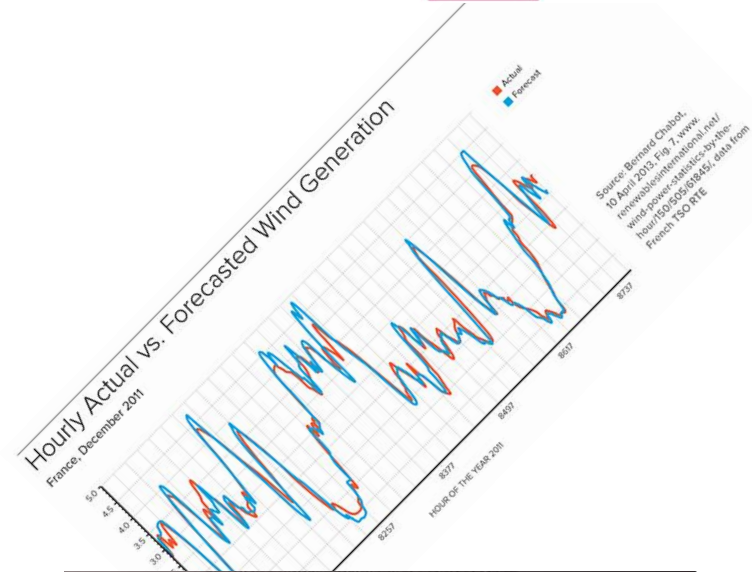


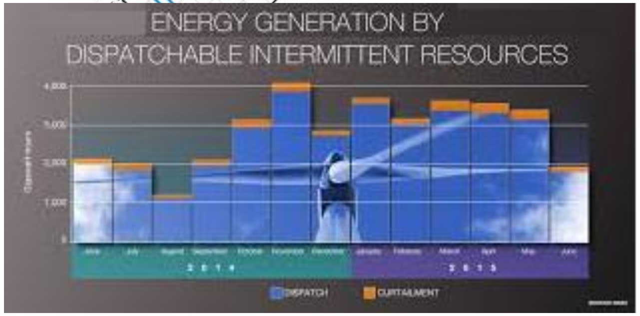
Renewable Code Components – II cont'd
Operations - Forecasting and Disp



Forecasting - Integrating renewable power generation into Utility's daily operations

- Accurate renewable power production forecasts are vital to **efficient** and **reliable** system operation
- Recommend to use centralized forecasting services to produce short term sub-hourly rolling forecasts (looking 6 hours ahead)
- Integrate into production planning and unit commitment software for constraint economic dispatch





Identifying the Requirements No one-size fits all

For example, in Jamaica, settings of FRT must take into account, among other things, current load shedding for under frequency

Frequency Ride Through Settings Examples

	Nominal Temporary Range	
	Range	Time
Azores Islands	50Hz ±1.5%	Continuous
	50Hz ±2% (95% of time)	Continuous
Canary Islands	49.85Hz - 50.15Hz	Continuous
	49.85Hz - 50.25Hz	5 min
	47.5Hz - 51Hz	5 min
Crete Islands	42.5Hz - 57.5Hz	Continuous
	49Hz - 51Hz (95% of time)	Continuous
Pantelleria Islands	47.5Hz - 51.5Hz	Continuous
French Islands	48Hz - 52Hz	Continuous
	47Hz - 48Hz	3 min
	46Hz - 47Hz	1 min
	44Hz - 46Hz	0.4 sec
	52Hz - 53Hz	5 sec

Identifying the Requirements Example

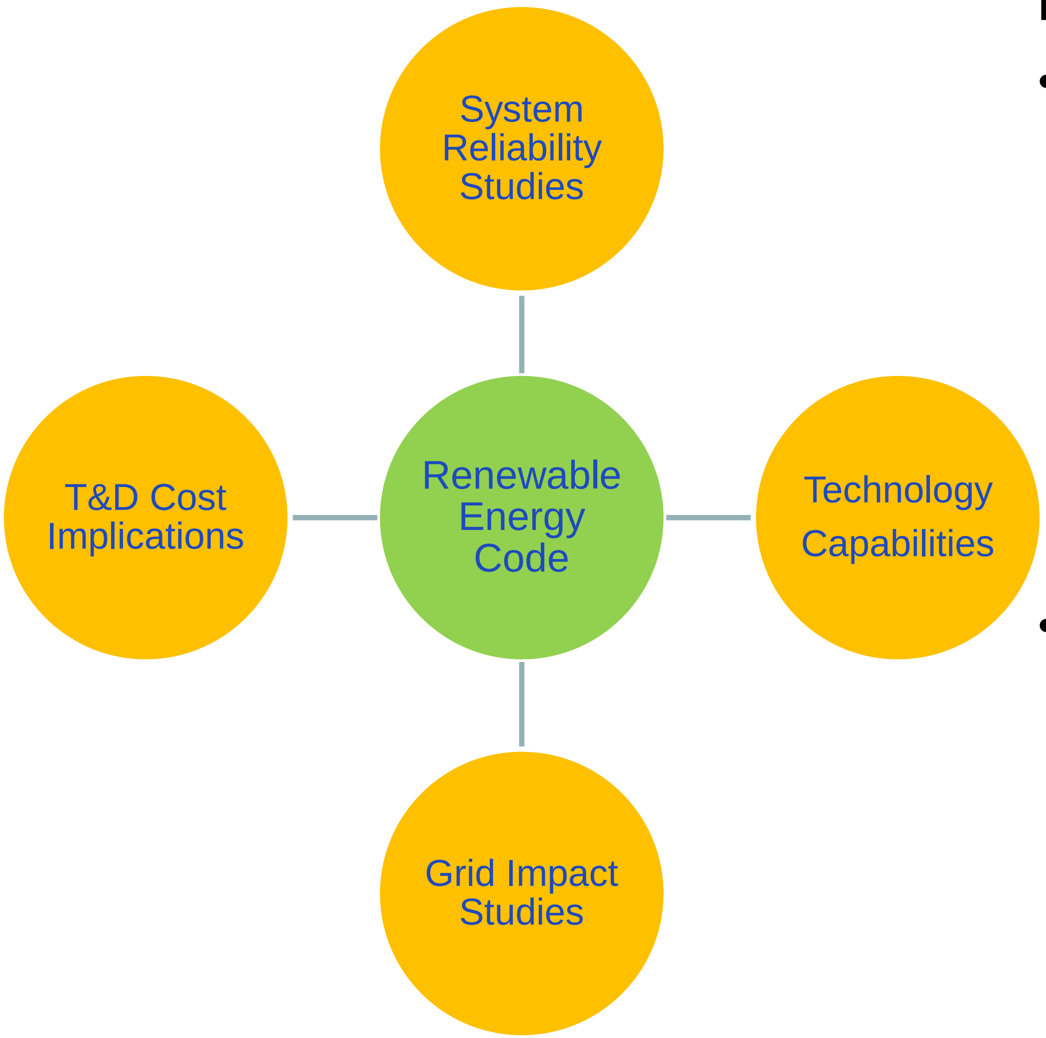
European example:

- PV installations before 2011 were required to disconnect at +/- 200 mHz

- As a result on a sunny day 200 mHz deviation in frequency can result in an outage of more than 10 GW in Central Europe, the contingency reserve was only 3 GW.

- **Retrofitting** installed PVs to avoid this issue is a very expensive option. In Germany the costs were estimated at **$84-229 million**.

Identifying the Right Requirements Inputs and Implications Balance



Decision boundaries:

- If the requirements are too strict, then the cost of producing renewable energy becomes high. Also some technologies cannot comply
- If the requirements are minimal, then the cost of grid re-enforcements may be very high, and grid reliability may suffer

Holistic Approach
Code + Studies, Programs and Services

CODE + STUDY

- Utility scale generators grid impact is location and size dependent
- Voltage and Frequency support requirements can only be determined by study

DISTRIBUTED ENERGY RESOURCE (DER) PROGRAMS

- Such as Net-metering, Demand Response, Energy Efficiency
- Power Wheeling
- These programs must be restudied frequently to assess impact on grid and cost

ANCILLARY SERVICE MARKET

- This will bring the right technologies to the right location, such as energy storage

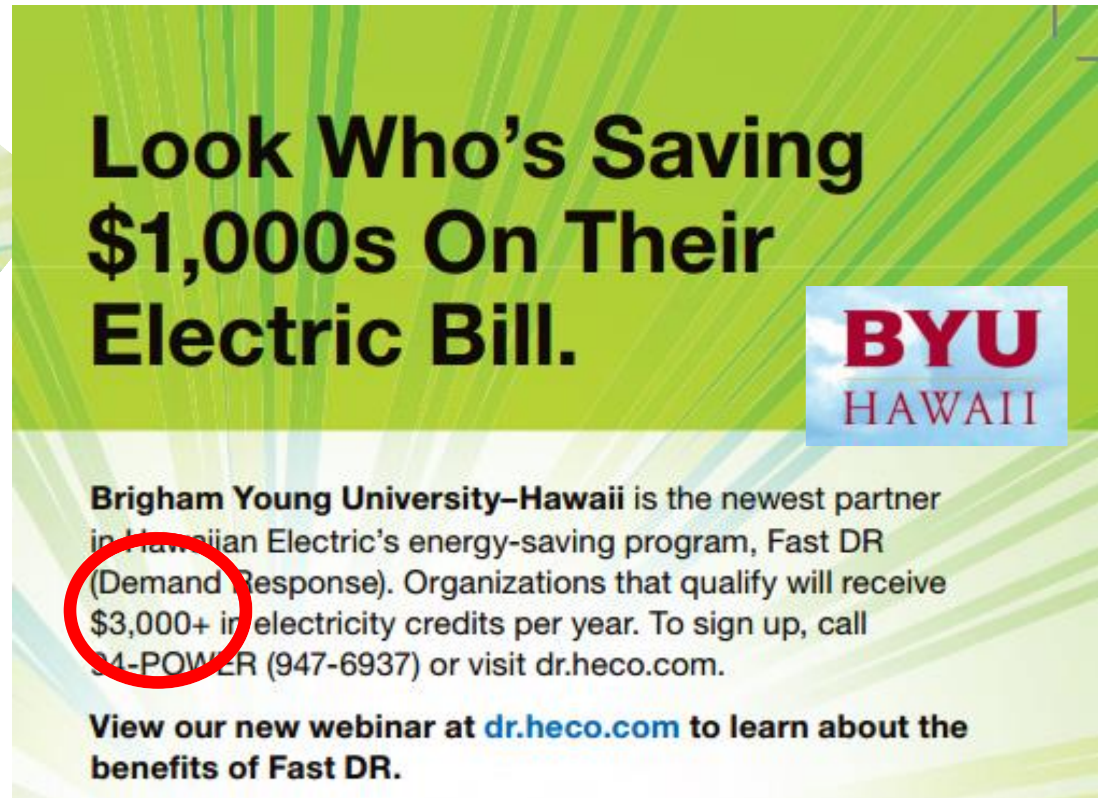
Holistic Approach
Distributed Resources &
Intelligent (Smart) Grid Integration Programs

- Example of Germany:
  - Installed at low voltage levels, many PV installations are of small size ≤ 100kW
  - 98% of over 1 million PV installations are connected to low voltage networks;
  - only 15% of PV installations are larger than 1 MW
  - No visibility or controllability for network operators (at distribution or transmission level)
  - Displaces conventional generation during certain hours

- Need for timely **interconnection requirements** (for utility scale and DG)
- Need to ensure that conventional generation fleet is able to follow net load ramps (including wind and PV) - **Studies**
- Need for PV Production **Forecasting** (utility scale and DG)
- Need for **Smart Meters and Data Analytics**
- Need for **SCADA and Controls**

Holistic Approach
Hawaii Fast DR (FDR) Service example

Bring the cost down by participating in Fast Demand Response



Testing and Compliance Checks

- Compliance checks
  - Engineering Compliance checks during interconnection process
  - Equipment specifications and certifications
- Testing
  - Compliance testing before approval for energization and/or commercial operation
  - Compliance Audits during operation
  - Periodic testing requirements
- Studies
  - Interconnection Studies that the Utility will complete
  - Plant specific studies that may be completed by the developer

Standing Committee & Working Groups

- **Industry Codes have significant cost impact on end users and stakeholders**
- **Codes must continuously grow and adapt to new developments**
- **Expect Issues to arise as the code gets implemented**

- Code Panel should represent all stakeholders and meet once a month
- Any stakeholder should be able to suggest a modification to the code
- Panel should address challenges and generate ideas
- Supplement with informal workshops
- Working groups should be appointed to address issues
- Consultation should be sought in difficult matters which should take into account all stakeholder responses
- Typically the Regulator should have final decision in case of conflict

Conclusion

Approach to Implement Renewable Generation Specific Code in Jamaica

1. Draft code using best available information and expertise by August 26 Ensure that code clearly allows study to supplement code.

2. Establish Code Committee and Workgroups to meet monthly to refine and further develop the code

3. Establish framework of studies necessary to continuously refine code and programs

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hballouz@epeconsulting.com