State of the Art and Future Trends in Grid Codes Applicable to Isolated Electrical Systems

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- Current Status of Isolated Power Systems
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INTRODUCTION (I)

Main characteristics of isolated grids

- **Found in remote or geographically isolated locations**
- **Abundance of renewable energy sources**
- **Radial networks with few generation nodes**
- **Largely dependent on fossil fuels**
- **Lack interconnection to the utility grid**

Need to develop specific grid codes with stricter technical requirements

INTRODUCTION (II)

Drawbacks related to the management and operation of isolated electrical grids

1. Management of energy reserves
2. Fulfillment of security requirements
3. Estimation of foreseen generation and demand

1. Management of energy reserves

Greater levels of energy reserves compared to interconnected systems and, sometimes insufficient

2. Fulfillment of security requirements

Difficulties to foresee incidents. High number of violations of N-1 security criterion

3. Estimation of foreseen generation and demand

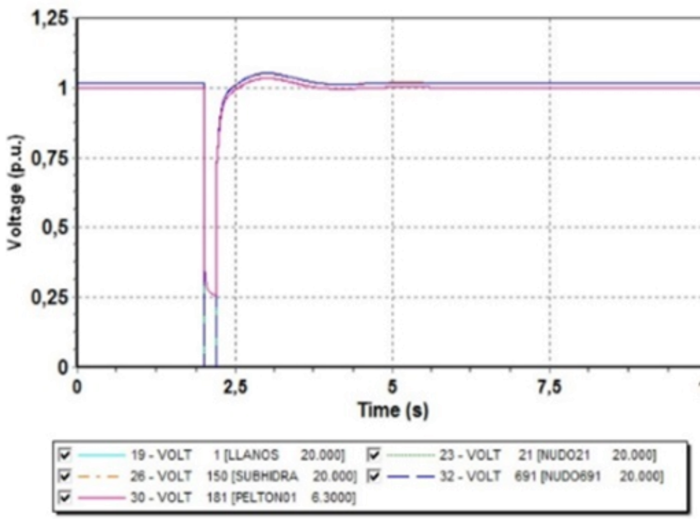
Difficulties in forecasting horizons in energy production from non-manageable generation or demand

CHARACTERIZATION OF VOLTAGE AND FREQUENCY DISTURBANCES IN ISOLATED POWER SYSTEMS (I)

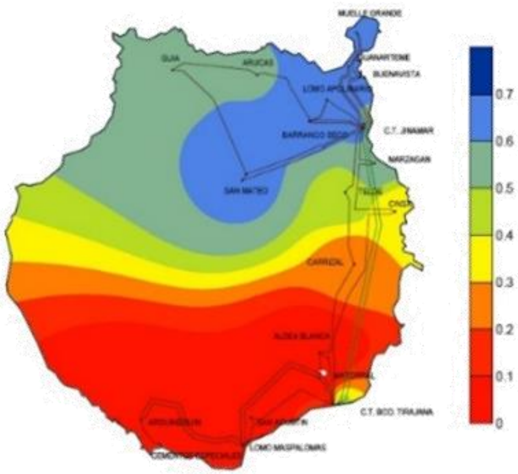
- <u>Voltage dip</u>

  - Nodes are physically close and connected through short distribution lines

  - Important relative potency of the groups of generation load with respect to the total power



Voltage dips in isolated systems are very deep and their area of propagation is very wide-spread.



- Voltage swell/Overvoltage/Undervoltage

  Lines offer a great impedance that causes a high dependence on the degree of load voltage drop, which seriously affects the power quality in the point of common coupling (PCC)

- Frequency oscillations

  Low inertia diesel generators can usually be found, which in the event of disturbance leads to frequency excursions greater than those that would occur in an interconnected system

CURRENT STATUS OF ISOLATED POWER SYSTEMS (I)

Many of the systems that were isolated have been connecting progressively to other networks with similar characteristics or the Mainland due to the development of underwater interconnections using HVDC/HVAC links

Examples of isolated networks which are connected to others and such that the set remains as isolated system

- Hawaiian islands
- Lanzarote-Fuerteventura
- New Zealand
- Guadaloupe-Martinica-Dominica (projected)

Examples of isolated networks which are connected to the Mainland

- Italian islands
- Sri Lanka - India
- Cyprus-Crete-Greece (projected)
- Ireland-UK-Europe
- Iceland-UK (projected)

Examples of isolated networks with no possibility of interconnection

- Canary Islands different from Lanzarote and Fuerteventura

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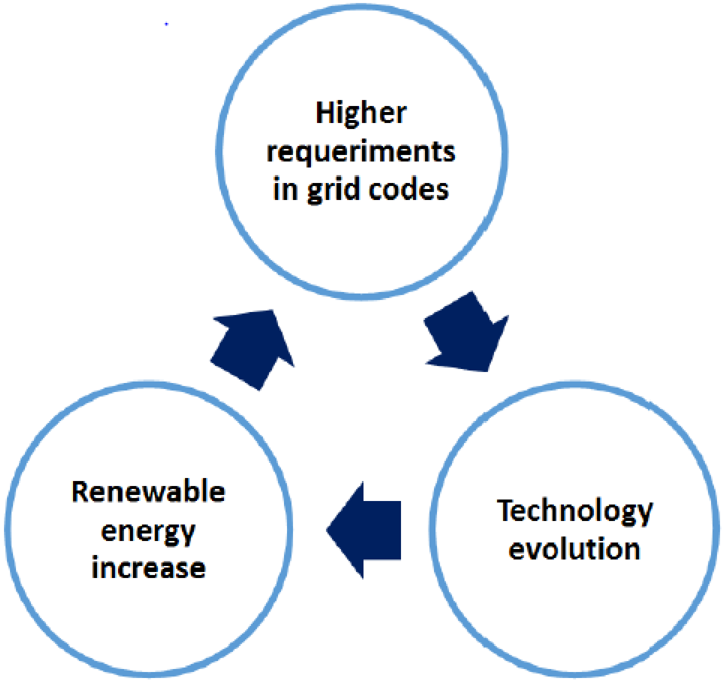
- Grid codes are sets of rules governing the connection and behaviour of generators.

- Grid codes takes as reference the electrical characteristics of the network and their degree of demand depends on the unmaneagable power present and expected penetration ratio.

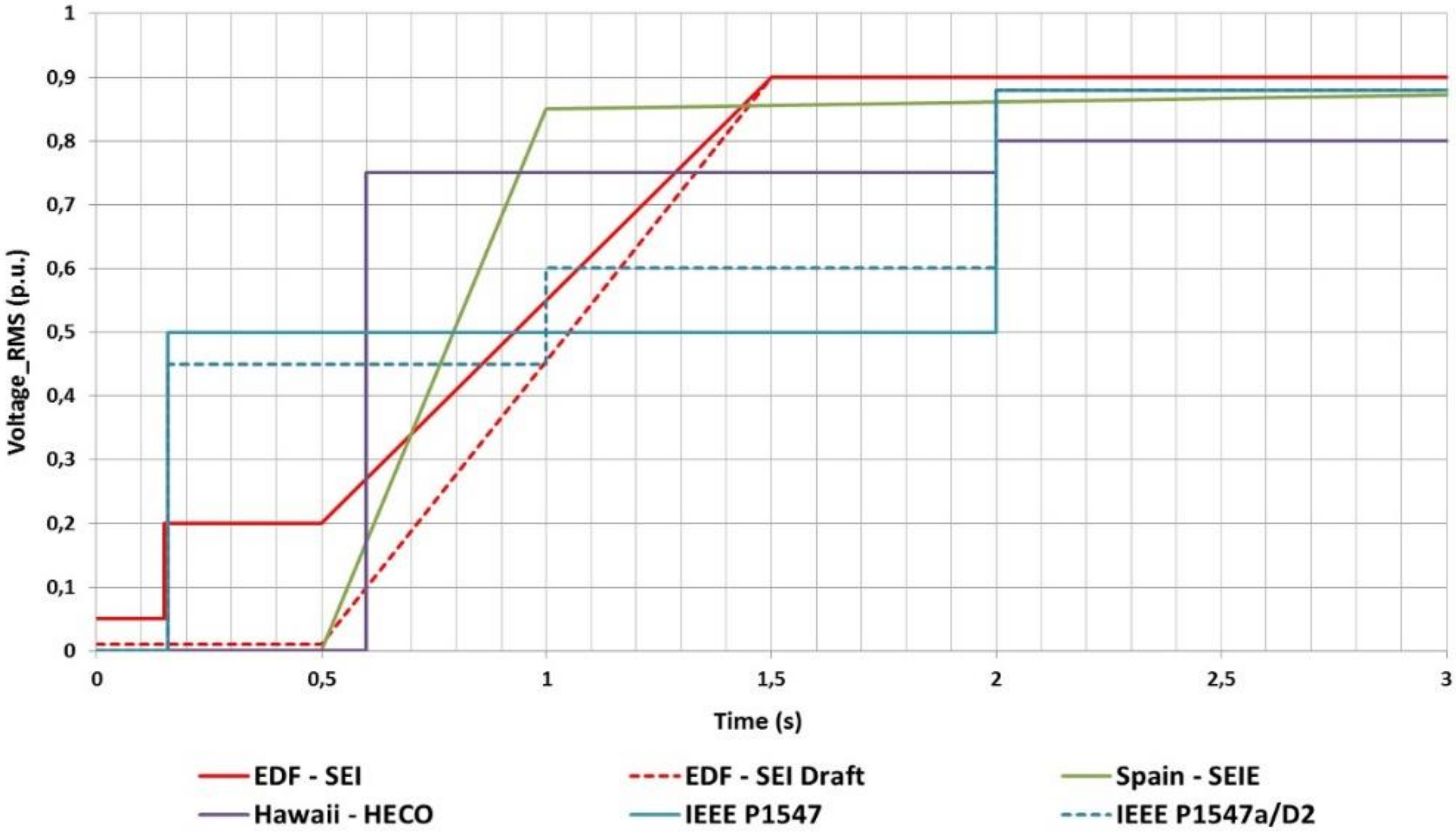
A close relationship exists between regulations, consequences for manufacturers and non disposable energy penetration rate in the system



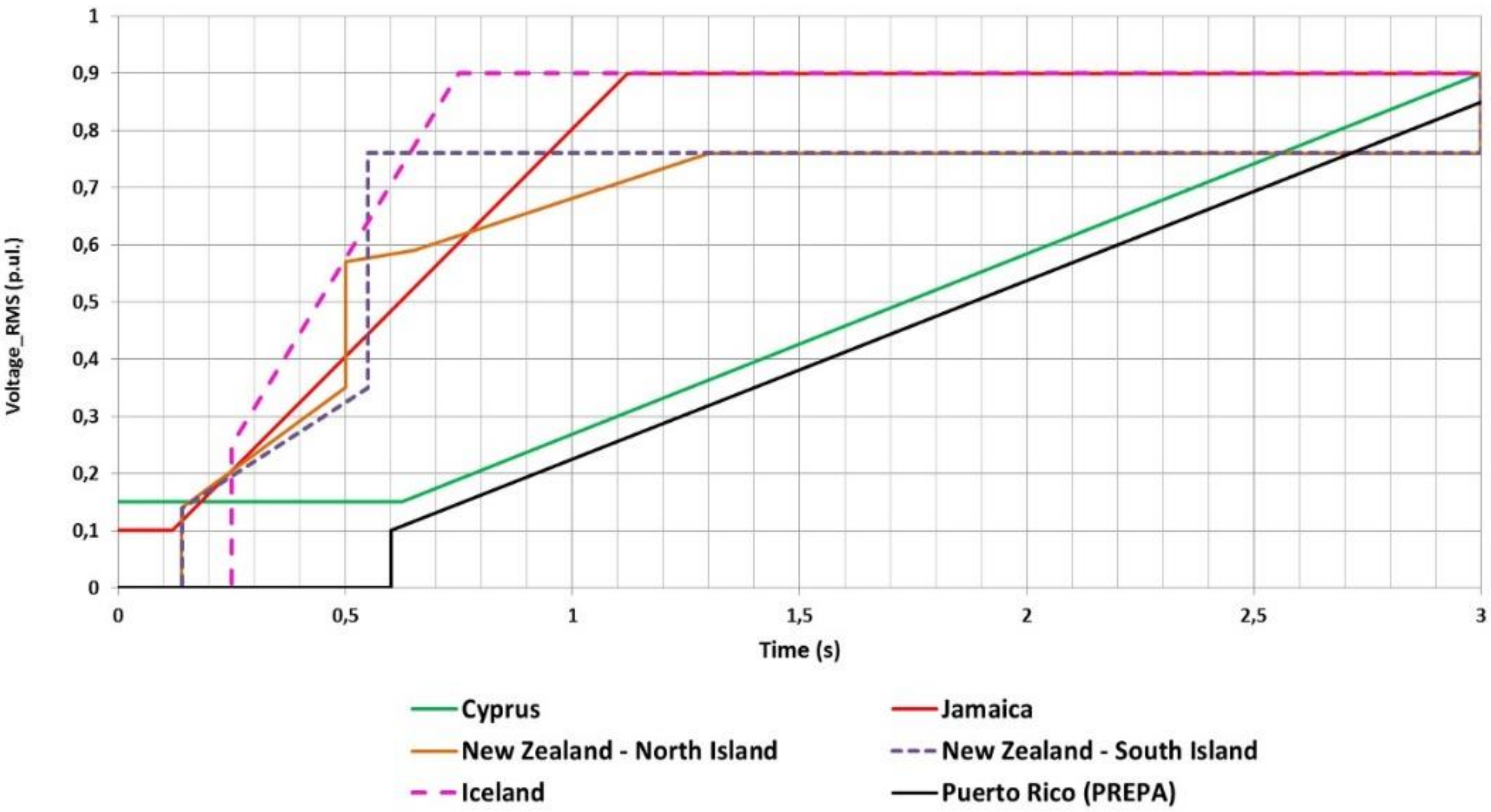
All electrical regulations are structured in a similar way, with three groups of codes:

1. Connection requirements	2. Operation and safety criteria (Operating Procedures)	3. Electricity market rules

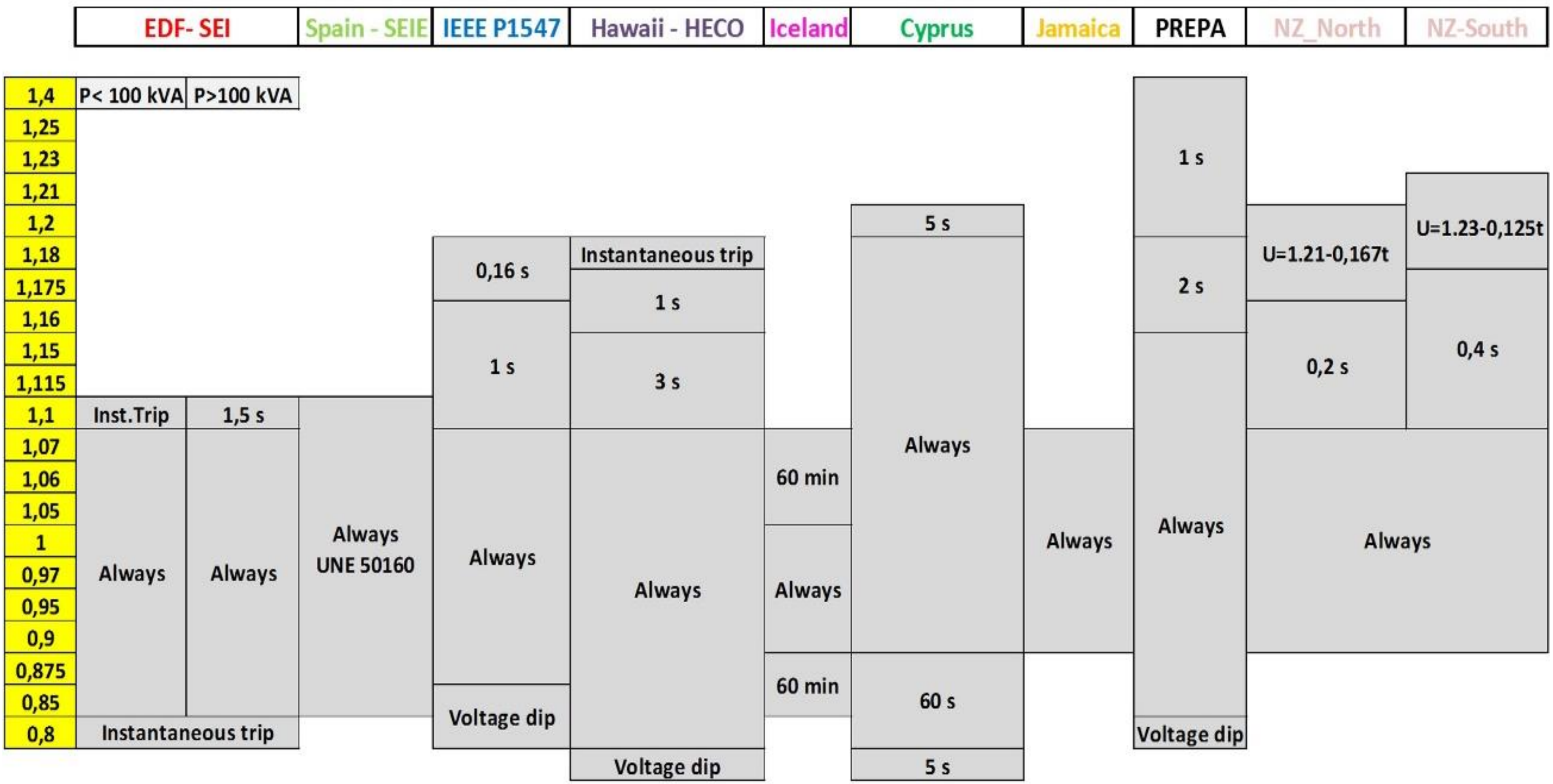
- Voltage dip requirements for systems of less than 50 MW



- Voltage dip requirements for systems over 50 MW

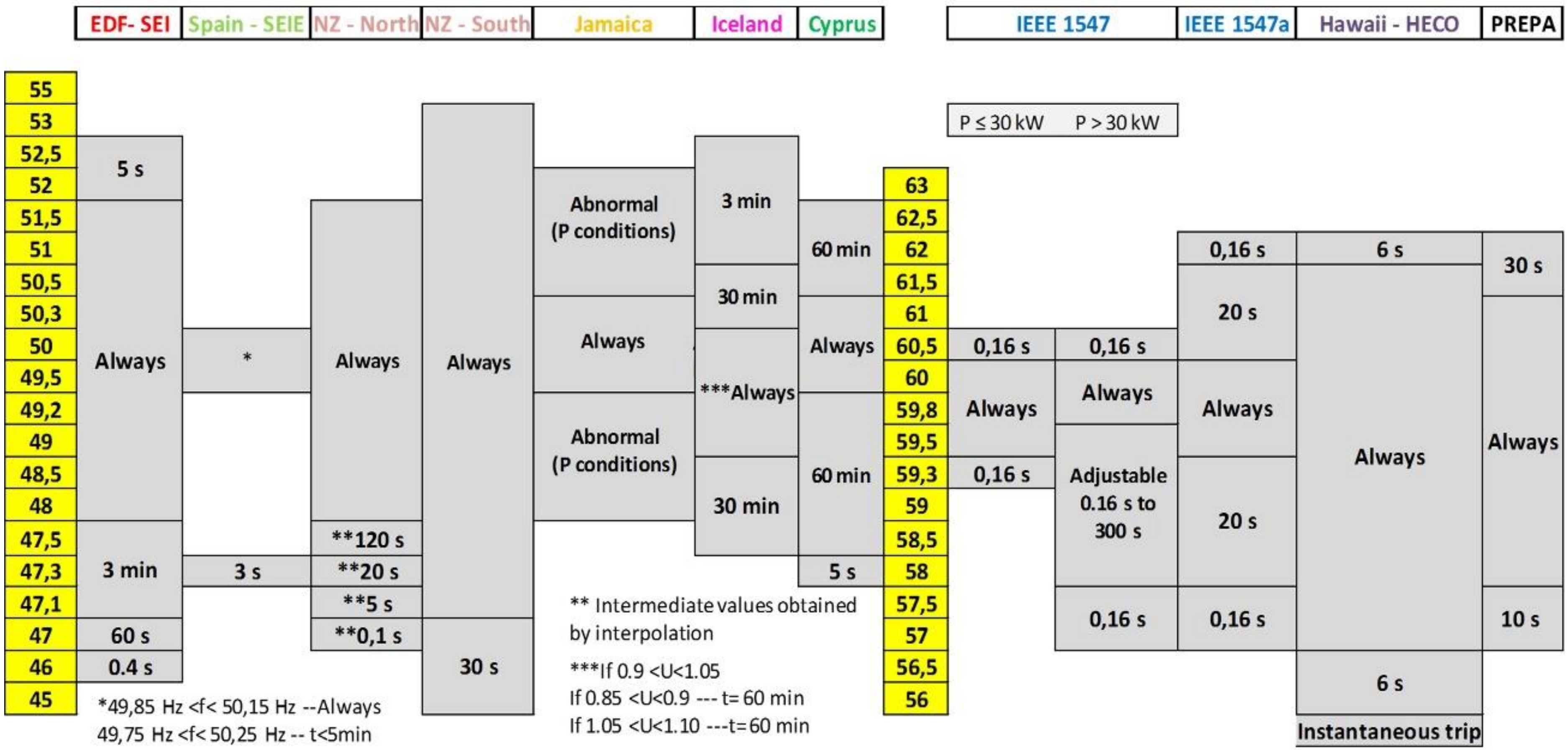


- Overvoltage/Undervoltage requirements



GRID CODES IN ISOLATED SYSTEMS (IV)

- Frequency requirements



FUTURE TRENDS IN ISOLATED GRID CODES

- Emulation of inertia through complex control systems
- Capacity of damping frequency oscillations in the system
- Desirability of control systems to evolve to provide reverse sequence current during power disturbances

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Particularities of isolated systems will be taken into account in future publications of the ENTSO-E code which is being developed to harmonize all European grid codes

CONCLUSIONS

- Isolated systems present difficulties for massive integration of renewable energy sources but integration is desirable to reduce the high external energy dependency

- Inability of isolated grids to connect to the utility grid and high relative size of the generating units/loads with respect to the total power magnify problems linked to the stability and security

- Grid codes facilitate the inclusion of non-conventional energy and due to the characteristics of isolated systems, requirements are stricter respect to the interconnected codes

- The development and approval of new grid codes is constantly changing. This work compiles current status of regulations applicable to isolated systems

Thank you very much for your interest

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