NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Technical Rationale for Reliability Standard VAR-002-5 - Generator Operation for Maintaining Network Voltage Schedules

~~October 2022~~May 2023

Introduction

This document is the technical rationale and justification for Reliability Standard VAR-002-5 to provide the rationale for changes in the current proposed version, VAR-002-4.1.

It is intended to provide stakeholders and the ERO Enterprise with an understanding of the revision, technology, and technical concepts of Reliability Standard VAR-002-5.- This document is not a Reliability Standard and should not be considered mandatory and enforceable.

Background

NERC Project 2021-02 proposed revisions address the NERC Inverter-based Resource Performance Task Force (IRPTF) Standard Authorization Request (SAR) and the VAR-002 Enhanced Periodic Review (EPR), NERC Project 2016-EPR-02, to address ambiguities of voltage and reactive resource ~~Requirements~~requirements concerning dispersed power producing resources. The IRPTF issued an IRPTF White Paper, March 2020, evaluating today's current standards and requirements of Inverter Based Resources (IBRs) to determine whether current ~~Standards~~standards sufficiently address the needs for IBRs. There were 19 recommendations from the VAR-002 EPR reviewed by the Standard Drafting Team (SDT) to be considered for inclusion into the VAR-002 working draft with the objective to address clarity and technical accuracy of the NERC requirements.

Key Concepts of IRPTF white paper, March 2020, for VAR-002-4.1

For dispersed power producing resources, it is not clear if a Generator Operator (GOP) is required to notify the Transmission Operator (TOP) for the status change of voltage control on an individual generating unit. NERC Project 2014-01 Standards Applicability for Dispersed Generation Resources (nerc.com) revised VAR-002, Requirement R4, to clarify that it is not applicable to individual generating units of dispersed power producing resources. The IRPTF did not identify any reason why Requirement R3 should be treated differently than Requirement R4 in this respect and recommends VAR-002-4.1 be modified to make this same clarification to Requirement R3.

Key Concepts of Project 2014-01 for VAR-002-4 Dispersed Generation R3 and R4 rationale

From a historical perspective, Requirements R3 and R4 dispersed Generation considerations, Project 2014-01 VAR-002-4 SDT Consideration of Comments, provided the following:

Project 2014-01 posted "*The DGR SDT understands that the generation facilities subject to Inclusion I4 of the BES definition can be comprised of individual generating units that are typically controlled by centralized voltage/reactive controllers that can be considered alternative voltage control devices as listed in*

Requirement R4. Additionally, there are generation facilities that perform voltage/reactive control at the individual power producing resource. The DGR SDT has determined that a status change of these controllers should be reported regardless of which voltage/reactive control design is used at a facility, which explains why the exclusion was not extended to Requirement R3. The exclusion in Requirement R4 was intended to exclude reporting of an individual generator at a dispersed generating facility coming offline as a change in reactive capability.

The SDT understands that a GOP's voltage controlling equipment and elements differ based on the type of generation facility, and that indeed system configurations vary. However, a "one size fits all" approach would not be appropriate due to the unique characteristics of dispersed generation. Each generation facility may have a different methodology to ensure the facility has an automatic and dynamic response to changes in voltage to ensure the voltage schedule is maintained. It is implied, for example, in NERC VAR-001-3 that each GOP and TOP should understand capabilities of the generation facility and the requirements of the transmission system to ensure a mutually agreeable solution and schedule is used."

Key Concepts of Project 2016-EPR-02 VAR-002

NERC is required to conduct a periodic review of each NERC Reliability Standard at least once every ten (10) years. Recommendations from the EPR team are to be considered by a NERC ~~Standard Drafting Team~~SDT should the ~~Standard~~standard be opened for revision. Results from review found in Attachment 5, Other Miscellaneous Corrections/Revisions, recommendations for clarity, compliance elements, terminology, and technical accuracy recommendations were accepted by the Project 2021-02 SDT acknowledging that the 2016 EPR recommendations were not addressed in the currently enforceable Reliability Standard and could provide more clarity to the requirements for IBRs and other Generation voltage control resources.

Summary of proposed revisions

~~• Introduction – Updated purpose and Applicability sections for clarity of dispersed Generation applicability.~~

NERC Project 2016-EPR-02 Attachment V Recommendations		**2021-02 SDT response to comments to proposed VAR-002-5 draft updates**
Identifier	Description	
2.1	Requirement R2, Part 2.3 has the clause "specified by the Transmission Operator" which is unnecessary and may introduce confusion with respect to whether it is referring to the voltage schedule or the methodology. Remove this phrase or reword to avoid confusion.	Requirement R2, Part 2.3 – Removed "specified by the Transmission Operator" to remove confusion of whether voltage schedule or methodology is being referred to in the requirement.

NERC Project 2016-EPR-02 Attachment V Recommendations		2021-02 SDT response to comments to proposed VAR-002-5 draft updates
Identifier	Description	
2.2	Requirement R6 uses the term "equipment rating." Equipment Rating is a NERC defined term. Requirement R6 should be updated to reflect the defined term "Equipment Rating" or "rating" should be removed to be consistent with other standard (e.g., TOP-001-3, Requirements R3 and R5).	Requirement R6 – Capitalized "equipment rating" for NERC defined term.
2.3	Requirement R4 is silent on the magnitude or quantity of "change in reactive capability" (e.g., 1 MVAR or 100 MVAR). Requirement R4 should be reviewed for potential improvements in establishing the level of change that trigger "change in reactive capability" or where that level of change would be identified.	Requirement R4 – Added "notify, in a mutually-agreeable criteria, its associated Transmission Operator of a status or functionality change of applicable AVR, volt/VAR controller(s), power system stabilizer (PSS), or alternative voltage controlling device which degrades or restores from degradation its ability to automatically control voltage. Status or functionality change notifications shall be made within 30 minutes. If the status has been restored within 30 minutes of the change, then the Generator Operator is not required to notify the Transmission Operator." This was to provide a requirement for the Generator Operator to seek out the clarity needed for reactive capability change reporting criteria needed for the Transmission Operator to assess the system reactive resource capability, per VAR-001 Requirement R2.
2.4	In Requirement R3, clarify that the Generator Operator shall provide notification to the Transmission Operator that is mutually agreeable to the Transmission Operator. This would clarify which medium is available or unavailable for Generator Operator to use for notification, which will avoid the Requirement from prescribing the method (e.g.,	Requirements R3 and R4 – Added "in a mutually-agreeable criteria" to provide clarity of what reporting medium and threshold the Generator Operator should provide to the Transmission Operator.

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	phone call, telemetry, email, etc.).	
2.5	Requirement R4 concerning reactive capability is based on the "D" Curve, which is a snapshot. Therefore, the notification component is for degradation or restoration from the degradation, not additional capability due to other factors. Revise the current Requirement R4 language for clarity (i.e., "change in reactive capability")	Requirements R3 and R4 – Added "degrades or restores from degradation" to clarify the status or functionality changes impacting ability to automatically control voltage and changes in reactive capability need reported to Transmission Operator.
2.6	Revise Requirement R4 to add clarity that a full "D" Curve (i.e., restatement of capabilities) is not required when Reactive Power output is affected.	SDT comments to EPR Attachment V recommendation 2.5 would provide recommended clarity.
2.7	In Requirement R4, visit whether criteria should be spelled out explicitly or "self-developed" for the term "status" in the main requirement.	Requirement R4 – Removed the word "status" in R4 for additional clarity that R4 is requiring notification of change in capability and not status as in Requirement R3.
2.8	In Requirement R4, the term "status" in the bulleted exception concerning dispersed generating resources (DGR) should be struck given the use of "status" is associated with Requirement R3 and not R4.	Removed bulleted Requirement R4 requirement to allow for Transmission Operator to indicate the threshold for reporting in a mutually agreeable criteria to access Generator Reactive resource capability per VAR-001, Requirement R2 and added applicability to dispersed generating resource in Section 4 of the proposed standard.
2.9	Requirement R4 refers to the Bulk Electric System (BES) definition in a manner that brings in applicability (exception) component of	Updated purpose and Applicability sections of standard for clarity of dispersed Generation applicability and BES definition considerations.

NERC Project 2016-EPR-02 Attachment V Recommendations		2021-02 SDT response to comments to proposed VAR-002-5 draft updates
Identifier	Description	
	certain Generator Operators. To the extent possible, this exception be considered for inclusion in the Applicability section of the standard.	
4.1	In Requirement R5 the time horizon of Real-time Operations is inappropriate. Requirement R5 requires the Generator Owner (GO) to provide data to the Transmission Operator (TOP) and Transmission Planner (TP) within 30 calendar days of a request. Therefore, mitigating a violation of this requirement could never occur in Real-time Operations, but rather be the Operations Planning time horizon. The violation of this requirement should garner sanctions associated with a longer time horizon.	Requirement R5 – Changed the time horizon from "Real-time Operations" to "Operations Planning" due to 30-day time provided in the requirement.
4.2	In Requirement R6, the time horizon of Real-time Operations is inappropriate. Requirement R6 requires that generator step-up (GSU) transformer tap changes be implemented by the Generator Owner, this will typically involve an outage of the GSU transformer and is the culmination of a longer-term process to determine if a GSU transformer tap change is appropriate. The violation of this requirement should garner	Requirement R6 – Changed the time horizon from "Real-time Operations" to "Operations Planning."

NERC Project 2016-EPR-02 Attachment V Recommendations		2021-02 SDT response to comments to proposed VAR-002-5 draft updates
Identifier	Description	
	sanctions associated with a longer time horizon.	
4.3	The Requirement R2 Violation Severity Level (VSL) High category does not note that the entity complied with maintaining the voltage or Reactive Power schedule, which must be achieved to have partial performance of the requirement. It is recommended to add an introductory phrase to the High VSL category stating: "The Generator Operator maintained the voltage or Reactive Power schedule but did not…"	Requirement R2 VSL – added introductory phrase to the High VSL stating, "The Generator Operator for each applicable Facility maintained the voltage or Reactive Power schedule but did not…" to show partial compliance and performance to Requirements R2 but not Requirement R2, Part R2.3.
4.4	The last sentence of Measure M1 should be clarified to make clear that the reference is referring to being exempted from automatic voltage control mode and not voltage schedule.	Measure M1 – Restructured last sentence for clarity of exemption.
6.1	Requirement R5, Part 5.1.x may not be technology neutral with respect to transformer modeling data because of the use of "fixed tap ranges." Revise the requirement to ensure that it is technology neutral and inclusive of load tap changing (LTC) transformers.	Requirement R5, Part R5.1.2 – Removed "fixed" to provide technology neutral language and to be inclusive of Load Tap Changing Transformers.
10.1	In Requirement R1 dispersed generation resources (DGR) can be comprised of numerous	Requirements R1 and R2 – Added "applicable Facility" and "volt/VAR controller" for inclusion and added clarity to VAR-002 standard equipment scope to align to BES Generation

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	generators. Each generator may have its own automatic voltage regulator (AVR) in addition to a site AVR that coordinates the voltage level of each of the distributed generators to regulate voltage at a common point such as the GSU transformer. Reword the requirement by replacing "generator" with "generator or DGR site AVR."	definition. The SDT reviewed other standards terminology to identify dispersed power generating resource and voltage control equipment for consistency.
10.2	In Requirement R2 typical dispersed generation resources (DGR) have a site automatic voltage regulator (AVR) that coordinates the voltage of all generators to a common regulation point. If this site AVR fails each generator will typically either continue to regulate at the last known set point or revert to unity power factor. If the site AVR fails, the Generator Owner should report a change per Requirement R3. Augment the requirement to accommodate these circumstances without a violation.	Requirement R2, Part R2.1 – Added "…or if no other method of control is available, notify the Transmission Operator as soon as becoming aware of the condition…" to accommodate dispersed power producing resource volt/VAR site controller failure and continued operation to last known set point or revert to unity power factor on individual dispersed power producing resources without a violation under Requirement R3.
14.1	Requirement R5, does not identify the Transmission Owner (TO) for cases where the TO owns the generator step-up transformer. Revise Requirement R6 to require the TO to communicate settings to the Transmission Operator.	The 2021-02 SDT did not accept this EPR recommendation due to the VAR-002 Reliability Standard not being applicable to the TO and outside scope of providing clarity to GO in VAR-002 standard for this SAR.

NERC Project 2016-EPR-02 Attachment V Recommendations		2021-02 SDT response to comments to proposed VAR-002-5 draft updates
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14.2	Requirement R3 requires the Generator Operator to notify the Transmission Operator of PSS unavailability. The operational requirements for initial state of PSS (on/off) clarity need to be assessed for inclusion within the VAR suite of standards (including expectations for startup, shutdown, or testing mode). Consider whether new requirements or alternative guidance is needed to identify the expected initial state for a PSS.	Requirement R3 – Added "…functionality change of applicable AVR, volt/VAR controller(s), PSS, or alternative voltage controlling device which degrades or restores from degradation its ability to automatically control voltage…" to accommodate the use of on/off operation of PSS during normal operations to only make notifications to Transmission Operator for abnormal PSS operation impacting voltage control to add clarity for when to report to Transmission Operator on PSS and other applicable voltage control equipment.
16.1	The standard does not address any specific PSS requirements. Consider including PSS requirements in the VAR standard(s) similar to PSS requirements in VAR-501-WECC-2 (or any subsequent new version), if there is a reliability need.	The SDT 2021-02 did not accept this EPR recommendation due to providing additional PSS requirements similar to the PSS requirements in VAR-501-WECC-2 was outside the scope of 2021-02 SAR to provide clarity with a focus on dispersed power producing resources and felt another project, if approved, specifically to the VAR suite of standards with PSS subject matter is recommended.

- ~~Requirements R1, R2 – Added "dispersed power producing resource" and "volt/VAR controller" for inclusion and added clarity to VAR-002 Standard (EPR Attachment 5 Recommendation 10.1).~~
- ~~Requirement R2, Part 2.1 – Added "control capability is limited" conditions for dispersed power producing resource if partial outage of facility voltage control equipment (EPR Attachment 5 Recommendation 10.2).~~
- ~~Requirement R2, Part 2.3 – Removed "specified by the Transmission Operator" to remove confusion of whether voltage schedule or methodology is being referred to in the requirement (EPR Attachment 5 Recommendation 2.1).~~
- ~~Requirements R3, R4 – Added "in a mutually agreeable format" to provide clarity of how and what reporting threshold to provide notification to the Transmission Operator (EPR Attachment 5 Recommendations 2.4 and 2.6).~~
- ~~Requirement R3 – Added "degrades/restores its ability to automatically control voltage to add~~

~~clarity for reporting to Transmission Operator on PSS and dispersed Generation operation (EPR Attachment 5 Recommendation 14.2).~~

- ~~Requirement R3 – Added "functionality" for computing functions or range of functions in a control system, such as the Power System Stabilizers or aggregated volt/VAR controller (EPR Attachment 5 Recommendation 14.1).~~
- ~~Requirement R4 – Added language for threshold of notification that indicates Transmission Generator Operator needs to provide notification criteria to Generator Operator to assess the system reactive resource per VAR-001 R2 (EPR Attachment 5 Recommendation 2.3).~~
- ~~Requirement R4 – Removed language that stated R4 is not applicable to individual generating units and rather have Transmission indicate the threshold for not applicable for assessing Generator Reactive resources per VAR-001, Requirement R2 (EPR Attachment 5 Recommendations 2.7 – 2.9).~~
- ~~Requirements R3 – Added language to clarify the changes impacting voltage and reactive control equipment are for changes that degrades/restores its ability to follow Transmission Instruction (EPR Attachment 5 Recommendation 2.5).~~
- ~~Requirement R5 – Changed the time horizon from Real-time to Operations Planning due to 30-day time provided in the requirement (EPR Attachment 5 Recommendation 4.1).~~
- ~~Requirement R5, part 5.1.2 – Removed "fixed" to provide technology neutral language and to be inclusive of Load Tap Changing Transformers (EPR Attachment 5 Recommendation 6.1).~~
- ~~Requirement R6 – Capitalized "equipment rating" for NERC defined term (EPR Attachment 5 Recommendation 2.2).~~
- ~~Requirement R6 – Changed the time horizon from "Real-time Operations" to "Operations Planning." (EPR Attachment 5 Recommendation 4.2).~~

~~• Measure M1 – Restructured last sentence for clarity of exemption (EPR Attachment 5 Recommendation 4.4).~~

- Measures M1-M6 – Minor updates in the Measures to align with ~~Requirements~~requirements' proposed changes.
- Added footnotes 5 and 6 for providing additional clarity to describe volt/VAR controller and mutually-agreeable criteria, respectively.
- Applicable Facility is applied throughout the standard to provide scope Generation Facility defined in Section 4 Applicability section.

Rationale for Applicability Section - Functional Entities

The purpose of the proposed VAR-~~005-5~~002-5 Reliability Standard is to ensure generators or dispersed power producing resources provide reactive support and voltage control, within generating Facility capabilities, in order to protect equipment and maintain reliable operation of the Interconnection. There are two functional entities that play a role in proposed VAR-002-5 requirements and have an obligation to comply with them. These are:

- ~~•~~ Generator Owner
- ~~•~~ Generator Operator

The Generator Owner is responsible for maintaining the Generation Owned voltage control equipment, to include Generator Step-up and auxiliary Transformer if owned, defined by the Bulk Electric System as applicable to the ~~Generator and Dispersed Power Producing~~generating resource and dispersed power producing resource. The Generator Owner will provide Transformer data as required in Requirement R5 and collaborate with Transmission Operator regarding any changes to equipment for new or modified equipment ensuring instructions are followed unless providing reason as stated in ~~Requirement~~the requirement.

The Generator Operator is responsible for operation to Generation Owned voltage and reactive power control equipment to follow the NERC requirements and Transmission Operator voltage and reactive power schedules, notifying the Transmission Operator when the threshold of notification criteria has been met. The Generator Operator will notify Transmission Operator of Reactive capability changes in real-time operations that meet the threshold of notification. The Generator Operator will notify and collaborate with the Transmission Operator to operate with instruction provided in a mutually-agreeable ~~format~~criteria within facility capabilities.

Facilities

The ~~Generator or Dispersed Power Producing~~generating resource or dispersed power producing resource will have met the definition of inclusion to the Bulk Electric System and have capability to control voltage to be required to follow the proposed VAR-002-5 Reliability Standard and, thus, requiring the Transmission Operator provide a voltage or reactive power schedule with notification instruction unless the Transmission Operator provides an exemption, as stated in the proposed Reliability Standard. Due to the various configurations of Generation ~~facilities~~Facilities, Generator Operator and Transmission Operator should collaborate as to the impacts that ~~Generator or Dispersed Power Producing~~generating resource generator or dispersed power producing resource may have to system operations for necessary reporting and any exemptions to reporting should be fully understood for clarity of operation and monitoring.

Rationale for Requirement R1

This requirement has been maintained due to the importance of Generator Operator running a unit with its automatic voltage regulator (AVR) or volt/VAR controller in service and in either voltage controlling mode, or the mode instructed by the Transmission Operator. The Project 2021-02 SDT proposed minor changes to bring attention to dispersed power producing resource as defined by the Bulk Electric System

definition in the NERC Glossary of Terms for inclusion to Generation voltage or Reactive Power control resources and difference in type of voltage control such as a volt/VAR controller for aggregated Generation system control at the Transmission Point of Interconnection or as stated in the Transmission Operator voltage or Reactive Power instruction.

Rationale for Requirement R2
This requirement has been maintained due to the importance of Generator Operator maintaining voltage or Reactive Power schedule within each generating Facility capabilities. The Project 2021-02 SDT proposed minor changes to bring attention to dispersed power producing resource as defined by the Bulk Electric System definition in the NERC Glossary of Terms for inclusion to Generation voltage or Reactive Power control resources and difference in type of voltage control as a volt/VAR controller for aggregated Generation system control at the Transmission Point of Interconnection or as stated in the Transmission Operator voltage or Reactive Power schedule instruction.

Typical dispersed power producing resources have a site automatic voltage regulator (AVR) or volt/VAR controller(s) that coordinates the voltage of all generators to a common regulation point. If this site AVR or volt/VAR controller(s) fails, each generator will typically either continue to regulate at the last known set point, or revert to unity power factor. The Project 2021-02 SDT proposes adding language to provide Transmission Operator notification ~~of limited~~if no alternative control ~~capability~~in Requirement R2, Part R2.1 and without violation to Requirement R3.

The Project 2021-02 SDT agreed with the Project 2016-EPR-02 recommendations as stated in background section. The EPR final report provides additional rationale and background to the recommendations.

Rationale for Requirement R3
This requirement has been modified to clarify the intent of the requirement for the Generator Operator to communicate to the Transmission Operator in a mutually-agreed ~~format~~criteria like other NERC ~~Standards~~standards, e.g., TOP-003, for required notifications for when an AVR or volt/VAR controller(s) meets the notification criteria. The Project 2021-02 SDT proposes additional clarity of status or functionality changes are those that impact the ability to control voltage which degrades or restores from degradation and to exclude notifications that have change in status due to normal characteristics of running the Generation resource or do not meet the Transmission Operator threshold for reporting.

The Generator Operator is required to notify the Transmission Operator of ~~power system stabilizer (~~PSS~~)~~ unavailability. The Project 2021-02 SDT agreed that the operational requirements for initial state of PSS (on/off) clarity was needed for expectations on startup, shutdown, or testing mode. To clarify notification for PSS status change, the Project 2021-02 SDT proposes to add language of functionality changes that degrade or restore its ability to automatically control voltage.
The SDT agreed with the Project 2014-01 VAR-002 SDT as to reasoning for not excluding the individual dispersed Generator for reporting change of status or functionality of volt/VAR control as shown in the background section. This determination for system impacts should have Transmission Operator determine in notification criteria taking facility configuration and type of control into consideration.

Rationale for Requirement R4

This requirement has been modified to clarify the intent of ~~Requirement for~~the requirement for the Generator Operator to communicate to the Transmission Operator in a ~~mutually agreed format~~mutually-agreed criteria like other NERC ~~Standards~~standards, e.g., TOP-003, for required notifications when Generator controlled reactive resources change in ~~real time~~Real-time operations and impact the output of the generation facility other than AVR or volt/VAR controller(s) specified in Requirement R3. The Project 2021-02 SDT proposes additional clarity of capability changes are those that meet the threshold for notification from the Transmission Operator that Transmission would deem to have an impact on assessing Generation reactive resources in ~~real time~~Real-time as required by the Transmission Operator in VAR-001, Requirement R2. The Project 2021-02 SDT proposes to remove the bulleted requirement exempting individual generating units of dispersed Generation resources, determining this requirement was not necessary if the Transmission Operator provides the threshold of reporting. The Transmission Operator would be in the best position to evaluate BES ~~element~~Element impacts to ~~system~~System operations for Real-time assessment and monitoring as reactive resources change and excluding single generating units of dispersed Generation does not provide enough clarity to what reporting is required for dispersed power producing resource. Furthermore, excluding individual generating units of dispersed power producing resources from Requirement R4 reporting may pose a conflict with other enforceable ~~Standards~~standards requiring this type of data, such as individual generating unit on/off status.

The SDT agrees with the Project 2014-01 VAR-002 SDT that coming offline for dispersed power producing would not need to be reported for capability changes, but feel the details of these impacts should be ~~mutually agreed~~mutually-agreed with the Transmission Operator.

Rationale for Requirement R5

This requirement and corresponding measure have been maintained due to the importance of having accurate tap settings. If not properly set, then the VARs available from that unit can be affected. This requirement has been modified to update Requirement Part R5.1 for technology neutral language with respect to transformer modeling data by removing the words, “fixed tap ranges.”

-The Project 2021-02 SDT agrees with the Project 2016-EPR-02 and proposes to update the Operations Planning ~~horizon~~Time Horizon to Real-Time ~~horizon,~~Time Horizon due to the requirement for Generator Owner to provide data to the Transmission Operator and Transmission Planner within 30 calendar days of a request.

Rationale for Requirement R6

This requirement and corresponding measure have been maintained due to the importance of having accurate tap settings. If not properly set, then the VARs available from that unit can be affected. This requirement has been modified to capitalize the words, “equipment rating,” for a NERC defined term. Step-up transformer tap changes, according to the specifications provided by the Transmission Operator, will typically involve an outage of the transformer and is the culmination of a longer term process to determine if a transformer tap change is appropriate~~,~~; therefore, the Project 2021-02 SDT agrees with the Project 2016-EPR-02 and proposes changing the ~~time horizon~~Time Horizon from Real-Time Operations to Operations Planning ~~horizon~~Time Horizon.