Fast Frequency Response (FFR), Primary, Secondary and Tertiary Reserve (POR, SOR, TOR1, TOR2)

System Services Test Procedure

Battery

 Unit Name

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# Document Revision History

Operating reserve test procedure revision 2.0, published 12th November 2019

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Version** | **Date** | **Comment** | **Name** | **Company** |
| 0.1 | Insert date | Minor version (v0.1) - First submission for review and approval | Insert name | Insert company |
| 1.0 | Insert Date | Major version (V1.0) Approved Version by EirGrid / SONI | Insert Name | EirGrid / SONI |

# Introduction

The Unit must submit the latest version of this test procedure as published on the EirGrid or SONI website[[1]](#footnote-2).

The order of this test can be rearranged only in agreement with EirGrid/SONI

The purpose of this document is to detail the data required to apply for a System Services Contract and to detail the necessary test procedures required to be performed should that data not be readily available.

If this data is already available then this document does not need to be completed. The Operating reserve test report should be completed and submitted to EirGrid/SONI

All yellow sections must be filled in before the test procedure will be approved. All grey sections must be filled in during testing. If any test requirements or steps are unclear, or if there is an issue with meeting any requirements or carrying out any steps, please contact generator\_testing@eirgrid.com or generator\_testing@soni.ltd.uk

On the day of testing, suitably qualified technical personnel are required on site to assist in undertaking the tests. The personnel shall have the ability to:

1. Set up and disconnect the control system and instrumentation as required;
2. Ability to fully understand the Unit’s function and its relationship to the System;
3. Liaise with NCC/CHCC as required;
4. Mitigate issues arising during the test and report on system incidents.

The availability of personnel at NCC/CHCC will be necessary in order to initiate the necessary instructions for the test. NCC/CHCC will determine:

1. If network conditions allow the testing to proceed.
2. Which tests will be carried out
3. When the tests will be carried out.

On completion of this test, the following shall be submitted to generator\_testing@eirgrid.com or generator\_testing@soni.ltd.uk

|  |  |
| --- | --- |
| **Submission** | **Timeline** |
| A scanned copy of the test procedure, as completed and signed on site on the day of testing | 1 working day |
| Test data in CSV or Excel format | 1 working day |
| Test report | 10 working days |

# Abbreviations

CHCC Castlereagh House Control Centre

NCC National Control Centre

MVAr Mega Volt Ampere – reactive

MW Mega Watt

TSO Transmission System Operator

MEC Maximum Export Capacity

MIC Maximum Import Capacity

RPM Revolutions Per Minute

kV kilovolt

EDIL Electronic Dispatch Instruction Logger

POR Primary Operating Reserve

SOR Secondary Operating Reserve

TOR Tertiary Operating Reserve

FFR Fast Frequency Response

# Unit DATA

|  |  |
| --- | --- |
| Unit Test Coordinator | Unit to Specify Name, Company and contact details. |
| Unit name | Unit to Specify |
| Unit connection point | HV Bushings of T101 in XX 110kV station |
| Unit connection voltage | Unit to Specify |
| Registered Import Capacity | Unit to Specify |
| Registered Export Capacity | Unit to Specify |
| Contracted MEC | Unit to Specify |
| Contracted MIC | Unit to Specify |
| Installed Plant | Unit to Specify |
| Control system Droop Setting (expected) | Unit to Specify |
| Energy Storage Capacity | Unit to Specify |
| Expected maximum overfrequency response | Unit to Specify |
| % Charge maintained in normal operation | Unit to Specify |

# System Services definitions

## Fast frequency response

FFR is defined as the additional increase in MW output from a unit or a reduction in demand following a frequency event that is available within two seconds of the start of the event and sustainable for at least eight seconds afterwards

The extra energy provided by the MW increase, in the timeframe from the FFR response time to 10 seconds **shall be greater** than any loss of energy in the ten-to-twenty second timeframe afterwards due to a reduction in MW output. The energy provided and drawn should be compared to the pre-event output.

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Figure 1: FFR being delivered after a frequency event

As shown in the diagram above, in order to be eligible for FFR the amount indicated by the blue hatched area (Power provided) must be greater than the green hatched area (Power drawn). If the amount of power drawn exceeds (or is equal to) the amount of power given (within the time frame) then the unit will not be eligible for an FFR contract.

## POR, SOR & TOR1[[2]](#footnote-3)

### Operating Reserve

Operating Reserve is defined as the additional MW output provided from Generation plant, reduction of Active power transfer to an external system or increase of Active power transfer to the Transmission system by interconnectors or storage plant, or reduction in Customer demand, which must be realisable in real time operation to contain and correct any potential Transmission system deviation to an acceptable level.

### Primary Operating Reserve (POR)

Primary Operating Reserve (POR) is the additional MW output (and/or reduction in Demand) required at the frequency nadir (minimum), compared to the pre-incident output (or Demand) where the nadir occurs between 5 and 15 seconds after an Event.

### Secondary Operating Reserve (SOR)

Secondary Operating Reserve (SOR) is the additional MW output (and/or reduction in Demand) required compared to the pre-incident output (or Demand), which is fully available and sustainable over the period from 15 to 90 seconds following an Event.

### Tertiary Operating Reserve band 1 (TOR1)

Tertiary Operating Reserve band 1 (TOR1) is the additional MW output (and/or reduction in Demand) required compared to the pre-incident output (or Demand) which is fully available and sustainable over the period from 90 seconds to 5 minutes following an Event.

### Tertiary Operating Reserve band 2 (TOR2)

Tertiary Operating Reserve band 2 (TOR2) is the additional MW output (and/or reduction in Demand) required compared to the pre-incident output (or Demand) which is fully available and sustainable over the period from 5 minutes to 20 minutes following an Event.

## Dynamic & Static Response

### FFR Dynamic Capability requirements

Dynamic response is when a Unit tracks the system frequency and adjust its response accordingly. A Unit providing a dynamic response shall meet the following criteria:

1. The unit shall track changes in frequency dynamically.
2. Contain **at least** 10 discrete steps or sources which can dynamically adjust load contributions in response to frequency. No individual step shall be larger than 5MW and the response shall be provided in a linear, monotonically increasing manner. All step sizes shall be no more than +/- 1MW of the average step size[[3]](#footnote-4).
3. The unit shall have the capability to commit to a frequency trigger set point greater than or equal to 49.8 Hz and less than or equal to 49.985 Hz.
4. Have frequency measurement installed locally.
5. The unit shall be able to operate with a minimum trajectory[[4]](#footnote-5) of 2Hz in response to a Reserve Trigger.
6. While the basic energy recovery requirement of the FFR product is to apply[[5]](#footnote-6), to qualify as a dynamic provider, the unit shall be able to operate without recovering its resource[[6]](#footnote-7) until the system frequency has recovered to within 5% of the pre-event frequency in steady-state for a period of up to 5 mins (the exact timeframe will be instructed by the TSOs);
7. The unit’s provision of POR, SOR and TOR1, if contracted for any of these Services, shall mirror its FFR response characteristics, i.e. the unit shall have the capability of continuing along the trajectory of the applicable frequency response curve for the extended timeframes obligated of POR, SOR and TOR1, as required of the TSOs in response to a Reserve Trigger.
8. The unit shall have a PMU in situ. PMU shall meet the current metering standards.



Figure 2: Example of a Dynamic unit response with a trigger point of 49.8Hz

As shown in figure 2, above, as the frequency drops the unit does not respond until the trigger point is reached (in this example the trigger point is set at 49.8Hz). When this point is reached the unit output begins ramping up in discrete steps (steps in accordance with the requirements stated in section 5.3.1), staying as close as possible to the expected output. The output steps down also as the frequency returns to nominal (50Hz). This is what is expected of a dynamic response.

### Static response capability requirements

A Static response is where the Unit provides its entire response at one single trigger point.

Figure 3: Example of a Static response from a unit with a trigger point of 49.8Hz

# site Safety requirements

The following is required for the EirGrid/SONI witness to attend site:

|  |  |
| --- | --- |
| Personal Protective Equipment Requirements1. Site Safety boots
2. Hard Hat with chin strap
3. Hi Vis
4. Arc Resistive clothing
5. Safety Glasses
6. Gloves
7. Safe Pass
 | 1. Yes / No
2. Yes / No
3. Yes / No
4. Yes / No
5. Yes / No
6. Yes / No
7. Yes / No
 |
| Site Induction requirements | Yes / No (If Yes, Unit to specify how and when the induction must carried out) |
| Any further information | Unit to specify |

# Test Description and Pre Conditions

## Purpose of the Test

The purpose of this test is to verify:

* The lowest sustainable amount of energy provided by the unit in the 2 – 10 second timeframe after a frequency event.
* The unit does not draw in more energy in the ten second timeframe after the event.
* The levels of Primary, Secondary and Tertiary Operating Reserves provided by the unit.
* Verify that the unit meets the conditions for dynamic response (**For dynamic response only**)
* Verify the trigger frequency(ies) of the Unit.
* Verify the response time of the Unit.

This is achieved by injecting simulated reference frequencies at different export and import levels and analysing the responses of the unit to those injections

|  |  |
| --- | --- |
|  |  |
| Is the frequency injected using software or external hardware? | Unit to specify |
| Can the frequency be injected as a ramp or as a step? | Unit to specify |
| Frequency injected as an offset to the system frequency or is the governor/control system isolated from the system frequency? | Unit to specify |

## Frequency injection profile – Trigger Frequency Testing

Figure 4 provides a visual representation of the frequency injections and corresponding expected responses from the battery during the Trigger Frequency tests detailed in Section 9.1.

 

**Figure 4: Expected response from Trigger Frequency testing**

## Frequency injection profile – Dynamic Frequency Response Tests

Figure 4 provides a visual representation of the frequency injections and corresponding expected responses from the battery during the dynamic frequency response tests detailed in Section 9.2.

 

**Figure 5: Expected response from Dynamic Frequency Response testing**

# IInstrumentation and Onsite Data Trending

All of the following trends and screenshots must be recorded by the Unit during the test. Failure to provide any of these trends will result in test cancellation.

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Signal Name** | **Sample Rate** | **Source** |
| 1 | Active Power at Connection Point (MW)  | Unit to specify, 100ms or as agreed with TSO (20ms for FFR scalar product) | Unit to specify |
| 2 | Reactive Power at Connection Point (MVAr) | Unit to specify, 100ms or as agreed with TSO (20ms for FFR scalar product) | Unit to specify |
| 3 | Actual active power from the WFPS in MW \* | Unit to specify, 100ms or as agreed with TSO (20ms for FFR scalar product) | Unit to specify |
| 4 | Reactive power measured at the lower voltage side of the grid connected transformer,  *Point Y*) | Unit to specify, 100ms or as agreed with TSO (20ms for FFR scalar product) | Unit to specify |
| 5 | Simulated Frequency (Hz) | Unit to specify, 100ms or as agreed with TSO (20ms for FFR scalar product) | Unit to specify |
| 6 | Battery Connection Voltage (kV) | Unit to specify, 100ms or as agreed with TSO (20ms for FFR scalar product) | Unit to specify |
| 7 | FFR Availability | Unit to specify, 100ms or as agreed with TSO (20ms for FFR scalar product) | Unit to specify |
| 8 | FFR Mode Status | Unit to specify, 100ms or as agreed with TSO (20ms for FFR scalar product) | Unit to specify |
| 9 | POR Availability | Unit to specify, 100ms or as agreed with TSO (20ms for FFR scalar product) | Unit to specify |
| 10 | SOR Availability | Unit to specify, 100ms or as agreed with TSO (20ms for FFR scalar product) | Unit to specify |
| 11 | TOR1 Availability | Unit to specify, 100ms or as agreed with TSO (20ms for FFR scalar product) | Unit to specify |
| 12 | TOR2 Availability | Unit to specify, 100ms or as agreed with TSO (20ms for FFR scalar product) | Unit to specify |
| 13 | Other signals as required by the unit or by the TSO | Unit to specify, 100ms or as agreed with TSO (20ms for FFR scalar product) | Unit to specify |
| 14 | Alarm/Event page | Screenshot of alarms / events for duration of the test. |
| 15 | Generator Overview Screen | Screenshots may be required where test data/milestone/event is not available through the trends listed above. |
| 16 | EDIL instructions  | Screenshot as logged during the test. |
|  | \* Data can be collected from point Y – Point Z if available. Please note that this may change in the future to point Z data **only** |

## Additional signals for system services

Please note that the list of signals required for this test, as stated above in section 8, may be altered at any time to include any additional signals deemed necessary for system services. If in any doubt please contact the generator testing team at: generator\_testing@eirgrid.com or generator\_testing@soni.ltd.uk

## Initial Conditions

Should “No” be answered to any of the following, contact the EirGrid/SONI test coordinator and agree next steps in advance of making any corrective actions.

|  |  |  |
| --- | --- | --- |
| **No.** | **Conditions** | **Check on day of test** |
| 1 | Test Profiles have been submitted and approved by EirGrid/SONI | Yes/No |
| 2 | The State of Charge of the Battery Unit is sufficient to complete the tests (XX%)  | Yes/No |
| 3 | Required signals, as described in section 8 are available | Yes / No |

# Test Steps

## Frequency Trigger Tests

The following test steps are to verify the high and low frequency deadbands as well as demonstrating proportional dynamic response in advance of full Dynamic Frequency Response testing (9.2).

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Parameter** |  | **Unit** |
| i | Nominal Frequency | 50.000 | Hz |
| ii | Deadband used for testing | + / - 0.2 | Hz |
| iii | High Frequency Deadband | 50.2 | Hz |
| iv | Low Frequency Deadband | 49.8 | Hz |

|  |
| --- |
| **FREQUENCY TRIGGER TEST** |
| **Step** | **Action** | **Time** | **Comment** |
| 1 | Request NCC/CHCC permission to begin test.  |  |  |
| 2 | Begin data recording of signals |  |  |
| 3 | NCC/CHCC issue an active power setpoint of 0 MW. Once achieved, battery to remain at 0 MW for 1 minute |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 4 | Inject a frequency step of 50HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 5 | Inject a frequency step of 49.81HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 6 | Inject a frequency step of 49.79HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export  |
| 7 | Inject a frequency step of 50HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 8 | Inject a frequency step of 50.19HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 9 | Inject a frequency step of 50.21HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 10 | Inject a frequency step of 50HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 11 | NCC/CHCC issue an active power setpoint of 25% of MEC. Once achieved, battery to remain at this setpoint for 1 minute  |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 12 | Inject a frequency step of 49.81HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 13 | Inject a frequency step of 49.79HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 14 | Inject a frequency step of 50HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export  |
| 15 | Inject a frequency step of 50.19HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 16 | Inject a frequency step of 50.21HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 17 | Inject a frequency step of 50HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 18 | NCC/CHCC issue an active power setpoint of [insert nominal recharging set-point]. Once achieved, battery to remain at this setpoint for 1 minute |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 19 | Inject a frequency step of 49.81HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 20 | Inject a frequency step of 49.79HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 21 | Inject a frequency step of 50HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 22 | Inject a frequency step of 50.19HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 23 | Inject a frequency step of 50.21HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 24 | Inject a frequency step of 50HzMaintain injection for one minuteNote Import / export value (MW).  |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 25 | NCC/CHCC issue an active power setpoint of 0 MW. Once achieved, battery to remain at 0 MW for 1 minute |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |

## Dynamic Frequency Response

The following test steps are to verify the amount of FFR, POR, SOR, TOR1 & TOR2 available. There are tests for Static and Dynamic responses. The unit shall agree in advance with EirGrid / SONI which tests the unit shall be undertaking on the day.

Dynamic Frequency Response testing (9.2) will only commence upon successful completion of deadband testing (9.1)

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Parameter** |  | **Unit** |
| i | Nominal Frequency  | 50.000 | Hz |
| ii | Deadband used for deadband tests | + / - 0.2 | Hz |
| iii | High Frequency Trigger | 50.2 | Hz |
| iv | Low Frequency Trigger | 49.8 | Hz |
| v | Trajectory (Underfrequency) | 0.3 | Hz |
| vi | Trajectory (Overfrequency) | 0.3 | Hz |

|  |
| --- |
| **DYNAMIC FREQUENCY RESPONSE TESTS** |
| **Step** | **Action** | **Time** | **Comment** |
| 1 | Request NCC/CHCC permission to begin test and confirm that the battery is at a % charge level as per normal operation.  |  |  |
| 2 | Begin data recording of signals |  |  |
| 3 | NCC/CHCC issue an active power setpoint of 0MW. Once achieved, battery to remain at 0MW for 1 minute  |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 4 | Inject a frequency step of 50HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export  |
| 5 | Inject a frequency step of 49.5HzMaintain injection for twenty minutesNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 6 | Inject a frequency step of 50HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export  |
| 7 | Inject a frequency step of 50.5HzMaintain injection for 90 secondsNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export  |
| 8 | Inject a frequency step of 50HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export  |
| 9 | NCC/CHCC issue an active power setpoint of 25% of MEC. Once achieved, battery to remain at this setpoint for 1 minute  |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 10 | Inject a frequency step of 49.5HzMaintain injection for five minutesNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export  |
| 11 | Inject a frequency step of 50HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export  |
| 12 |  Inject a frequency step of 50.5HzMaintain injection for 90 secondsNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export  |
| 13 | Inject a frequency step of 50HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 14 | NCC/CHCC issue an active power setpoint of [insert nominal recharging set-point]. Once achieved, battery to remain at this setpoint for 1 minute  |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export  |
| 15 | Inject a frequency step of 49.5HzMaintain injection for five minutesNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export  |
| 16 | Inject a frequency step of 50HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export  |
| 17 | Inject a frequency step of 50.5HzMaintain injection for 90 secondsNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |
| 18 | Inject a frequency step of 50HzMaintain injection for one minuteNote Import / export value (MW) |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export  |
| 19 | NCC/CHCC issue an active power setpoint of 0 MW. Once achieved, battery to remain at 0 MW for 1 minute |  | \_\_\_\_\_\_\_\_\_\_ MW Import / Export |

# Comments & Sign-off

|  |
| --- |
| **Comments:**  |
| Unit Witness signoff that this test has been carried out according to the test procedure above.Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date / Time: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| EirGrid/SONI Witness signoff that this test has been carried out according to the test procedure above.Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date / Time: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

1. <http://www.eirgrid.com/operations/gridcode/compliancetesting/cdgutestprocedures/#d.en.17699> [↑](#footnote-ref-2)
2. Definitions form DS3 System Services Decision Paper SEM-13-098: <https://www.semcommittee.com/sites/semcommittee.com/files/media-files/SEM-13-098%20%20DS3%20System%20Services%20Technical%20Definitions%20Decision%20Paper%20-%20FINAL_0.pdf>

 [↑](#footnote-ref-3)
3. Where average step size = (Available FFR volume / number of discrete steps) [↑](#footnote-ref-4)
4. Trajectory is defined in the DS3 System services contract paper Pg.39: <http://www.eirgridgroup.com/site-files/library/EirGrid/DS3-System-Services-Contracts-Recommendations_final.pdf> [↑](#footnote-ref-5)
5. DS3 System Services Technical Definitions Decision Paper SEM-13-098 20/12/2013, page 10

<https://www.semcommittee.com/sites/semcommittee.com/files/media-files/SEM-13-098%20%20DS3%20System%20Services%20Technical%20Definitions%20Decision%20Paper%20-%20FINAL_0.pdf> [↑](#footnote-ref-6)
6. For example, a battery charging to its pre-event output [↑](#footnote-ref-7)