Requirements for WECC Model Submission

Version 1.0 - 14 February 2022

EIRGRID

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Revision History

Ver.	Date	Notes	Prepared by	Checked by	Approved by
1.0	14 Feb. 2022	Initial version	Kahraman Yumak	Alan Rogers Marta Val Escudero	Robbie Aherne

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Acronyms

APC	Active Power Control
AVR	Automatic Voltage Regulation
BESS	Battery Energy Storage System
CP	Connection Point
DC	Distribution Code
DSO	Distribution System Operator
ESPS	Energy Storage Power Station
FRT	Fault Ride Through
GC	Grid Code
GCC	Grid Code Compliance
HV	High Voltage
HVDC	High Voltage Direct Current
LV	Low Voltage
MEC	Maximum Export Capacity
MIC	Maximum Import Capacity
MV	Medium Voltage
Mvar	Mega Volt Ampere Reactive
PPM	Power Park Module
PV	Photovoltaic
RfG	Requirements for Generators
RMS	Root Mean Square
SPGM	Synchronous Power Generating Module
TSO	Transmission System Operator
WECC	Western Electricity Coordinating Council

Table 1 - Demarcation of Requirements

Symbol	Applicable To
○	RfG Generation Units
⊖	Non-RfG Generation Units

1. Introduction

The purpose of this document is to provide a guideline for the submission and validation requirements for the Western Electricity Coordinating Council (WECC) 2nd generation model parameters of the connecting Power Park Modules (PPMs) to the Irish electrical network covering only the following types of generators:

- Wind Farms
- Solar Photovoltaic Plants
- Battery Energy Storage Power Stations

The Synchronous Power Generating Modules (SPGM) and HVDC are out of the scope of this document as full detailed models are required for those connections.

Presently, EirGrid requests detailed dynamic models of the connecting facilities for Fault Ride-Through (FRT) studies. Information on the requirements of the FRT studies and FRT dynamic models can be found in the FRT template provided in EirGrid's library [1].

Besides the FRT dynamic models with vendor-specific libraries, the WECC generic models of the facilities are still needed because the control centres in Ireland and Northern Ireland use 2nd generation WECC generic models to assess the impact and performance of the facilities on the transmission system in real time operations.

The FRT dynamic model is expected to be a detailed Root-Mean-Square (RMS) representation of the facility using vendor-specific libraries which are hard-coded and are not disclosed to users for confidentiality reasons. The vendor libraries are regarded as "black box" with essentially unknown characteristics. On the other hand, generic models provide a medium for the manufacturers to represent their equipment without revealing any proprietary data to other users. The detailed RMS-based dynamic models are of great importance, but generic models are used in real-time operations due to the limitations and complexities presented by the vendor specific libraries.

The 2nd generation generic models developed by WECC are RMS-based positive sequence reduced order models reflecting normal operation controls as well as the dynamic controls managed by the generation units. They are non-proprietary and accessible to all users without the need for non-disclosure agreements. Further information on WECC generic models can be found in [2] and [3].

EirGrid also provides a spreadsheet titled "WECC-Model-Submission-Spreadsheet-v1.0.xlsx" to the customers to be used in the parameter submissions. Check up-to-date version in EirGrid's Library. The current version (v1.0) of the spreadsheet is available in [4].

Note that for a realistic assessment, the submitted models must reflect site-specific parameters. Generic values for the parameters will not be accepted.

The sections are briefly described below:

- In the second section, the WECC models are specified for each type of the generator.
- In the third section, testing requirements for validation studies are described.
- In the appendices, the tables from the spreadsheet are given for the completeness of this document.

All the TSO PPM customers are requested to submit WECC 2nd generation models of their facility to EirGrid. For the DSO PPM customers, it depends on the voltage level of the Connection Point (CP) and Registered Capacity of the facility as given in the following table.

Table 2 - Customers Required to Submit WECC Models

Generator Type	Customer Type	Registered Capacity
Wind Farms Solar PV Plants Battery ESPS	TSO Customers	All Customers
	DSO Customers	• for CP ≥ 110 kV: All Customers • for CP < 110 kV: Reg. Cap. ≥ 5 MW*

* EirGrid doesn't require any WECC model submission from the DSO customers < 5MW for CP < 110 kV.

The indicative timeline for the submission of the WECC model parameters is given in the figure below. Customers are required to submit an initial version of the parameters at least 3 months before the scheduled energisation of the facility. After the completion of Grid Code Compliance (GCC) Tests including approval of the pertaining test reports by EirGrid, a validation report should be submitted no later than 6 weeks demonstrating that the provided set of values reflect the site-specific configuration of the generation units.

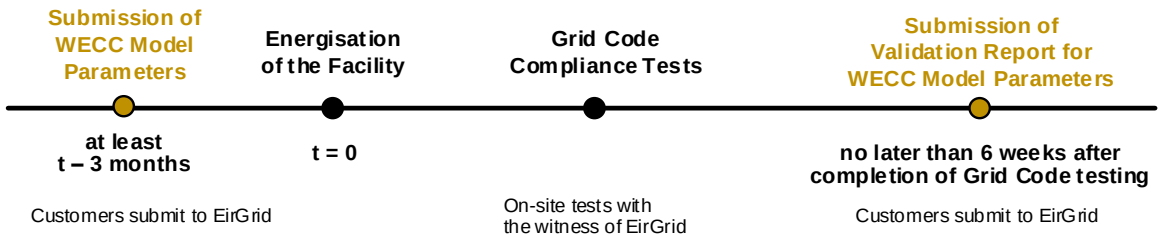

Figure 1 - Timeline for the WECC Model Parameters Submission

Contact ped[at]eirgrid.com, for any questions on this document.

2. Grid Code Requirements

In the Grid Code, a PPM is defined as a generation unit or ensemble of generation units generating electricity which is connected to the network non-synchronously or through power electronics, and has a single connection point onshore to a transmission system, distribution system, or HVDC system.

Note that Battery Energy Storage Power Stations (ESPS) can also be called Battery Energy Storage Systems (BESS) and are classified as PPMs.

The active Grid Code and Distribution Code at the time of preparation of this document are as follows:

- The EirGrid Grid Code: Version 9, 21/12/2020.

  Check up-to-date version in [5].

- The ESB Networks Distribution Code: Version 7, 06/08/2020.

  Check up-to-date version in [6].

The modelling requirements are specified in Grid Code PC.A8 and Distribution Code DCC11.7. See the following excerpts from the Grid Code:

- **Grid Code PC.A8.1: Introduction**
  - The TSO requires suitable and accurate dynamic Models for all Users connected to, or applying for a connection to, the Transmission System, in order to assess the impact of the proposed installation on the transient and dynamic performance, and security and stability of the Power System for a range of timeframes, disturbances and system conditions. The TSO bases the safe and secure design and operation of the Power System on the Models provided by the Users. All Users of the Power System shall provide suitable Models of their Plant in a timeframe and manner specified by the TSO in this Grid Code.
- **Grid Code PC.A8.6: Validation of Model**
  - The User shall simulate the dynamic Models such that Model outputs can be compared against measurements from Grid Code compliance testing to ensure appropriate responses from the Model.
  - After commissioning, the User shall provide the TSO with documentation comparing the predicted behaviour of the balanced, root mean square, positive phase-sequence time-domain Model against the tested performance.
  - The TSO shall also perform studies and ongoing validation to ensure that Models submitted by the User are representative of the User's Plant throughout its operational lifetime.

- If the on-site measurements, Grid Code compliance tests or other information provided indicate that the dynamic Model is not valid in one or more respects, the User shall provide the revised dynamic Model, source code and documentation whose behaviour corresponds to the observed on-site behaviour as soon as reasonably practicable, but in any case no longer than 90 Business Days after the conclusion of the Grid Code compliance tests.

The RfG and Non-RfG Generation Units are described in the Grid Code as follows:

1. **RfG Generation Unit:**

   Indicated with the symbol of  . A Generation Unit that is <u>not</u> a Non-RfG Generation Unit.

2. **Non-RfG Generation Unit:**

   Indicated with the symbol of  . A Generation Unit with a signed Connection Agreement:

   a) Connected to the Network on or before the 30th November 2018; or

   b) Whose owner has concluded a final and binding contract for the purchase of the main Plant on or before the 30th November 2018 and provides evidence of same, as acknowledged by the TSO, on or before the 31st May 2019. Such evidence shall at least contain the contract title, its date of signature and date of entry into force, and the specifications of the main Plant to be constructed, assembled, or purchased; or

   c) Is one of the exceptions to the applicability of the RfG Generation Unit requirements and is a Generation Unit as follows:

      (i) Installed to provide back-up power and operate in parallel with the Network for less than five minutes per calendar month while the system is in normal system state; or

      (ii) No permanent Connection Point and is used by the TSO to temporarily provide power when normal system capacity is partly or completely unavailable; or

      (iii) Energy Storage Units except for Pumped Storage Plant.

   A Non-RfG Generation Unit that undergoes modernisation, refurbishment or replacement of equipment which drives a modification to its Connection Agreement, and had concluded a final and binding contract for the purchase of the Plant being modified after the 30th November 2018 will be deemed an RfG Generation Unit, unless the Plant being modified is one of the exceptions listed in c) above.

3. WECC Models

The required 2nd generation WECC generic models for each type of generator are listed in the table below. The model parameters are expected to be site-specific.

If a 2nd generation WECC model is not available for a plant, and for the generator types not listed in the table below, contact EirGrid.

The model names are given in the PSS/E v34 format just for information purposes. The set values of the parameters are required to be submitted through the provided spreadsheet by EirGrid.

Table 3 - The 2nd Generation WECC Models in PSS/E v34 Format

Model Name	Generator Type			
	Wind Type 3	Wind Type 4	Solar Photovoltaic	Energy Storage
Generator/Converter	REGCA1	REGCA1	REGCA1	REGCA1
Electrical Controller	REECA1	REECA1	REECDU1	REECCU1
Plant Controller	REPCTA1	REPCA1	REPCA1	REPCA1
Drive-Train	WTDTA1	WTDTA1*	-	-
Pitch Control	WTPTA1	-	-	-
Aerodynamic	WTARA1	-	-	-
Torque Control	WTTQA1	-	-	-

* Optional

The WECC models for the protection systems are shown in the following table. The submission of the site-specific parameters for the protection systems is also required.

Table 4 - WECC Models for the Protection Systems

Model Name for Generator Protection	For All Facilities
Low/High Frequency Ride-Through	FRQTPAT, FRQDCAT
Low/High Voltage Ride-Through	VTGTPAT, VTGDCAT

If the parameters change in different operating modes, this should be clearly indicated along with the associated values.

For Battery ESPS connections, the WECC model parameters for all operating modes including the five frequency response modes are required to be submitted.

4. Validation Report

The dynamic models play a crucial role in the real-time stability analysis of the transmission network. Generic parameters are not acceptable and submitted models should reflect site-specific behaviour of the generation units. Therefore, validation of the submitted parameters against on-site Grid Code Compliance tests is required. EirGrid require that the WECC 2nd generation models are validated against site specific Grid Code Compliance tests.

Information on the Grid Code Compliance & Testing procedures is available on EirGrid's website [7].

The required Grid Code Compliance tests for validation purposes are as follows:

- Frequency Response Tests
- Reactive Power Control Tests

The validation report should demonstrate that the WECC models provided prior to energisation can reproduce with reasonable accuracy the Grid Code Compliance tests for that specific site.

The actual set points and measurements taken during the Grid Code Compliance tests should be considered for validation purposes.

If any control parameters have been re-tuned during commissioning tests, these should be highlighted in the report and the updated parameters and set values should be submitted to EirGrid.

Any software capable of running dynamic studies can be used for the validation of WECC model parameters.

The simulation outputs of the submitted model should be compared against recorded results of the tests at the physical site. The comparison can be done by plotting the outputs on graphs. Evaluation on the obtained results is required.

Note that there might be updates in the Grid Code Compliance templates and different procedures might be followed for older connections. Also, there might be differences in the specified test parameters and on-site measurements due to generator specifications or other conditions. Use the on-site setpoint values, measurements and the test procedures for reference in the validation studies.

EirGrid is primarily interested in the verification of the dynamic aspects of the Grid Code tests. For the tests with extensive duration, it is possible to split the simulations and focus only on the time periods where the dynamic response is provided.

Also note that a sufficient state-of-charge level could be assumed for the simulation studies of Battery ESPS units.

4.1. Frequency Response Tests

The purpose of the Grid Code Compliance Frequency Response Tests is to demonstrate that the active power output of the generators is correctly altered for simulated frequencies.

The frequency response tests for the validation studies are listed in the following table.

Table 5 - GCC Frequency Response Tests

Generator Type	Required Procedures for Validation
RfG & Non-RfG PPM	Frequency Droop Settings
	Frequency Response ON, Curve 1, APC ON
	Frequency Response ON, Curve 1, APC OFF
	Frequency Response ON, Curve 2, APC ON
	Frequency Response ON, Curve 2, APC OFF
Battery ESPS	Frequency Response ON, Mode 1
	Frequency Response ON, Mode 2
	Frequency Response ON, Mode 5

Information on the test procedures are available online:

- RfG PPM Frequency Response Test Procedure [8].
- Non-RfG PPM Frequency Response Test Procedure [9].
- ESPS Frequency Response Test Procedure [10].

4.2. Reactive Power Control Tests

The purpose of the Grid Code Compliance Reactive Power Control Tests is to confirm correct operation of Automatic Voltage Regulation (AVR) system of the facilities in Voltage Regulation (kV), Reactive Power (Q) and Power Factor (PF) modes, and also changing between these modes.

Table 6 - GCC Reactive Power Control Tests

Generator Type	Required Procedures for Validation
RfG/Non-RfG PPM & Battery ESPS	Automatic Voltage Regulation Mode
	Automatic Voltage Regulation Response Rate
	Mvar Control Mode
	Power Factor Control Mode

Information on the test procedures are available online:

- RfG PPM Reactive Power Control Test Procedure [11].
- Non-RfG PPM Reactive Power Control Test Procedure [12].
- ESPS Reactive Power Control Test Procedure [13].

4.3. Accuracy Requirements

The limitations of using generic models to emulate the behaviour of actual systems are acknowledged. The responses of the facilities should be simulated in a reasonable manner and as accurately as the generic models allow. Therefore, the accuracy requirements should be considered as target values to reach. There could be deviations out of the given limits. In such cases, the results should be analysed and discussed if it is possible to obtain more accurate responses while adjusting the parameters of the WECC models.

The validation studies shall have the following accuracy requirements:

- For a linear response over a frequency range of 0.1 to 5 Hz, deviations between simulated and measured waveforms of the control system must be less than 10% for amplitude and less than 5 degrees for the phase angle. Discrete waveform changes (amplitude spikes) on the simulated waveform should be less than 10% in relation to measured quantity and in the case of where this level is exceeded due to numerical integration issues, this should be documented in the report.
- For dynamic time domain simulations where non-linear response is included to replicate set point changes or response to disturbances on the wider network, the following requirements apply for deviations between simulated and measured responses:
    - Oscillation in active power, reactive power, voltage and frequency in the 0.1-5Hz range must have damping and the deviation in the frequency of oscillation must be less than 10% for 95% of the recorded samples;
    - Considering possible difference in the voltage at the connection point, deviation in generator response (active power, reactive power, etc.) must be less than 10% for 95% of the samples;
    - Considering possible difference in the final settled value of voltage at the connection point, the final value of generator response (active power, reactive power, etc.) must settle to within 2% of the plants rated capacity.

References

[1] EirGrid Library
https://www.eirgridgroup.com/library/index.xml

[2] Western Electricity Coordinating Council (WECC)
https://www.wecc.org

[3] “WECC Approved Dynamic Model Library”, WECC, December 2021. Available on:
https://www.wecc.org/Reliability/Approved Dynamic Models December 2021.pdf

[4] Spreadsheet for WECC Model Submission
https://www.eirgridgroup.com/site-files/library/EirGrid/WECC-Model-Submission-Spreadsheet-v1.0.xlsx

[5] EirGrid Grid Code
https://www.eirgridgroup.com/customer-and-industry/general-customer-information/grid-code-info/

[6] ESBN Distribution Code
https://www.esbnetworks.ie/who-we-are/distribution-code

[7] EirGrid website on Grid Code Compliance & Testing
https://www.eirgridgroup.com/customer-and-industry/general-customer-information/grid-code-compliance-test/compliance-testing/

[8] RfG PPM Test Procedure Frequency Response
https://www.eirgridgroup.com/site-files/library/EirGrid/RfG_PPM_Test-Procedure-Frequency-Response.docx

[9] Non-RfG PPM Test Procedure Frequency Response
https://www.eirgridgroup.com/site-files/library/EirGrid/Non-RfG_PPM_TestProcedureFrequencyResponse.docx

[10] ESPS Frequency Response Test Procedure Template
https://www.eirgridgroup.com/site-files/library/EirGrid/ESPS-Frequency-Response-Test-Procedure-Template.docx

[11] RfG PPM Test Procedure Reactive Power Control
https://www.eirgridgroup.com/site-files/library/EirGrid/RfG_PPM_Test-Procedure-Reactive-Power-Control.docx

[12] Non-RfG PPM Test Procedure Reactive Power Control
https://www.eirgridgroup.com/site-files/library/EirGrid/Non-RfG_PPM-Test-Procedure-Reactive-Power-Control.docx

[13] ESPS Reactive Power Control Test Procedure Template
https://www.eirgridgroup.com/site-files/library/EirGrid/ESPS-Reactive-Power-Control-Test-Procedure-Template.docx

Appendix A: Spreadsheet - Steps

Submission of
the 2nd Generation WECC Model Parameters

Step 1 - Provide information on the facility

Facility Data	
Project Number	CP/TG/DG number
Name of the Facility	Facility name
Customer Type	TSO/DSO
Connecting Station	Station name
Connection Point Voltage	Voltage [kV]

Step 2 - Select generator type from the dropdown list,
the required models will be populated.

The 2nd Generation WECC Models for the Generation Plants (PSS/E v34)	
Generator Type	
Generator/Converter	-
Electrical Controller	-
Plant Controller	-
Drive-Train	-
Pitch Control	-
Aerodynamic	-
Torque Control	-

The 2nd Generation WECC Models for the Protection Systems (PSS/E v34)	
Low/High Frequency Ride-Through	FRQTPAT & FRQDCAT
Low/High Voltage Ride-Through	VTGTPAT & VTGDCAT

Step 3 - Provide values for the required models in the sheet:
'Parameters_Mode 1'.

Step 4 - Fill in other sheets as needed.

- Battery Energy Storage Power Stations, the parameters for the five frequency response modes are required (Mode 1, 2, 3, 4 and 5).
- Other PPMs (Wind Farms and Solar PV Plants) only need to fill in Mode 1.

Step 5 - Submit updated file to EirGrid
after including facility name in the title.

Note:

** The provided set of values should reflect the site-specific configurations. Generic values for the parameters will not be accepted.*

Appendix B: Model Parameters

B.1. Generator/Converter

Table 7 - Parameters of Generator/Converter

Generator/Converter	
REGCA1	
Parameter	**Value**
Lvplsw	
Tg	
Rrpwr	
Brkpt	
Zerox	
Lvpl1	
Volim	
Lvpnt1	
Lvpnt0	
Iolim	
Tfltr	
Khv	
Iqrmax	
Iqrmin	
Accel	

B.2. Plant Controllers

Table 8 - Parameters of Plant Controllers

Plant Controller			
REPCTA1		**REPCA1**	
Parameter	**Value**	**Parameter**	**Value**
VCFlag		VCFlag	
RefFlag		RefFlag	
Fflag		Fflag	
Tfltr		Tfltr	
Kp		Kp	
Ki		Ki	
Tft		Tft	
Tfv		Tfv	
Vfrz		Vfrz	
Rc		Rc	
Xc		Xc	
Kc		Kc	
emax		emax	
emin		emin	
dbd1		dbd1	
dbd2		dbd2	
Qmax		Qmax	
Qmin		Qmin	
Kpg		Kpg	
Kig		Kig	
Tp		Tp	
fdbd1		fdbd1	
fdbd2		fdbd2	
femax		femax	
femin		femin	
Pmax		Pmax	
Pmin		Pmin	
Tg		Tg	
Ddn		Ddn	
Dup		Dup	

B.3. Electrical Controller - REECA1

Table 9 - Parameters of Electrical Controller - REECA1

Electrical Controller			
REECA1			
Parameter	**Value**	**Parameter**	**Value**
PFFLAG		Kvi	
VFLAG		Vbias	
QFLAG		Tiq	
PFLAG		dPmax	
PQFLAG		dPmin	
Vdip		PMAX	
Vup		PMIN	
Trv		Imax	
dbd1		Tpord	
dbd2		Vq1	
Kqv		Iq1	
Iqh1		Vq2	
Iql1		Iq2	
Vref0		Vq3	
Iqfrz		Iq3	
Thld		Vq4	
Thld2		Iq4	
Tp		Vp1	
Qmax		Ip1	
Qmin		Vp2	
VMAX		Ip2	
VMIN		Vp3	
Kqp		Ip3	
Kqi		Vp4	
Kvp		Ip4	

B.4. Electrical Controller - REECCU1

Table 10 - Parameters of Electrical Controller - REECCU1

Electrical Controller			
REECCU1			
Parameter	**Value**	**Parameter**	**Value**
PFFlag		Pmax	
VFlag		Pmin	
QFlag		Imax	
PQFlag		Tpord	
Vdip		Vq1	
Vup		Iq1	
Trv		Vq2	
dbd1		Iq2	
dbd2		Vq3	
Kqv		Iq3	
Iqh1		Vq4	
Iql1		Iq4	
Vref0		Vp1	
Tp		Ip1	
Qmax		Vp2	
Qmin		Ip2	
Vmax		Vp3	
Vmin		Ip3	
Kqp		Vp4	
Kqi		Ip4	
Kvp		T	
Kvi		SOCini	
Tiq		SOCmax	
dPmax		SOCmin	
dPmin			

B.5. Electrical Controller - REECDU1

Table 11 - Parameters of Electrical Controller - REECDU1

Electrical Controller					
REECDU1					
Parameter	**Value**	**Parameter**	**Value**	**Parameter**	**Value**
PFFLAG		Tiq		Ip1	
VFLAG		dPmax		Vp2	
QFLAG		dPmin		Ip2	
PFLAG		PMAX		Vp3	
PQFLAG		PMIN		Ip3	
VcmpFlag		Imax		Vp4	
Vdip		Tpord		Ip4	
Vup		Vq1		Vp5	
Trv		Iq1		Ip5	
dbd1		Vq2		Vp6	
dbd2		Iq2		Ip6	
Kqv		Vq3		Vp7	
Iqh1		Iq3		Ip7	
Iql1		Vq4		Vp8	
Vref0		Iq4		Ip8	
Iqfrz		Vq5		Vp9	
Thld		Iq5		Ip9	
Thld2		Vq6		Vp10	
Tp		Iq6		Ip10	
Qmax		Vq7		rc	
Qmin		Iq7		Xc	
VMAX		Vq8		Tr1	
VMIN		Iq8		Kc	
Kqp		Vq9		Ke	
Kqi		Iq9		Vblkl	
Kvp		Vq10		Vblkh	
Kvi		Iq10		Tblk	
Vbias		Vp1			

B.6. Other Controllers

Table 12 - Parameters of Drive Train & Pitch Control

Drive-Train		Pitch Control	
WTDTA1		**WTPTA1**	
Parameter	**Value**	**Parameter**	**Value**
H		Kiw	
DAMP		Kpw	
Htfrac		Kic	
Freq1		Kpc	
DSHAFT		Kcc	
		Tp	
		TetaMax	
		TetaMin	
		RTetaMax	
		RTetaMin	

Table 13 - Parameters of Aerodynamic & Torque Control

Aerodynamic		Torque Control	
WTARA1		**WTTQA1**	
Parameter	**Value**	**Parameter**	**Value**
Ka		Tflag	
Theta0		Kpp	
		KIP	
		Tp	
		Twref	
		TeMax	
		TeMin	
		p1	
		spd1	
		p2	
		spd2	
		p3	
		spd3	
		p4	
		spd4	
		TRATE	

B.7. Protection Systems

Table 14 - Parameters of Low/High Frequency Ride-Through

Low/High Frequency Ride-Through			
FRQTPAT		**FRQDCAT**	
Parameter	**Value**	**Parameter**	**Value**
FL		FL	
FU		FU	
TP		TP	
TB		TB	

Table 15 - Parameters of Low/High Voltage Ride-Through

Low/High Voltage Ride-Through			
VTGTPAT		**VTGDCAT**	
Parameter	**Value**	**Parameter**	**Value**
VL		VL	
VU		VU	
TP		TP	
TB		TB	