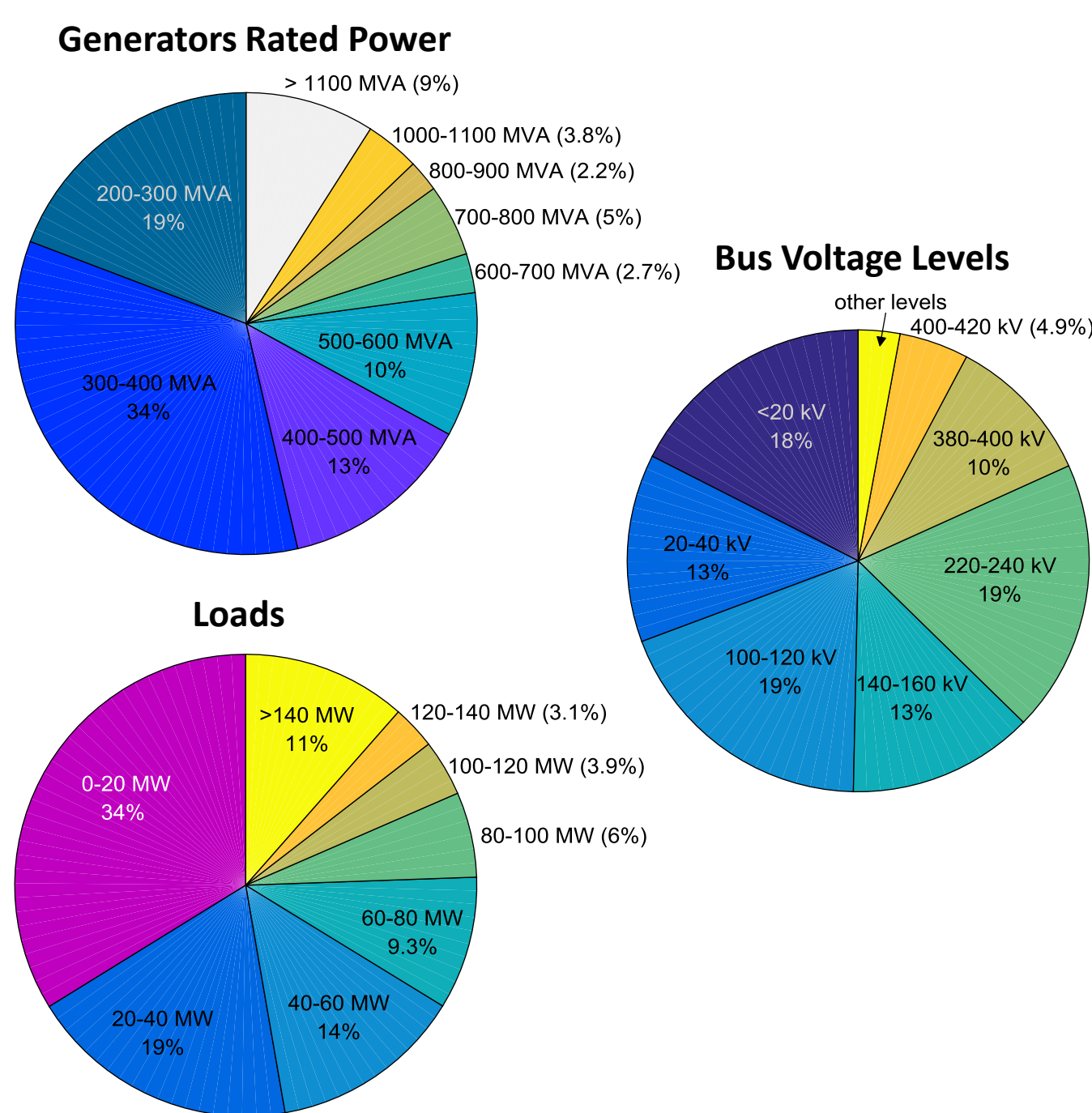


Robustness Assessment of the Continental European Power System Dynamic Model

I. The interconnected network of ENTSO-E

Code	Country	Lines	Buses	Loads	Generators
AL	Albania	193	339	110	77
AT	Austria	123	104	40	31
BA	Bosnia & Herz.	312	294	164	37
BE	Belgium	178	140	36	52
BG	Bulgaria	787	798	419	77
CH	Switzerland	244	193	82	88
CZ	Czech Rep	106	288	76	113
DE	Germany	3378	3939	859	898
DK	Denmark	250	397	66	71
ES	Spain	1338	1385	646	496
FR	France	2599	2665	991	1564
GR	Greece	1133	1312	367	128
HR	Croatia	334	329	171	73
HU	Hungary	94	120	37	28
IT	Italy	817	1264	341	458
LU	Luxembourg	41	38	11	12
ME	Montenegro	80	94	35	18
MK	Macedonia	146	163	85	25
NL	Netherlands	905	1031	244	178
PL	Poland	988	648	199	140
PT	Portugal	365	506	87	158
RO	Romania	1194	1171	654	185
RS	Serbia	619	553	303	62
SI	Slovenia	111	230	65	73
SK	Slovakia	52	48	18	82
TR	Turkey	1943	4888	1245	1022
EU*	Europe*	9	316	26	1
Total		18339	23253	7377	6147



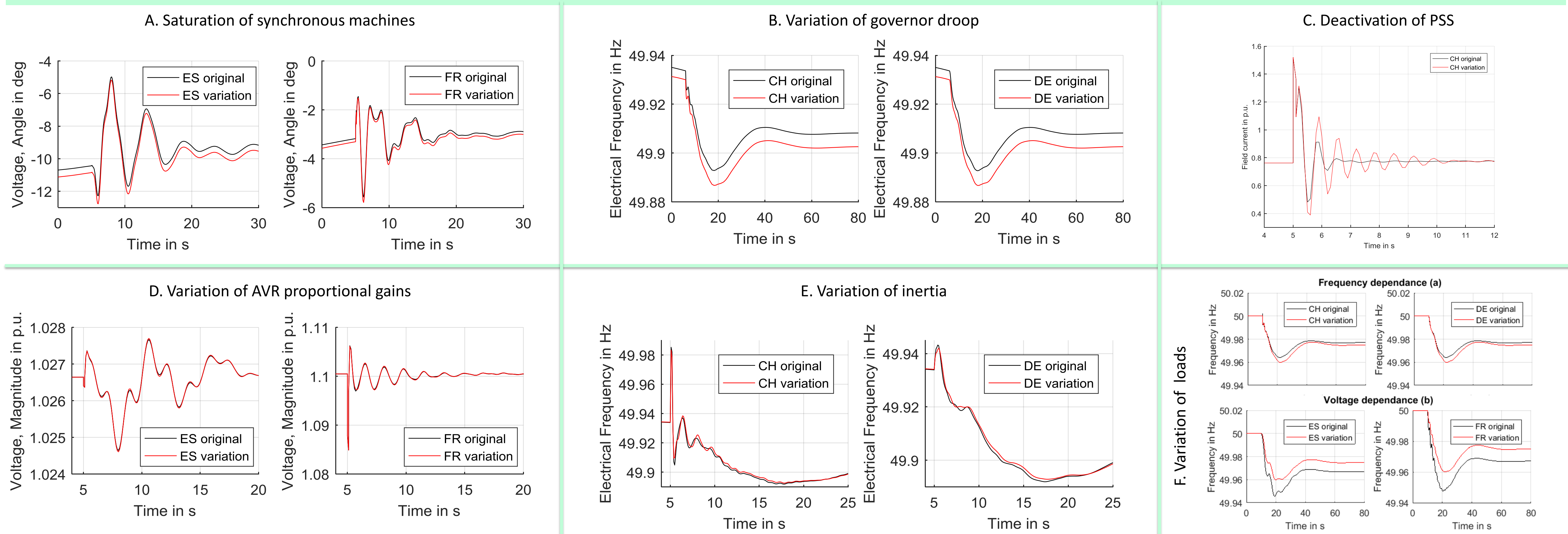
III. Perturbation of the model

Assessment of parameter variations are based on a perturbation in the form of a three phase short circuit on the HV-side of the transformer associated to a synchronous machine in Switzerland. The fault and the associated synchronous machine were disconnected after 100 ms.

II. Variations of the model

- Saturation of synchronous machines.** Synchronous machines are modelled without saturation. We have introduced saturation in all machines and it was modelled as quadratic function of the total flux magnitude.
- Variation of governor droop.** All synchronous machines are equipped with governor type TGOV1 and have similar parameters. Droop parameter on machines in France was increased 40% the original value.
- Deactivation of PSS.** All synchronous generators are fitted with automatic voltage regulators AVR-SEX and with power system stabilizers PSS2A. To examine their impact, all PSS in Switzerland were switched off.
- Variation of AVR proportional gains.** To investigate the response of the system to variation on the AVRs proportional gains, the value of the gains on all AVRs in Switzerland were increased 4 times the original value.
- Variation of inertia.** To examine how the inertia can affect the behaviour of the system, the corresponding parameter on all the synchronous machines in Germany was increased 33%.
- Variation of loads.** Variations regarding voltage dependency and frequency dependency of the loads has been tested using static load models.

IV. Simulation Results



Further reading: F.R. Segundo et. al, *Evaluation of the ENTSO-E Initial Dynamic Model of Continental Europe Subject to Parameter Variations*, IEEE ISGT, USA, April 2017

Rafael Segundo & Petr Korba
Zurich University of Applied Science

Emil Hillberg & Göran Lindahl*
STRI

Kjetil Uhlen
Norwegian University of Science and Technology

* Corresponding contributor: Goran.Lindahl@stri.se

