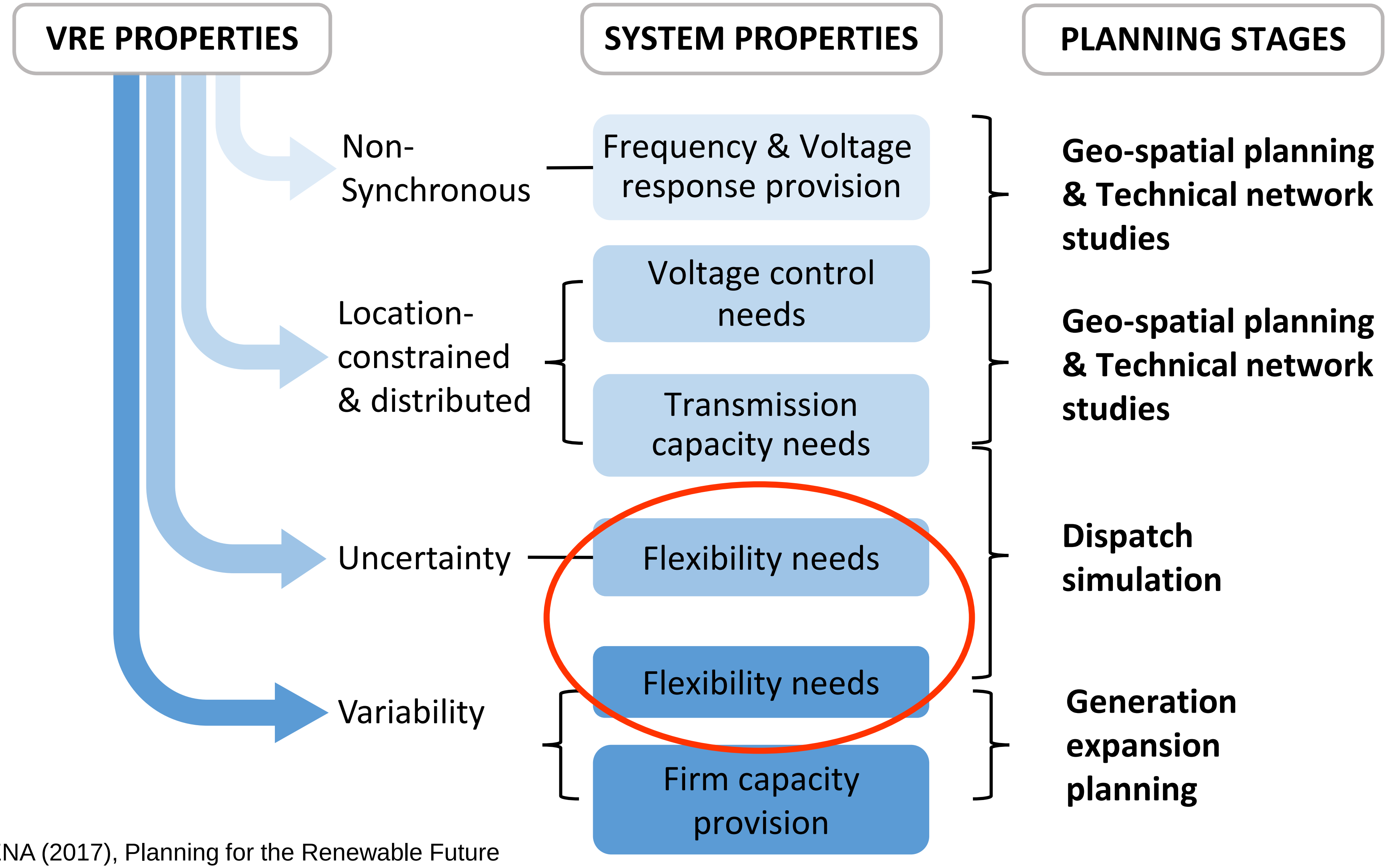
Session 5:
System Flexibility
Representation in energy planning models

Asami Miketa
Senior Programme Officer, Power Sector Investment Planning
IRENA Innovation and Technology Centre

23 April 2019

VRE in the planning process



Source: IRENA (2017), Planning for the Renewable Future

VRE: Long-term investment implications

	Generation	Networks
Adequacy	Firm capacity	Transmission capacity
Security	Flexibility	Voltage control capability
	Stability (frequency response and voltage response)	

High relevance

Flexibility impacts on the long-term planning

- **Desired capacity mix**
- **Flexibility investment**
- **Curtailment**

Non-technical sources of flexibility – market and institutional

IRENA
International Renewable Energy Agency

- Operational standards, grid code
- Appropriate market structure and organization including ancillary services
- VRE forecasting
- Power exchange scheme

→ typically inexpensive to be implemented

Main modelling solutions to better address flexibility under a high VRE scenario

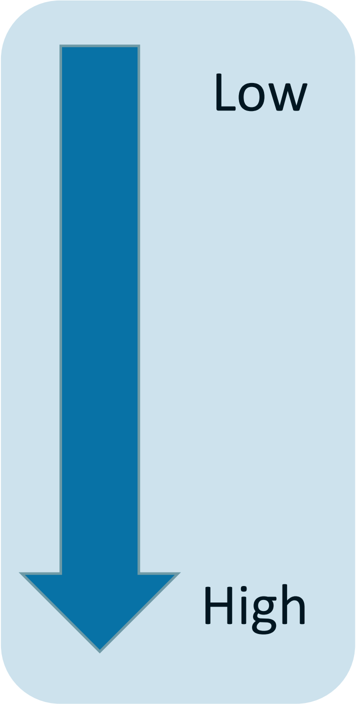
0. Increase temporal resolution (and improve the characteristics of the system flexibility)

1. Incorporating constraints on flexibility provision

2. Validating flexibility balance in a system

3. Coupling with production cost models

Complexity



Representing flexibility parameters

Parameters to represent **<u>supply</u>** of flexibility within an energy system

- Power generators
  - Ramp rate
  - Minimum load levels
  - Start-up times
  - Minimum up and down times

- Storage
- Interconnectors
- Demand response

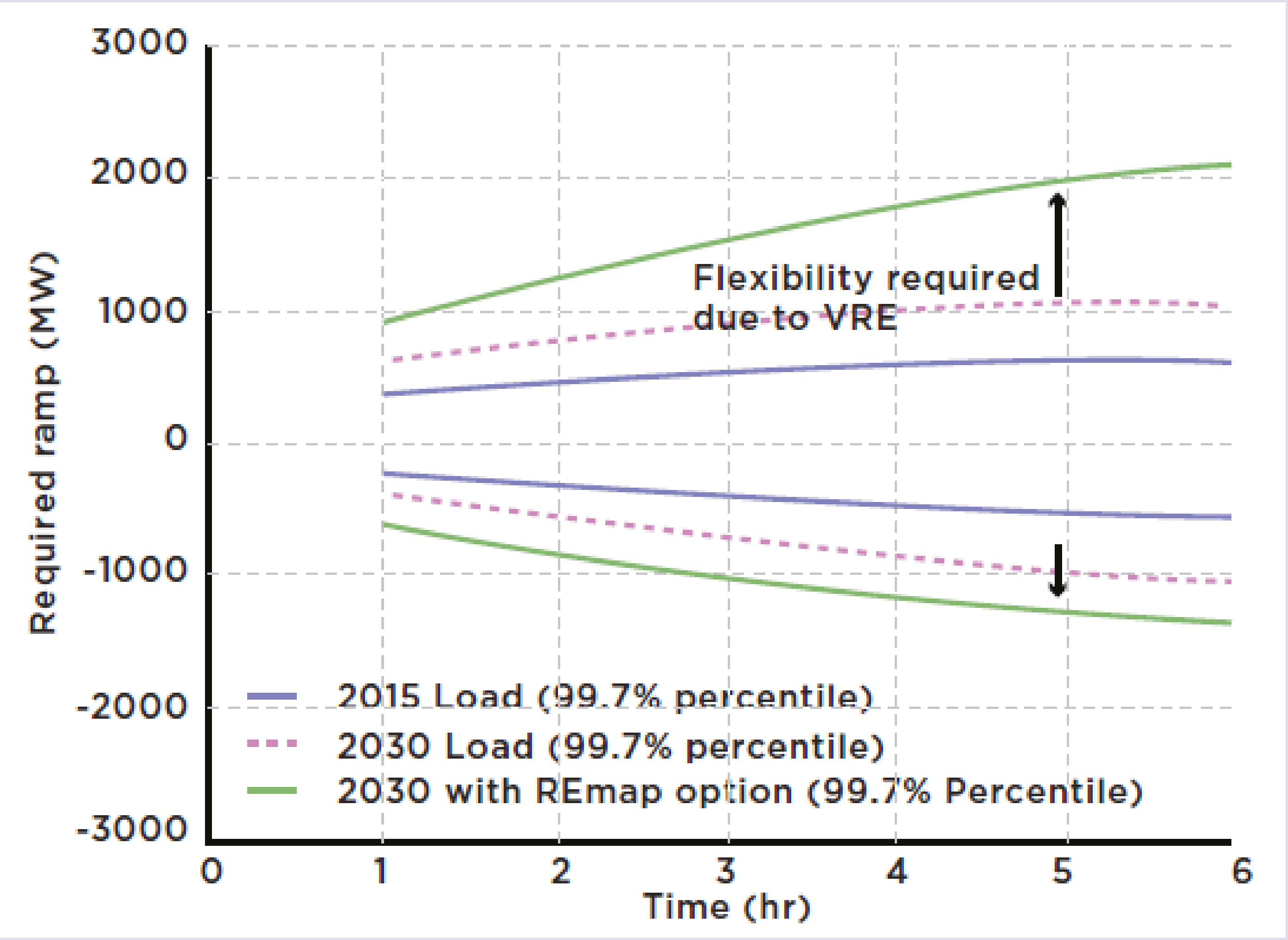
- Sector coupling (eg. Desalination)

Flexibility characteristics (from literature)

IRENA International Renewable Energy Agency

	Max ramp rate (% per min)	Start-up time (cold/hot) (hours)	Minimum load (%)	Min up/down time (hours)
Nuclear	0 – 10	24 – 50 / 0.3 – 48	40 – 100	6 – 48 / 4 – 48
coal	0.6 – 20	4 – 13 / 1 – 8	20 – 65	3 – 15 / 1 – 15
Solar CSP	4 – 8	NA / 1 – 4	20-30	
CCGT	0.8 – 15	0.5 – 5 / 0.1 – 3	15 – 53	1 – 6 / 1 – 6
OCGT	0.8 – 30	< 1 / 0.1 – 1	0 – 50	0 – 6 / 0 – 6
Pumped hydro	3.5		3.4	
Hydro reservoir	15 – 25	0 / < 0.1	5 – 6	

Flexibility needs assessment – ramping requirements



Case study on Dominican Republic (4.6 GW peak, 4.1 GW PV and wind)

Calculated based on chronological VRE generation and load data

1. Incorporating constraints on flexibility provision

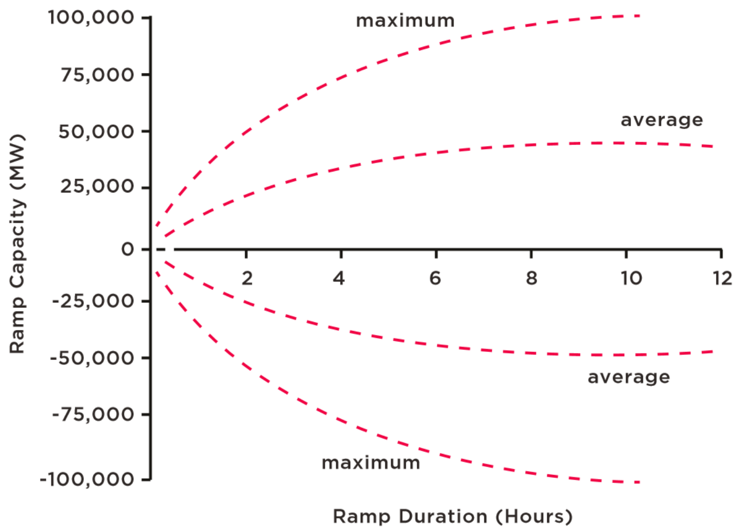
Provision ≥ Requirement

Flexibility from power plants

» Ramp rate
» Minimum load levels
» Partial load efficiency
» Start-up times
» Minimum down and up times

Other flexibility sources

» Storage
» Interconnectors
» Demand response
» Sector coupling



Source: King et al., 2011

Important to review and understand which sources of flexibility are included

→ If an important flexibility source is omitted, the model may produce unrealistic VRE curtailment, and sub-optimal investment decisions

Country application examples: Representing flexibility

- **Germany** (Ueckerdt et al., 2015): A **REMIND-D** model for Germany with a 100 year planning time horizon is developed in this study.
- **Flexibility coefficients are attributed to each generating technology** to represent the fraction of its generation that is considered to be flexible and the additional flexible generation that would be required for each unit of the technology's generation.
- **These coefficients are used in a flexibility constraint**, which demands flexibility requirements associated with load and VRE are met by flexibility provided by other generation technologies in the model.

- **Western United States** (Olsen et al., 2013): A comprehensive methodology is developed in this study to **assess future profiles of demand-response availability of 13 end-use loads** for the calendar year 2020.
- Annual load profiles are evaluated to obtain an estimate of the available demand-side amount to participate in flexibility provision in different ways – an energy and a capacity product, and three ancillary services – for each hour of that year. **The availability profiles that result serve as inputs to a production cost model.**
- This type of exercise can be useful for gauging the scale and characteristics of providing demand-side flexibility in a balancing approach.

2. Validating flexibility balance

Post-scenario assessment of flexibility in a system using specialized assessment tools

- Tier 1: **Tools with light data requirements**
  - Based on data such as the generation portfolio, interconnectors or other potential sources of flexibility
  - Require expert judgement
  - Examples: NREL System Evaluation, GIVAR (IEA)
- Tier 2: **Tools that calculate sufficiency of flexibility based on time series and more detailed unit data or based on a separate dispatch from an external tool**
  - Calculations performed in a spreadsheet without any type of optimisation
  - Examples: FAST2 (IEA), IRRE (IEA), INFLEXION (EPRI)
- Tier 3: **Tools based on dispatch models**
  - IRENA Flextool in this tier, including additionally a simplified capacity expansion problem
  - Other examples: FESTIV (NREL), RESOLVE (E3)

3. Coupling with production cost models

IRENA
International Renewable Energy Agency

Long-term capacity expansion models

- Capacity mix
- Dispatch schedule (not so detailed)

Capacity mix (↓)

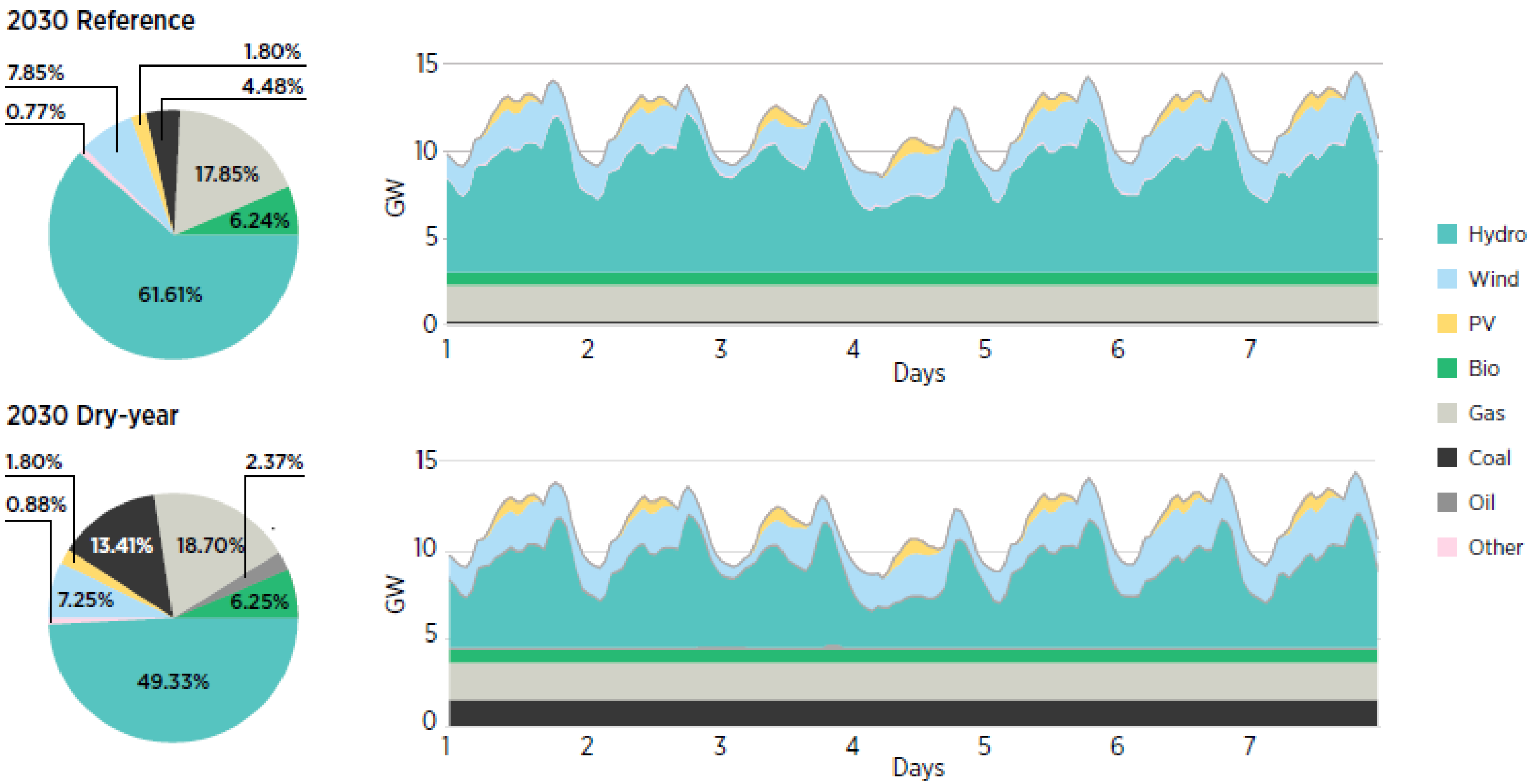
Capacity factor (plant utilization) (↑)

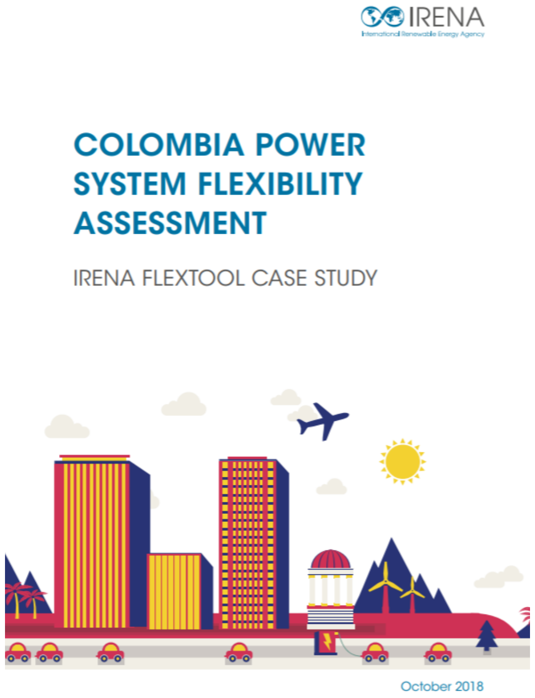
Production cost models

- Detailed dispatch analysis for a one (or several) years

- **Advanced approach…**
- **Requires significant time and resources**

IRENA Flextool: Validating flexibility balance



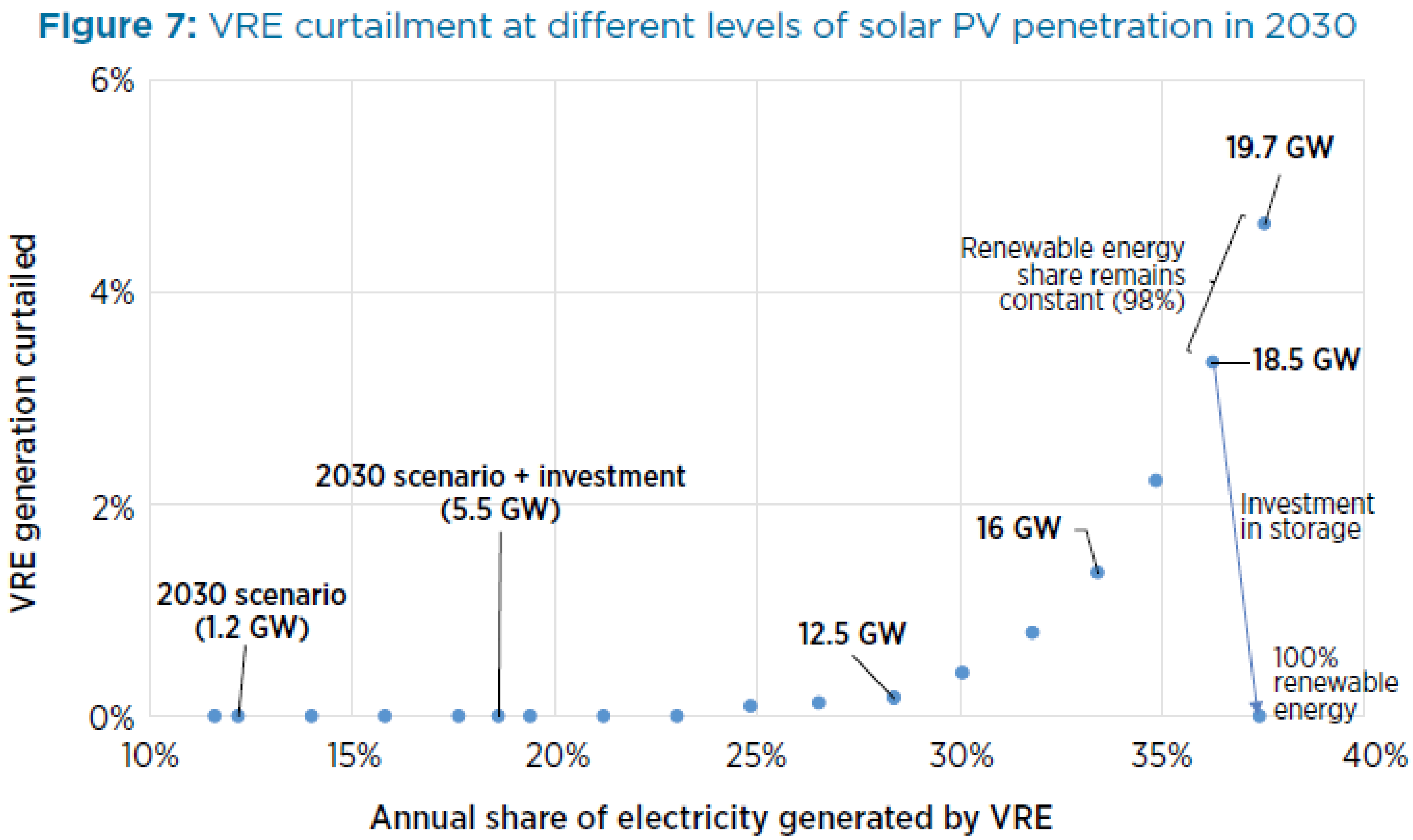


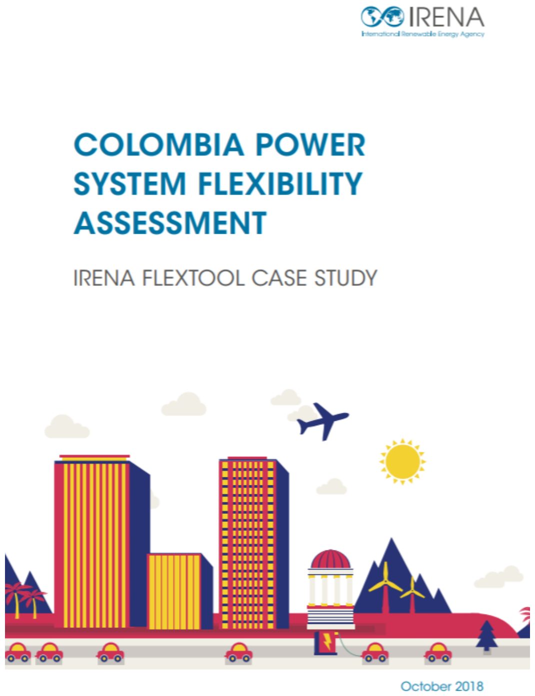
	2030 Reference		2030 Dry Year	
	Total (GWh)	Peak (MW)	Total (GWh)	Peak (MW)
Curtailment	0	0	0	0
Loss of load	0	0	0	0
Spillage	0	0	0	0
Reserves inadequacy	0	0	0	0

Note: These flexibility indicators are defined in IRENA (2018b).

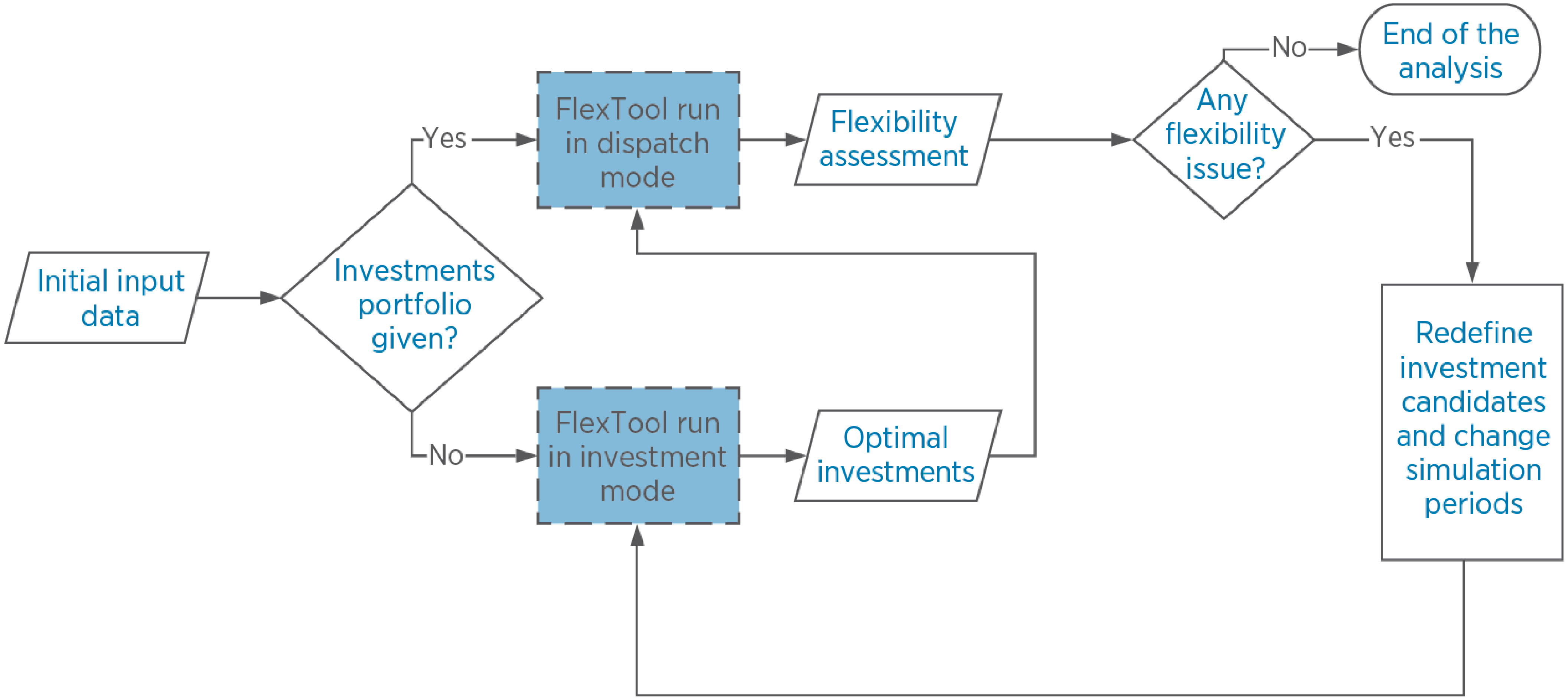
IRENA Flextool: Validating flexibility balance

IRENA
International Renewable Energy Agency

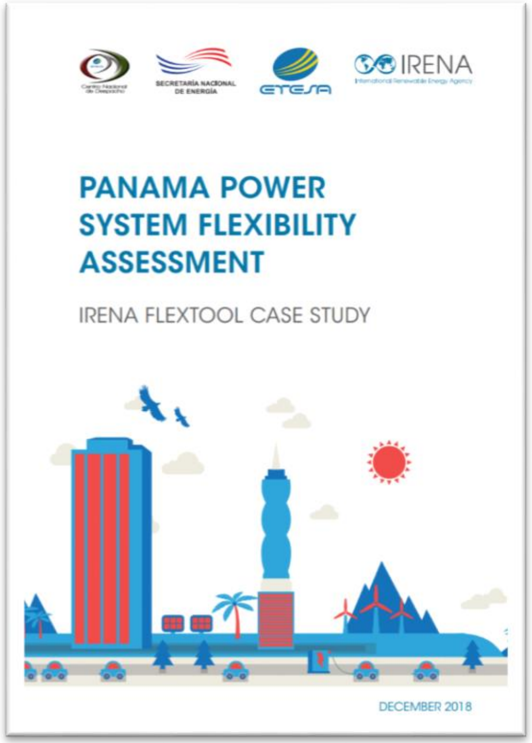


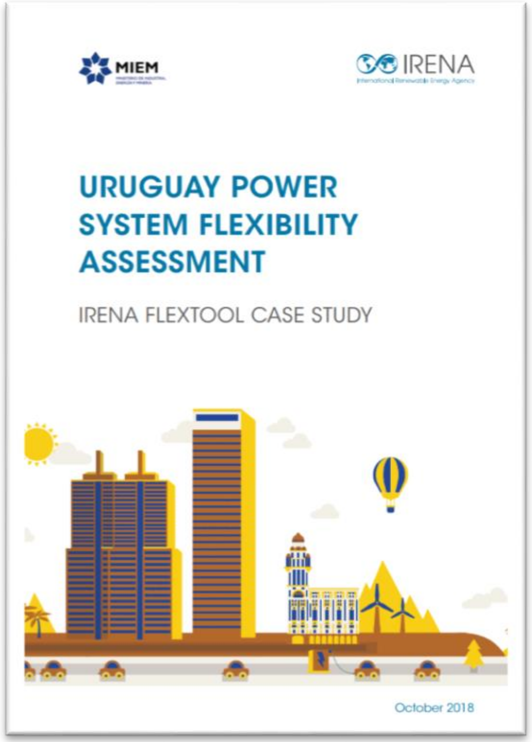


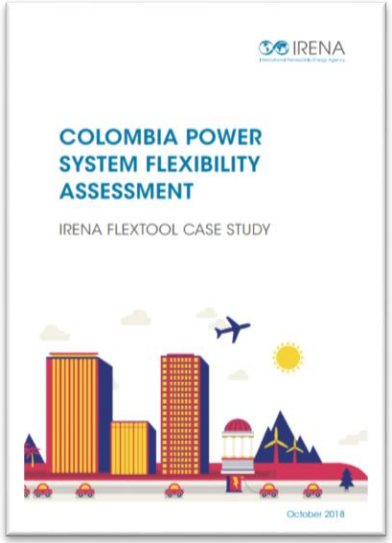
Finding flexibility solutions using IRENA Flextool

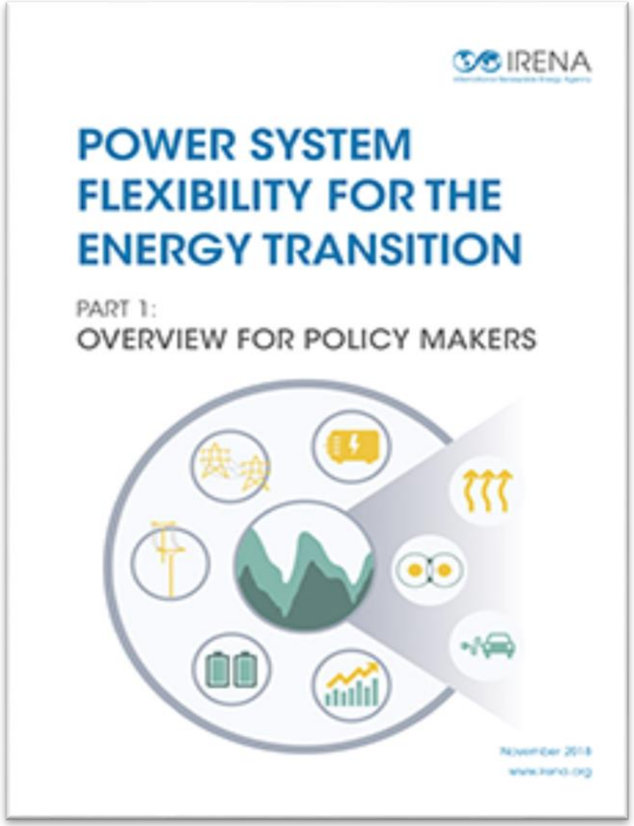


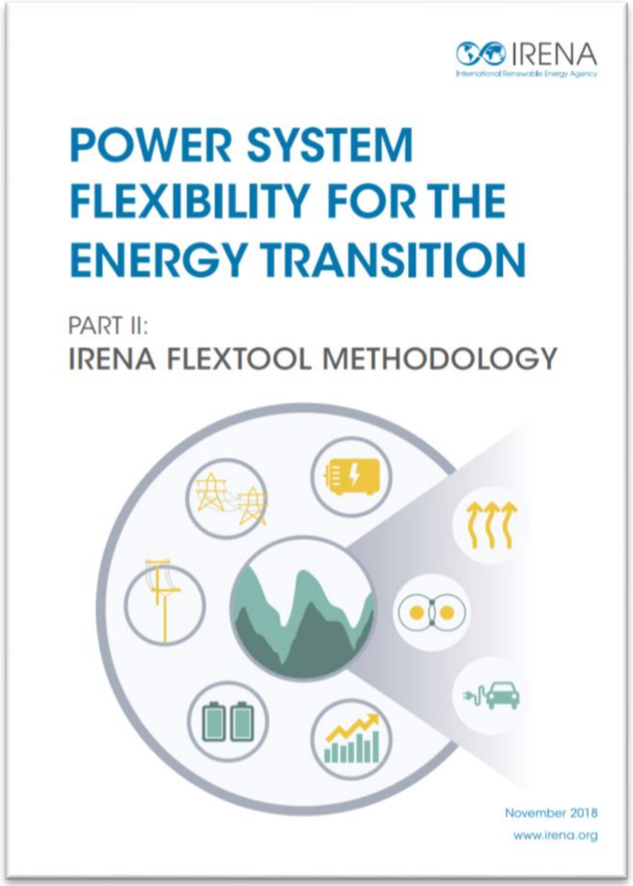
IRENA
International Renewable Energy Agency



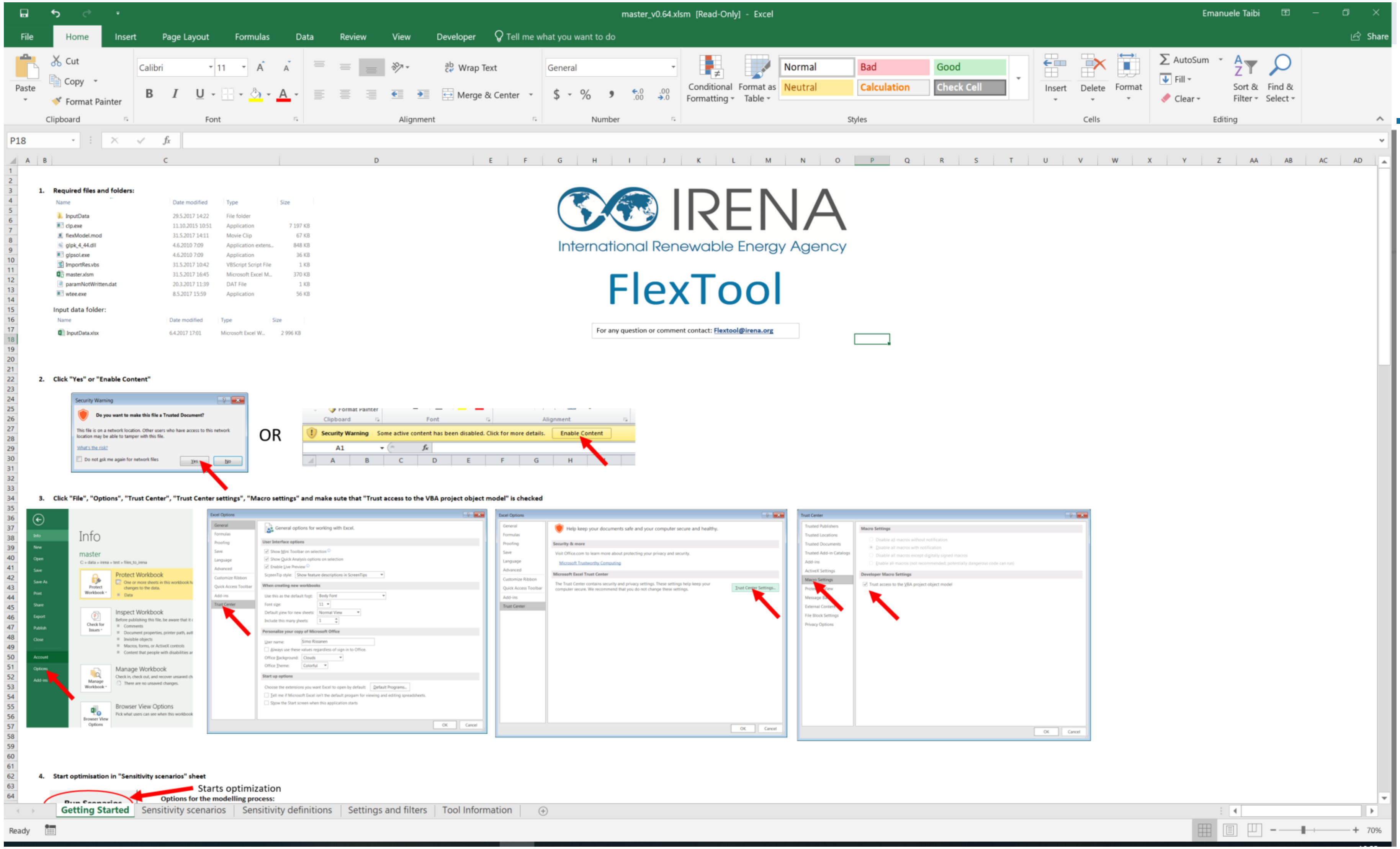








IRENA
International Renewable Energy Agency



http://irena.org/publications/2018/Nov/Power-system-flexibility-for-the-energy-transition

High-level modelling checkpoints

- Which of the non-technical (e.g. policy, regulation) constraints need tp be retained?
- To what extent are sources of flexibility represented?
  - Ramp rate
  - Minimum load levels
  - Start-up times
  - Storage
  - Interconnectors
  - Demand response
- Do we know flexibility needs?
- Do we have enough flexibility in the system?
- How much curtailment?

IRENA

International Renewable Energy Agency

Thank you!

irena

irena.org

irenaimages

irena

IrenaOrg

irenaimages

For discussion

For discussion: Flexibility

IRENA International Renewable Energy Agency

- Is the concept of the flexibility relevant to your country?
- How do you represent power system flexibility in your long-term planning process?
- Is a flexibility study performed to check long-term capacity results?
- How could you improve the representation of power system flexibility in your long-term planning process?
- Do you have the data/resources to perform a flexibility study? What are the barriers?