Network Flow Allocation: An Overview

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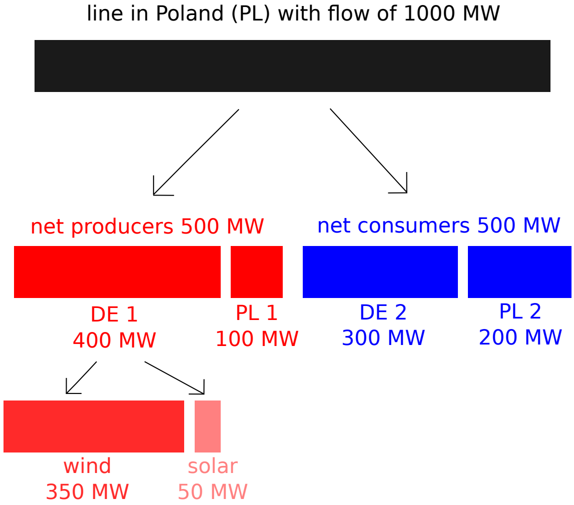
What is flow allocation?

Flow allocation refers to algorithms that assign the flow of power in electricity network assets (e.g. lines and transformers) to particular users (e.g. generators and consumers).

Source: Comillas EC report, 2002

What is flow allocation?

Flow allocation gives a **break-down** of the flow in each asset in terms of the network users.



Source: Brown et al, IET, 2014

What is flow allocation?

Different algorithms deliver **different results**, including:

- Assigning fractions of flow on each line to individual generators and consumers
- Assigning fractions of flow on each line to pairs of generators and consumers
- Matching consumers of power to generators of power via particular paths in the network
- Assigning fractions of flows to different groups, e.g. national vs. international, renewable vs. non-renewable

Some methods may not be suitable in certain circumstances, e.g. for HVDC lines or aggregated networks (principally because of cyclic flows).

What is flow allocation useful for?

Flow allocation can be used to **assign costs** to particular network actors of . . .

- operation and maintenance costs for existing network assets
- compensation for network losses
- new network assets
- grid connection charges for new generators
- redispatch
- international redispatch (multi-lateral remedial actions (MRAs))

Nota Bene: Most of these use cases would **not** be necessary in a market with **nodal pricing** at (partial) **equilibrium**. These use cases compensate for **imperfect market design**.

Flow allocation can also be used to increase understanding of the network, e.g. to increase public acceptance by seeing the source of network flows.

Where is flow allocation currently used?

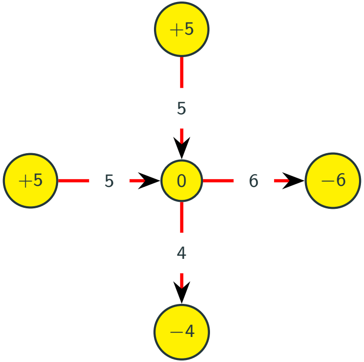
Commission Regulation (EU) No 838/2010 sets the terms for inter-TSO compensation (ITC) in Europe for costs incurred by cross-border flows ('transits') for

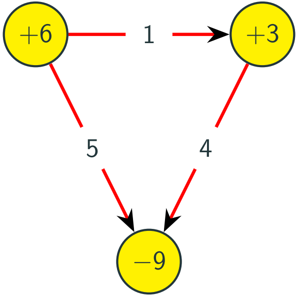
- **infrastructure usage** (total compensation limited to 100 million €/a until new metholodogy can be implemented; distributed today using transit-load factor 'postage stamp' method)
- **losses** (total compensation was 153 million € in 2015 (losses valued at around 50 €/MWh), assessed using With and Without Transit (WWT) method)

Flow allocation is also used around the world for cost allocation, e.g. in South America, the United States and Great Britain (where it's used for the G- and L-components of Transport Network Use of System (TNUoS)). German TSOs also examining using flow allocation for MRA cost-sharing.

Why flow allocation is non-trivial and non-unique

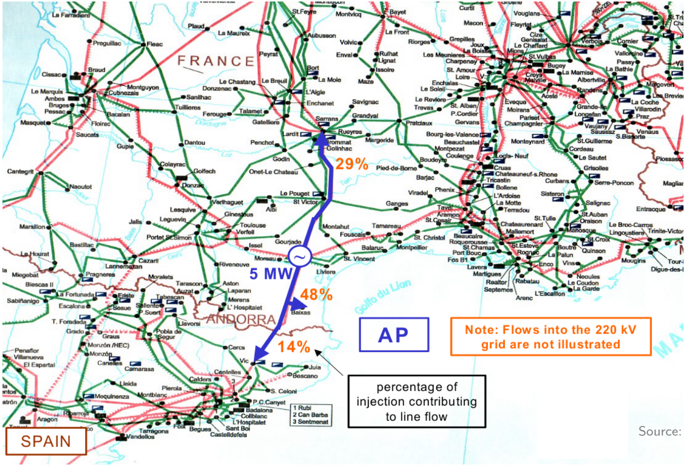
There is **no unique** way to do flow allocation. There are **ambiguities** both at network junctions and due to multiple paths through the network (i.e. closed cycles).





Why flow allocation is non-trivial and non-unique

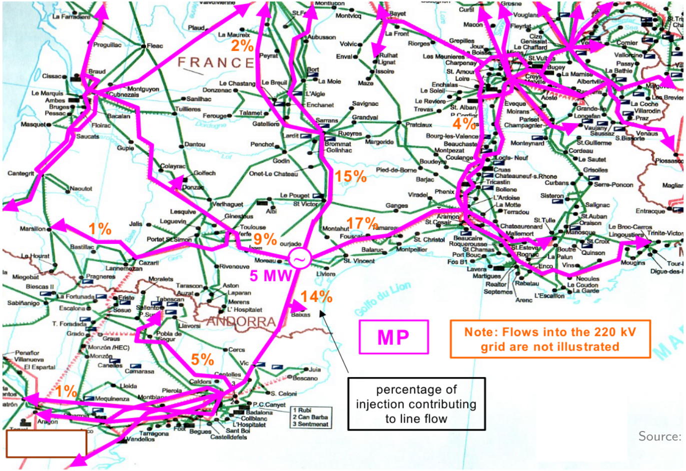
For example the Bialek **flow tracing method** (also called Average Participation (AP)) is like a "water flow" and stays relatively **localised**:



Source: CONSENTEC, Frontier EC report, 2006

Why flow allocation is non-trivial and non-unique

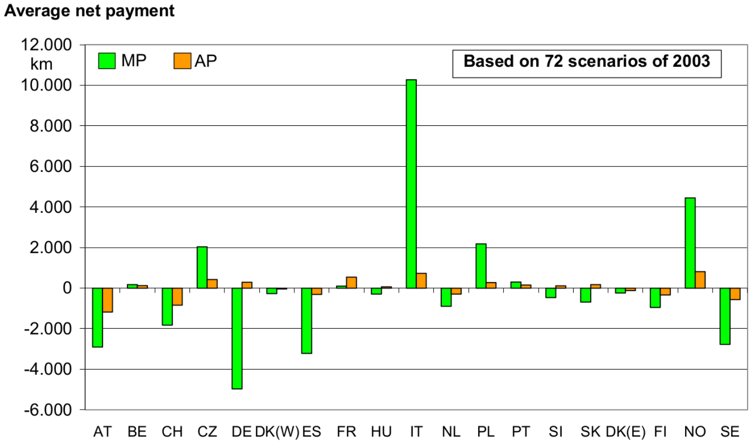
Whereas the **power-flow-sensitivity method** (also called Marginal Participation (MP)) sees effects from nodes **across the network**:



Source: CONSENTEC, Frontier EC report, 2006

Why flow allocation is non-trivial and non-unique

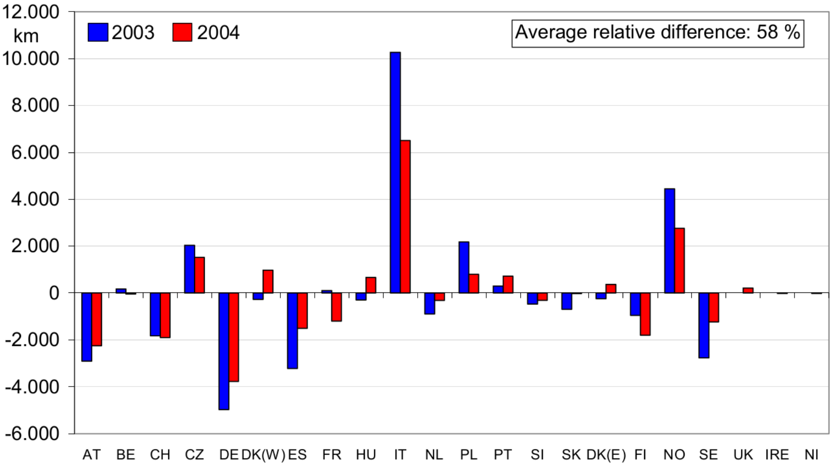
This results in **very different** assessments of the amount of compensation due to each European country for **transit flows** from other countries (AP versus MP for 2003):



Source: CONSENTEC, Frontier EC report, 2006

Why flow allocation is non-trivial and non-unique

They are also **unstable** from year to year (example of MP for 2003 and 2004):



Source: CONSENTEC, Frontier EC report, 2006

Why flow allocation is non-trivial and non-unique

Therefore it is **no wonder** that in the 7 years since Commission Regulation (EU) No 838/2010, there has been **no agreement** on a new methodology for inter-TSO compensation.

Private quotation from Midcontinent Independent System Operator (MISO) employee:
"Flow allocation is the **single most contentious subject** I've ever encountered".

So: **How to proceed?**

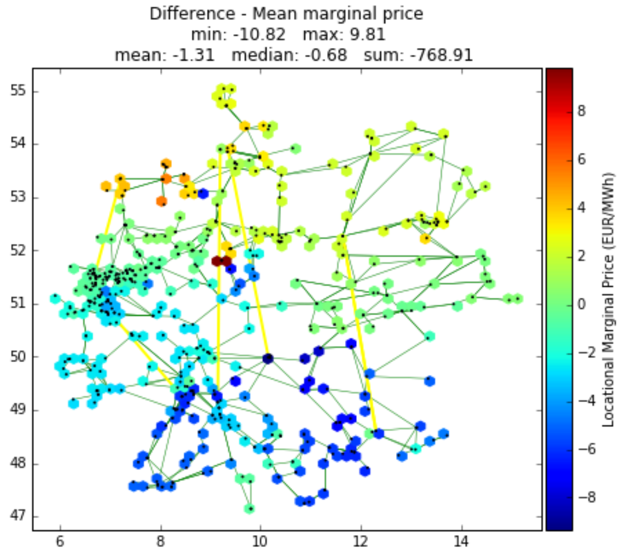
NET-ALLOK: Towards new methods

In the NET-ALLOK project we will not just evaluate existing methods, but also develop **new methods**. These will use both physics and the **(re)distribution of social welfare**, i.e. identifying those consumers and generators who profit from particular infrastructure.

This is in line with existing methods for assessing new projects and new market designs, and should be compatible with **long-term efficiency**.

In the second half of the project, the consequences for short-term operation and long-term investment decisions will be examined.

NET-ALLOK: Towards new methods



Example: the introduction of new HVDC corridors in Germany would cause an increase in average prices in the North and a decrease in the South **if** Germany had nodal pricing.

Generators in the North and consumers in the South profit from this.

This can be used as a geographical key for distributing the costs of the new transmission lines to those who benefit most from them.

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