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Adapting water distribution networks to uncertain futures through a phased design approach

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There is a great challenge to identify adequate solutions for the design of water distribution networks (WDNs) mainly because these are large scale infrastructures that have to be planned and managed under uncertainty for a long planning horizon. The uncertainty related with the imperfect knowledge of future is a central issue to be deal with by new tools, based on phased approaches, allowing water utilities to plan short term upgrades, which aim at guarantying high standard network performances while keeping in mind the long term planning.
This work proposes a new decision aid tool based on multi-criteria decision analysis (MCDA) to find and help to select adequate solutions to WDNs design. This is performed by following 5 main steps. In the first step, a set of future demand scenarios is generated considering a planning horizon divided into phases (in the beginning of each phase, the WDN can be upgraded, if needed). In the second step, alternative option for the networks design are built, taking into account hydraulic compatibility. In the third step they are evaluated for all the demand scenario generated and all phases, using criteria previously defined (economic, environmental and hydraulic performance). After the alternatives and criteria are determined, the fourth step entails proposing weights to criteria. These weights are stated for giving the relative importance to criteria at specific phases of the planning horizon. Finally in the fifth step, the alternatives are ranked by a MCDA method (Mareschal and De Smet, 2009) to identify the best ranked solutions to implement according to different weights ascribed to criteria.
This approach was applied to a case study proposed by Fujiwara and Khang (1990) composed by a single reservoir, 34 pipes and 31 nodes to find the alternative solutions for the phased design of this network. Afterwards, the MCDA method was used to identify the best design alternatives to adopt according to criteria and weights.
The analysis of the solutions makes it possible to understand how weights ascribed to criteria at different phases (in the initial or in final phases) influences the best positioned design solutions to adopt.

Fujiwara, O., and Khang, D. B. (1990). A two-phase decomposition method for optimal design of looped water distribution networks. Water Resources Research, 26(4), 539–549.
Mareschal, B. and De Smet, Y. (2009). Visual PROMETHEE: Developments of the PROMETHEE & GAIA multicriteria decision aid methods. In Industrial Engineering and Engineering Management, 2009. IEEM 2009. IEEE International Conference (pp. 1646–1649).