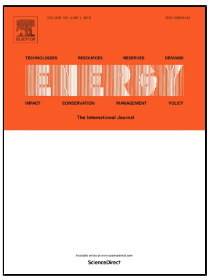
Accepted Manuscript



A Two-Stage Reactive Power Optimization in Transmission Network Incorporating Reserves from Voltage-Dependent Loads

Hongyang Jin, Zhengshuo Li, Hongbin Sun, Qinglai Guo, Bin Wang

PII:	S0360-5442(18)30937-X
DOI:	10.1016/j.energy.2018.05.112
Reference:	EGY 12947
To appear in:	*Energy*
Received Date:	08 January 2018
Accepted Date:	16 May 2018

Please cite this article as: Hongyang Jin, Zhengshuo Li, Hongbin Sun, Qinglai Guo, Bin Wang, A Two-Stage Reactive Power Optimization in Transmission Network Incorporating Reserves from Voltage-Dependent Loads, *Energy* (2018), doi: 10.1016/j.energy.2018.05.112

A Two-Stage Reactive Power Optimization in Transmission Network Incorporating Reserves from Voltage-Dependent Loads

Hongyang Jin [1], Zhengshuo Li [2], Hongbin Sun [1*], Qinglai Guo [1], Bin Wang [1]

[1] Department of Electrical Engineering, Tsinghua University, Beijing, China

[2] Smart Grid and Renewable Energy Laboratory, Tsinghua-Berkeley Shenzhen Institute (TBSI), Shenzhen, Guangdong, China

[*]shb@tsinghua.edu.cn

ARTICLE INFO

Key words:

Voltage dependent load

Reactive power optimization

Two-stage optimization

Fast reserve

ABSTRACT

With the integration of intermittent resources, more reserves are required for uncertainties. Traditionally, reactive power optimization in transmission network focuses on loss minimization problems, regarding loads as voltage-independent injections. In fact, the bus voltage magnitude affects the load active/reactive injection, providing a possibility for system operators to regulate the power of loads through voltage regulation. Inspired by this inherent feature of loads, this paper considers the regulation of voltage-dependent loads (VDLs) for fast reserves through reactive power optimization and voltage control under the coordination of transmission and distribution networks. A two-stage multi-objective optimal power flow model is developed to incorporate reserves from VDLs. The first stage is to optimize the minimization of losses and the maximization of the reserves that the VDLs can provide, which is modeled as an AC optimal power flow problem. In the second stage, it is verified whether the reserves from the first stage can be delivered by voltage regulation to settle down the possible imbalance power in the power system. Case studies show that the proposed method can estimate the amount of reserves from VDLs and optimize the bus voltages accordingly.

Nomenclature

Indices and Sets:

i, j	Index of the buses.
r	Index of iterations
Bus	Set of bus indices
$\boldsymbol{\Omega}_1$	Set of constraints in first level optimization
$\boldsymbol{\Omega}_2$	Set of constraints in second level optimization
$\boldsymbol{\Omega}_3$	Set of constraints in third level optimization

Variables

$\boldsymbol{y}$	Variable of the first level optimization (also the variable of the master problem, i.e. **MP**)
$\mathcal{P}$	Variable of the second level optimization (also part of the variable in the slave problem, i.e. **SP**)
$\boldsymbol{x}$	Variable of the third level optimization (also part of the variable in the **SP**)
V_i	Set value of the voltage magnitude at bus i
P_i^L , Q_i^L	Active/ Reactive load under V_i at bus i
ΔP_i^L	Incremental value of P_i^L
ΔQ_i^L	Incremental value of Q_i^L
ΔV_i	Incremental value of V_i
rh_i^{RVDL}	Positive reserve from the VDLs at bus i
rl_i^{RVDL}	Negative reserve from the VDLs at bus i
P_i , Q_i	Active/reactive power injection of bus i
P_i^{Gen}	Total active power injection of the generators that connected to bus i
Q_i^{Gen}	Total reactive power injection of the generators that connected to bus i

[*]Corresponding author. Present address: Department of Electrical Engineering, Tsinghua University, Rm. 3-120, West Main Building, Tsinghua University, 100084, Beijing, China. Tel.: +86 137 0107 3689; Fax: +86 10 6278 3086 – 800. E-mail address: shb@tsinghua.edu.cn.