International Symposium

Renewables Integration into the Japanese Power Grid by 2030

Blackout and Protection System in Hokkaido

17 Dec, 2018

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Blackout in Hokkaido, Japan

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The first blackout in Japan occurred on September 6th (2018) in Hokkaido Area due to the earthquake.

Trip of 7 equipment by earthquake

- three thermal generators (coal)
- four transmission lines (by short circuit fault)

(separation of eastern part of the system, and many hydro generators included in the area were stopped.)

Almost half of power supply was lost.

Overview of Blackout in Japan

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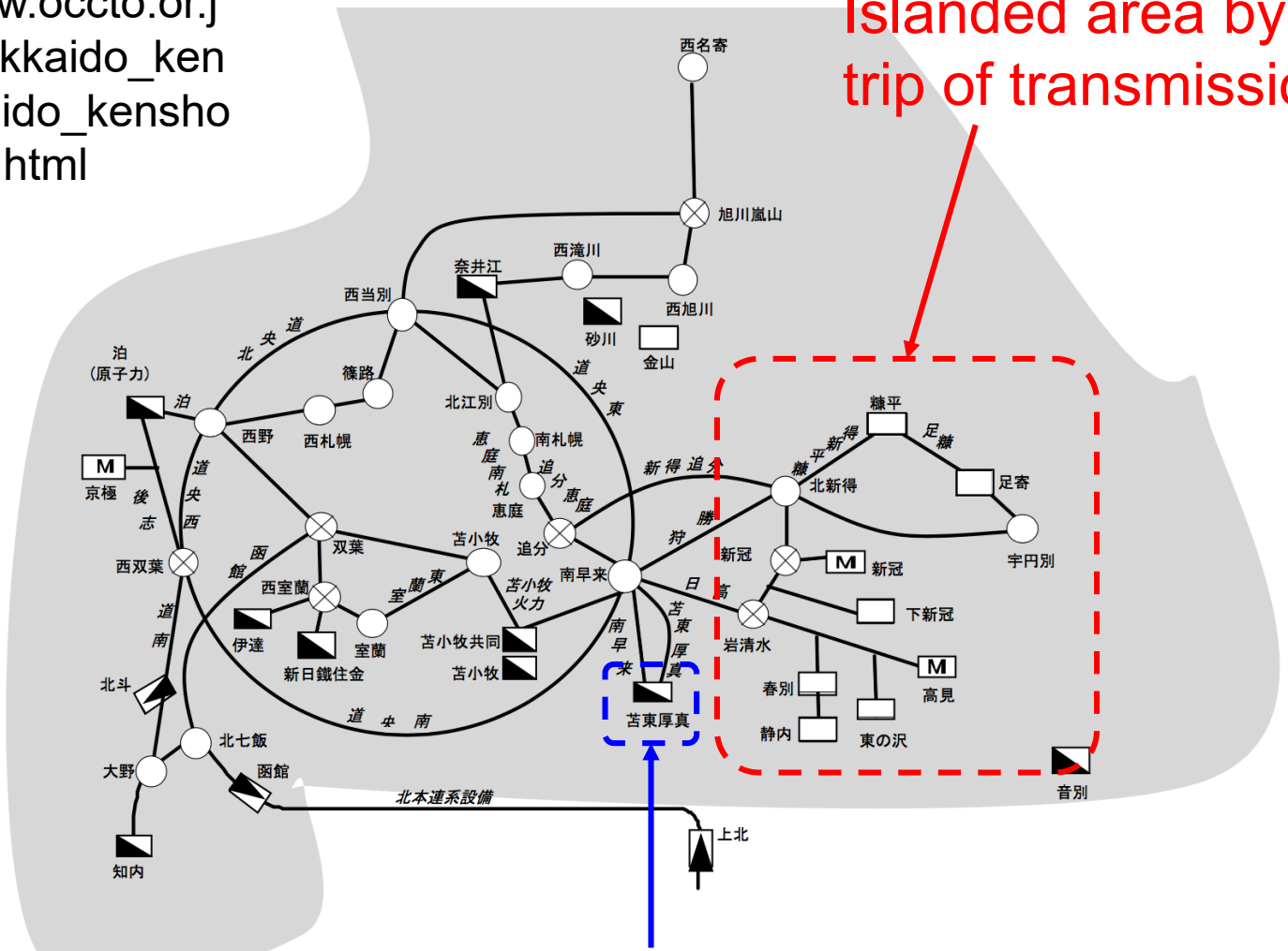
https://www.occto.or.jp/iinkai/hokkaido_kensho/hokkaido_kensho_1_shiryo.html



Frequency Drop

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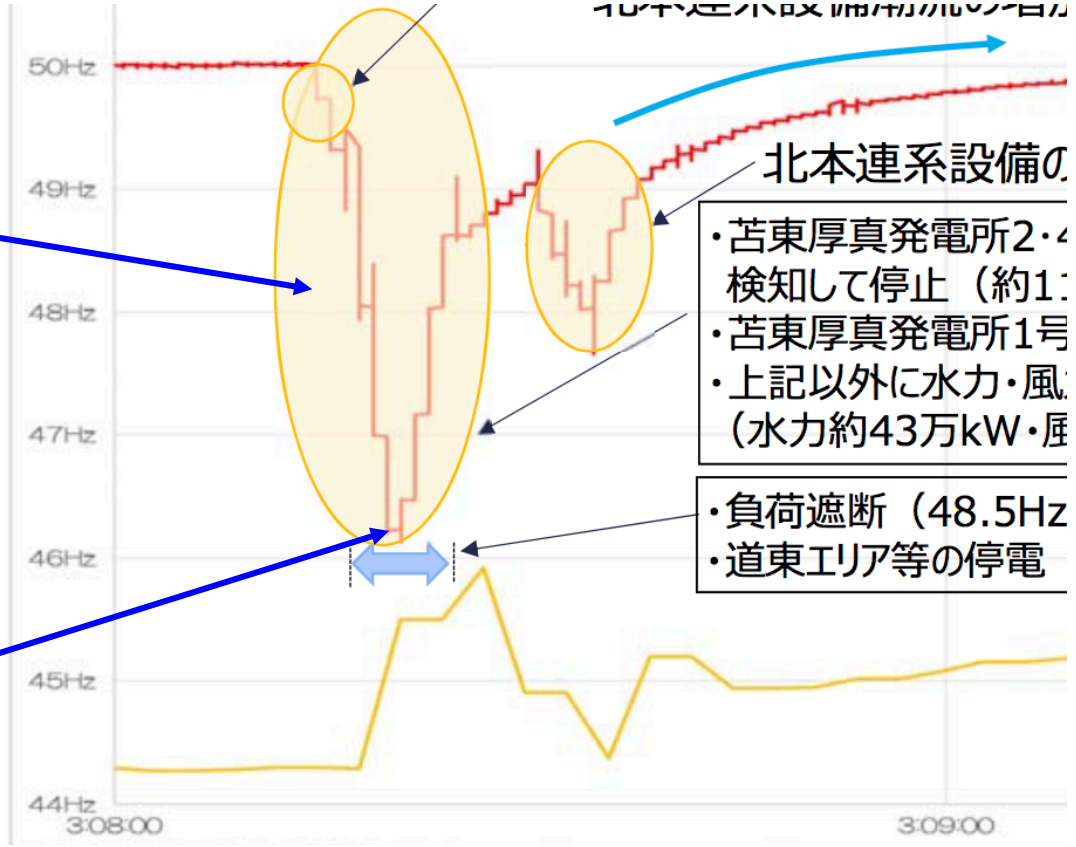
serious frequency drop caused by the trip of two thermal generators and many hydro generators.



Frequency started to restore at this point due to

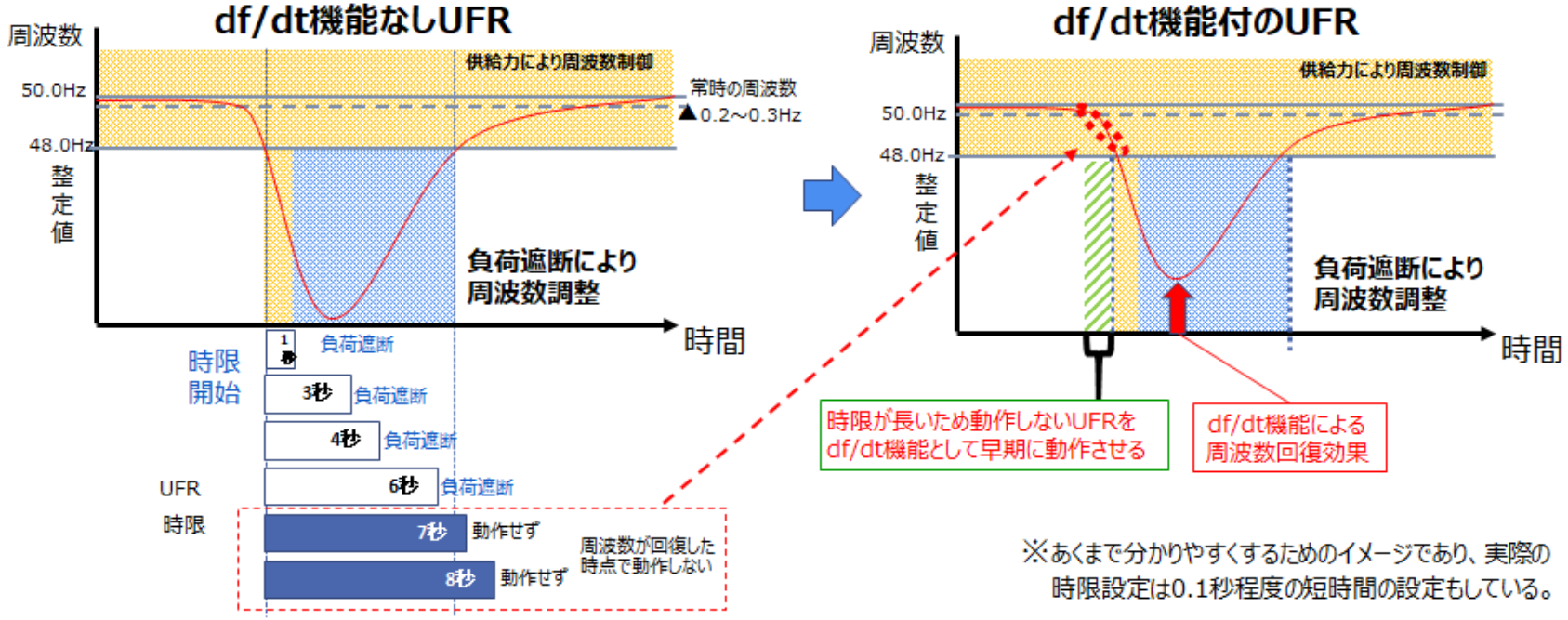
- Emergent control of DC connection (500MW)
- Load shedding by under frequency relays (1460MW)

→ frequency nadir was 46.1 Hz

（参考）周波数低下リレー（UFR）の仕組み

- 周波数低下リレー（UFR）は、大規模な電源脱落等により大幅に周波数が低下する稀頻度リスクに対応して、供給力（発電側）で周波数を制御できる範囲にまで負荷遮断することで周波数を回復させる緊急的な措置を実施する。
- 周波数低下による連鎖的な電源トリップや停電を防ぐため、何段階かの時限を設定し、それぞれの時限で周波数の整定値まで回復しなければ順次負荷遮断、周波数の整定値まで回復した時点で負荷遮断は止まる仕組み。
- df/dt機能付UFRは、上記仕組みに加えて周波数の急激な低下を周波数変化率で検出し、早期の負荷遮断が実施できる。（北海道電力では、UFR更新に合わせ同機能の導入を開始しており今回のシミュレーションでは整定完了分約１割を反映する。）⇒スライド63

周波数低下リレー（UFR）の仕組み＜イメージ例＞



※あくまで分かりやすくするためのイメージであり、実際の時限設定は0.1秒程度の短時間の設定もしている。

出典：http://www.occto.or.jp/iinkai/hokkaido_kensho/hokkaido_kensho_4_shiryo.html

Countermeasures for the future

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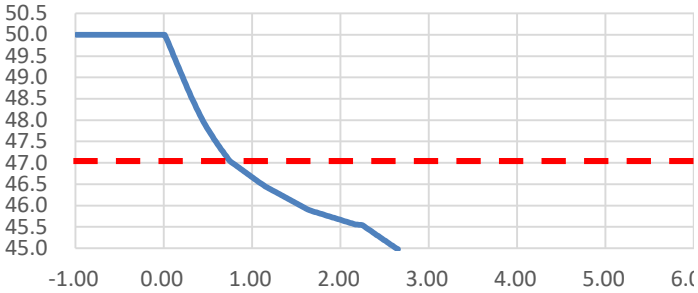
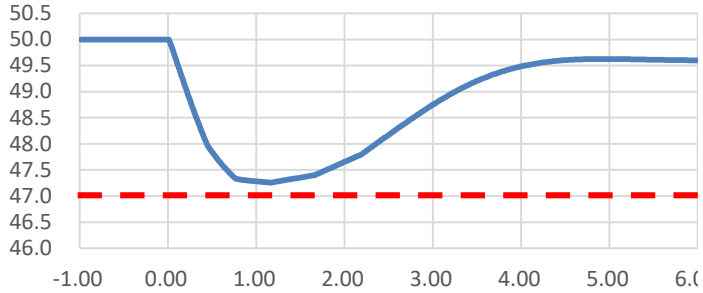
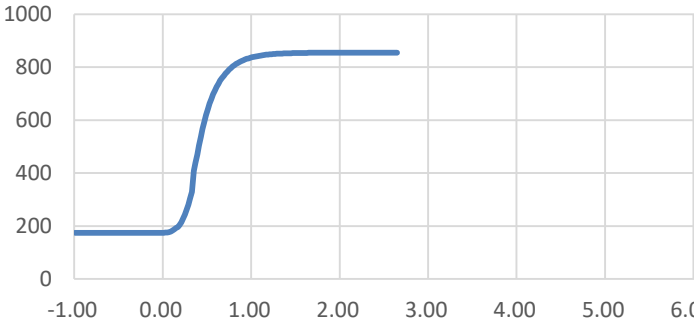
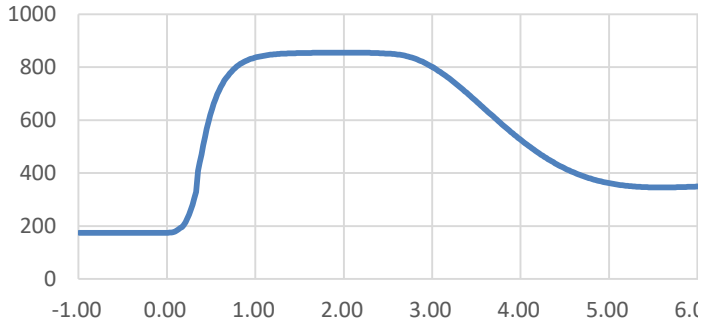
Frequency (Hz)





DC power flow to Hokkaido (MW)





without df/dt relays

with df/dt relays

It is shown in the final investigation committee that blackout could be avoided even with Tomari Nuclear Power Station by applying df/dt relays to more UFR (for load shedding)

出典：http://www.occto.or.jp/iinkai/hokkaido_kensho/hokkaido_kensho_4_shiryo.html
より図面を引用

Discussions

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- Protection system was a “key” to avoid the blackout.
- Application of much more “df/dt relays” to UFR, or “centralized stabilization system” is being discussed for the future.
- Frequency behavior after disturbance depends on changing inertia and FFR from various resources.

What is the ideal protection system in the future considering the cooperation with VRES ?

Operation before the blackout

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Total demand : 3087 MW

Thermal generation :

Naie-1 (Coal) 61MW / 175MW

Date-2 (Oil) 76MW / 350MW

Tomato Atsuma-1 (Coal) 338MW / 350MW

Tomato Atsuma-2 (Coal) 556MW / 600MW

Tomato Atsuma-4 (Coal) 598MW / 700MW

Shiriuchi-1(Oil) 96MW / 350MW

Trip just before the blackout

Hydro generation : 780MW

Wind generation : 166MW / 319MW

Trip right after the earthquake (430MW of hydro, and all the wind)

DC power flow (to Hokkaido) : 72MW / 600MW

Overview of Blackout

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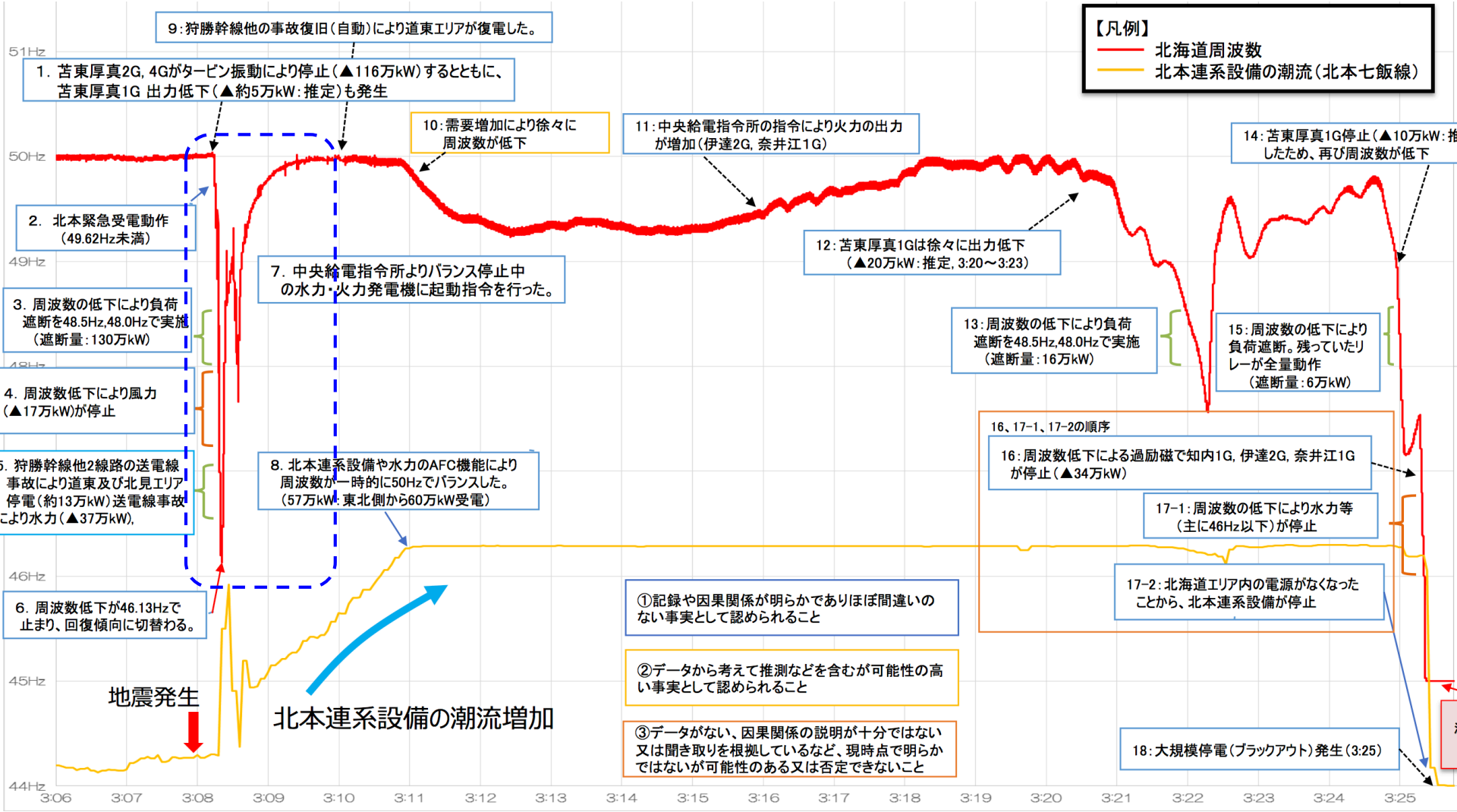

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