Tokyo Lights Africa 2011

Digital Grid in Africa for Innovative Future of Electricity

Professor
Rikiya ABE

18, November. 2011

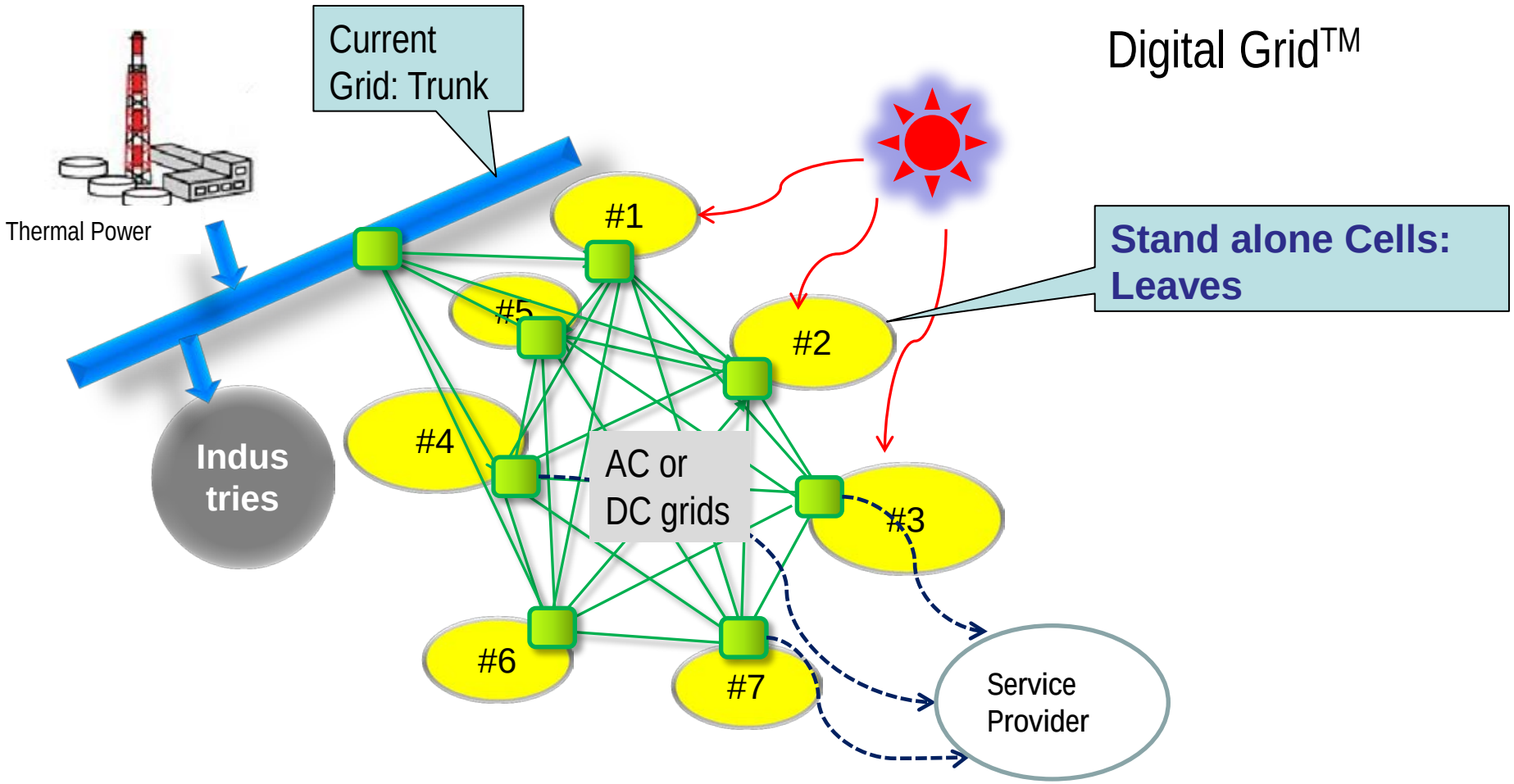
School of Engineering, Graduate Course of
Technology Management for Innovation

THE UNIVERSITY OF TOKYO
Advantage Partners

Socio-Strategic
Engineering/
Investment
Laboratory

- ✓ Digital Grid is the future of electric grid beyond Smart Grid.
- ✓ Small standalone cell grids will be independent in the beginning, then asynchronously connected each other.
- ✓ Main grid is like a trunk in a tree with traditional power generation, and cell grids are like leaves with a lot of renewable generations.
- ✓ These structure will compose new electrical grid system.
- ✓ Africa will be a test bed of this structure.
- ✓ Africa is treasury land in terms of renewable energy.

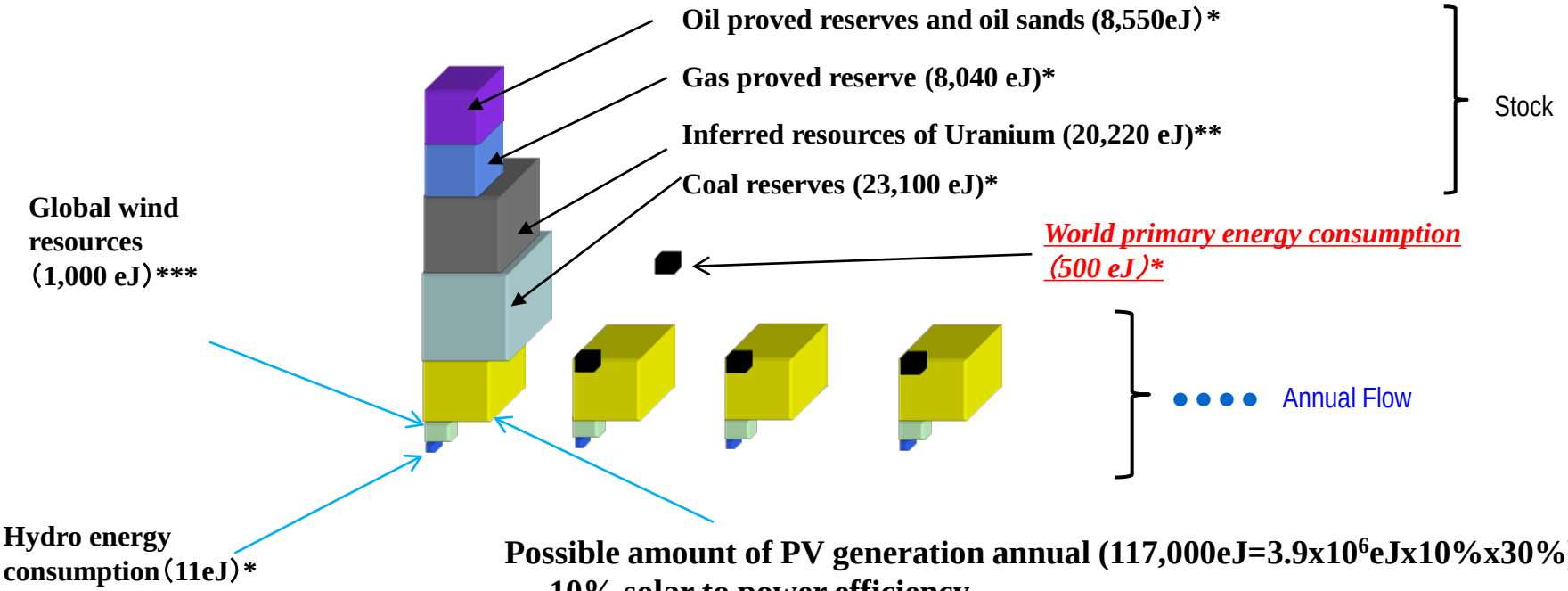
Trunk and leaves with sun-shine



Shift from Fossil to Renewable Energy

Is this possible?

Solar Potential



Possible amount of PV generation annual (117,000eJ=3.9x10^{6}eJx10%x30%)
- **-10% solar to power efficiency**
- **-10% of land area**

* : BP world energy 2009
** : OECD nuclear energy data 2008
*** : World energy council survey of energy resources 2007
eJ : exajoule (10^18 J)

PV Myth: Solar electricity cannot serve any significant fraction of US or world electricity needs.

THE UNIVERSITY OF TOKYO Advantage Partners | Socio-Strategic Engineering/ Investment Laboratory

Technologies

Concentrating Solar Power

Photovoltaics
- Why PV is Important
- PV Basics
- PV in Use
- Research & Development
- For Builders
- For Consumers
- - Decision-making Tools
- - So You Want PV on Your Roof...
- - PV Quick Facts
- - PV Myths

Solar Heating

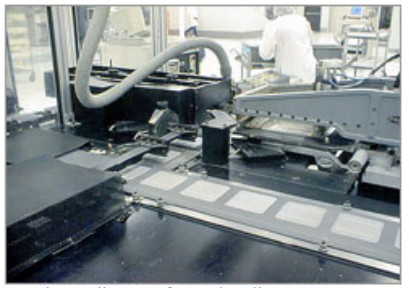
Solar FAQ

Solar Timeline

Printable Version

Learning About PV: The Myths of Solar Electricity

Solar electricity, or photovoltaics (PV), is a thriving business worldwide. It makes good on its promise of "delivering clean, reliable, on-demand power."



A solar cell manufacturing line.

Research progress continues, better positioning current and next-generation photovoltaic (PV) technologies to meet future electricity needs. But these successes seem to spark some criticisms and questions. Some are warranted. Some are based on partial truths. And others are perpetuated from urban legends or myths about the technology.

Common among these criticisms and questions are the seven myths of solar electricity:

- Myth 1: Solar electricity cannot serve any significant fraction of U.S. or world electricity needs.
- Myth 2: Solar electricity can do everything — right now!
- Myth 3: Photovoltaics cannot significantly offset environmental emissions.
- Myth 4: Photovoltaics is a polluting industry.
- Myth 5: Photovoltaics is merely a cottage industry, appealing only to small niche markets.
- Myth 6: PV is too expensive and will never compete with "the big boys" of power generation. Besides, you can never get the energy out that it takes to produce the system.
- Myth 7: Nothing remains to be done. Essential R&D is complete, the product works — just close the laboratory doors and let industry fight it out.

Myth 1: Solar electricity cannot serve any significant fraction of U.S. or world electricity needs.

PV technology can meet electricity demand on any scale. The solar energy resource in a 100-mile-square area of Nevada could supply the United States with all its electricity (about 800 gigawatts) using modestly efficient (10%) commercial PV modules.

A more realistic scenario involves distributing these same PV systems throughout the 50 states. Currently available sites—such as vacant land, parking lots, and rooftops—could be used. The land requirement to produce 800 gigawatts would average out to be about 17 x 17 miles per state. Alternatively, PV systems built in the "brownfields"—the estimated 5 million acres of abandoned industrial sites in our nation's cities—could supply 90% of America's current electricity.

http://www1.eere.energy.gov/solar/myths.html

The solar energy resource in a 100-mile-square area of Nevada could supply the United States with all its electricity (about 800 GW) using modestly efficient (10%) commercial PV modules.

jic

Technologies

Concentrating Solar Power

Photovoltaics
- Why PV is Important
- PV Basics
- PV in Use
- Research & Development
- For Builders
- For Consumers
- - Decision-making Tools
- - So You Want PV on Your Roof...
- - PV Quick Facts
- - PV Myths

Solar Heating

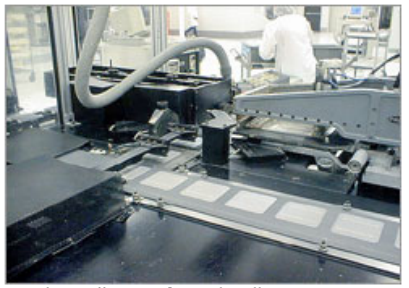
Solar FAQ

Solar Timeline

Printable Version

Learning About PV: The Myths of Solar Electricity

Solar electricity, or photovoltaics (PV), is a thriving business worldwide. It makes good on its promise of "delivering clean, reliable, on-demand power."



A solar cell manufacturing line.

Research progress continues, better positioning current and next-generation photovoltaic (PV) technologies to meet future electricity needs. But these successes seem to spark some criticisms and questions. Some are warranted. Some are based on partial truths. And others are perpetuated from urban legends or myths about the technology.

Common among these criticisms and questions are the seven myths of solar electricity:

- Myth 1: Solar electricity cannot serve any significant fraction of U.S. or world electricity needs.
- Myth 2: Solar electricity can do everything — right now!
- Myth 3: Photovoltaics cannot significantly offset environmental emissions.
- Myth 4: Photovoltaics is a polluting industry.
- Myth 5: Photovoltaics is merely a cottage industry, appealing only to small niche markets.
- Myth 6: PV is too expensive and will never compete with "the big boys" of power generation. Besides, you can never get the energy out that it takes to produce the system.
- Myth 7: Nothing remains to be done. Essential R&D is complete, the product works — just close the laboratory doors and let industry fight it out.

Myth 1: Solar electricity cannot serve any significant fraction of U.S. or world electricity needs.

PV technology can meet electricity demand on any scale. The solar energy resource in a 100-mile-square area of Nevada could supply the United States with all its electricity (about 800 gigawatts) using modestly efficient (10%) commercial PV modules.

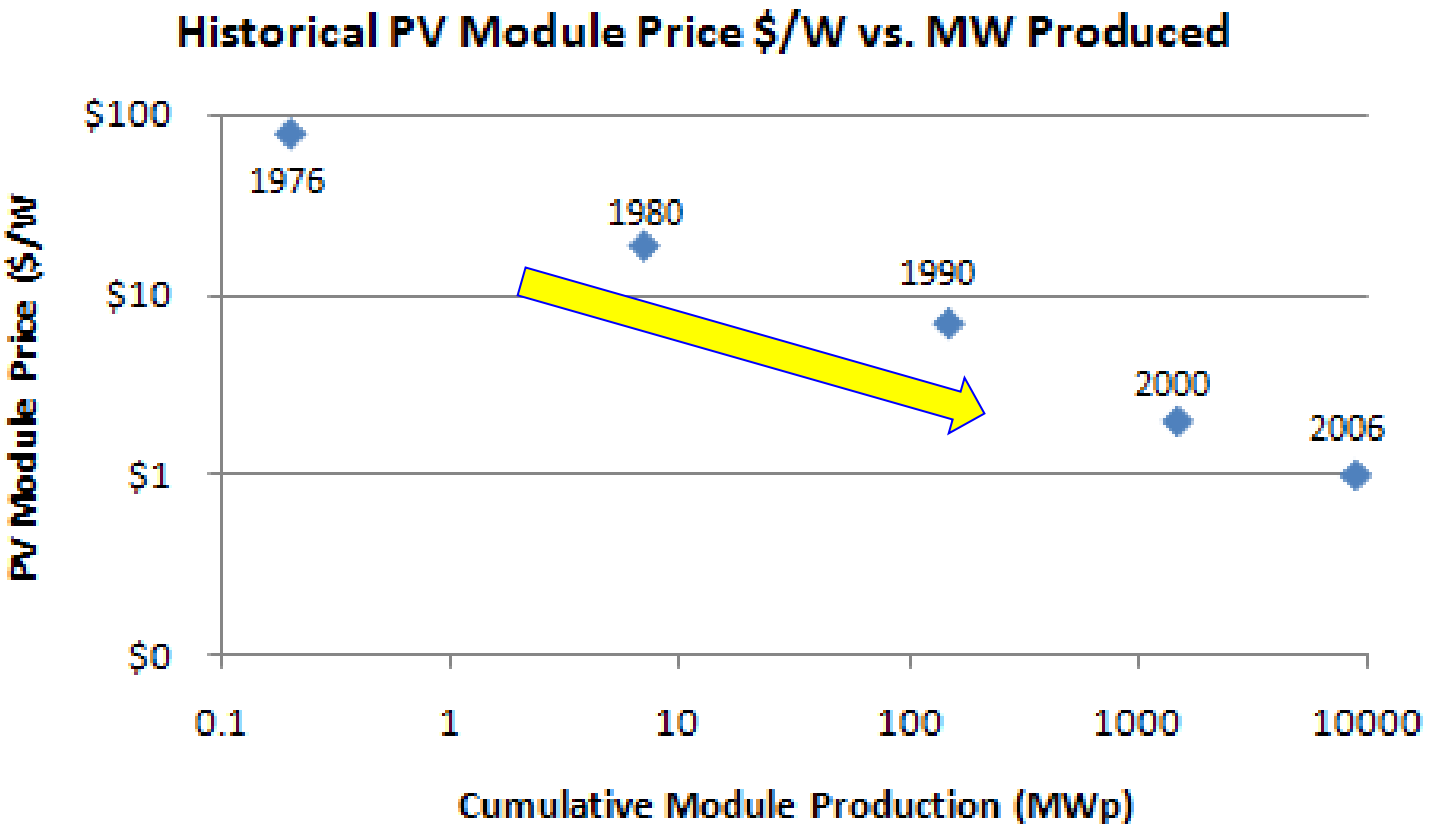
A more realistic scenario involves distributing these same PV systems throughout the 50 states. Currently available sites—such as vacant land, parking lots, and rooftops—could be used. The land requirement to produce 800 gigawatts would average out to be about 17 x 17 miles per state. Alternatively, PV systems built in the "brownfields"—the estimated 5 million acres of abandoned industrial sites in our nation's cities—could supply 90% of America's current electricity.

http://www1.eere.energy.gov/solar/myths.html

100 miles x 100 miles PV area

17 miles x 17 miles PV area per each state

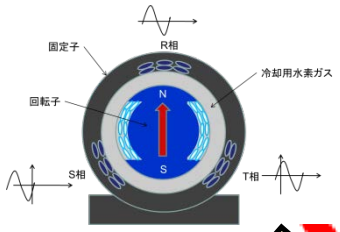
Will PV become affordable?



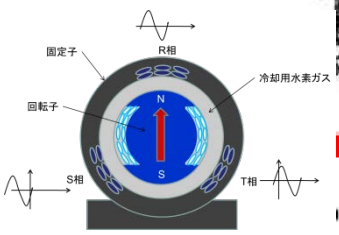
Earth Policy Institute "World Average Photovoltaic Module Cost per Watt, 1975-2006", December, 2007; http://www.earth-policy.org/datacenter/xls/indicator12_2007_7.xls

What is RE's problem to the electric grid?

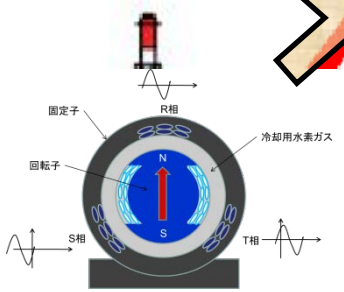
Fragile mechanism in large synchronous grid



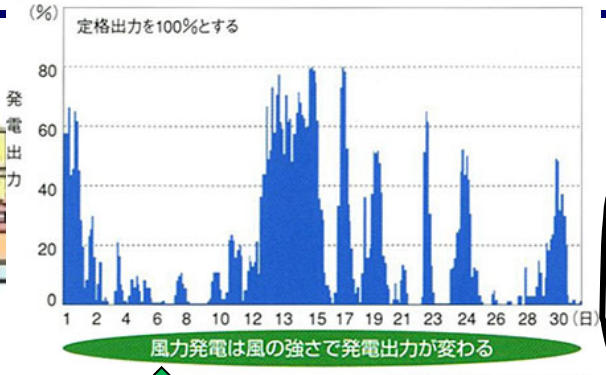
Hydro Electric

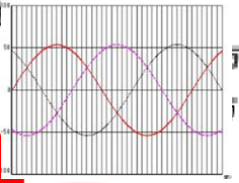


Generator



Thermal Power





4000V
～
6000V

超高圧変電所

15万4000V

6万6000

変電所

2万2000V

6600V

200V

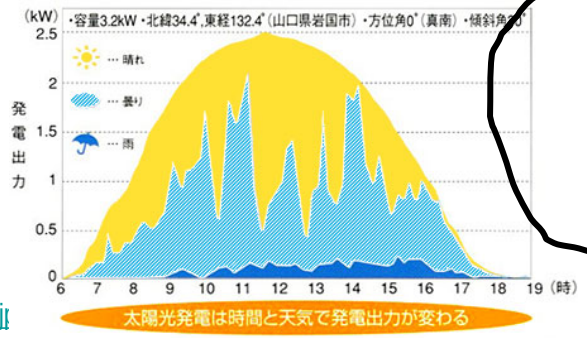
柱上変圧器

100V

6600V

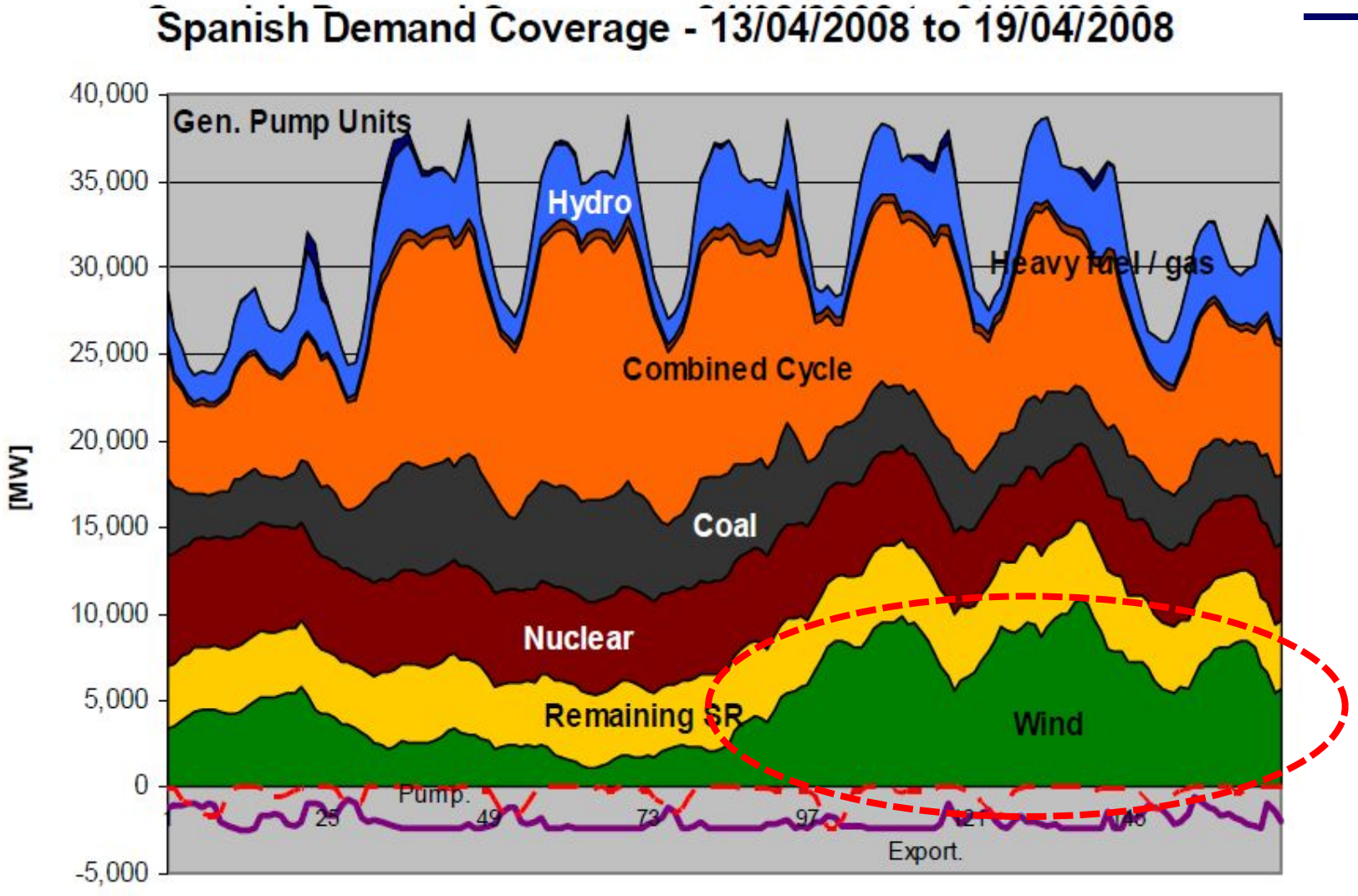
15万400

万V
～
27万5000V



http://www.fepc.or.jp

Large synchronous grid won't accept REs



Small accident will trigger Large Scale - Cascading Blackouts

An old transformer triggered a large scale blackout in North East USA I August, 2003.

⇒Large synchronized electrical system will be affected each other.

⇒Variable power generation such as PV, Wind affects this system

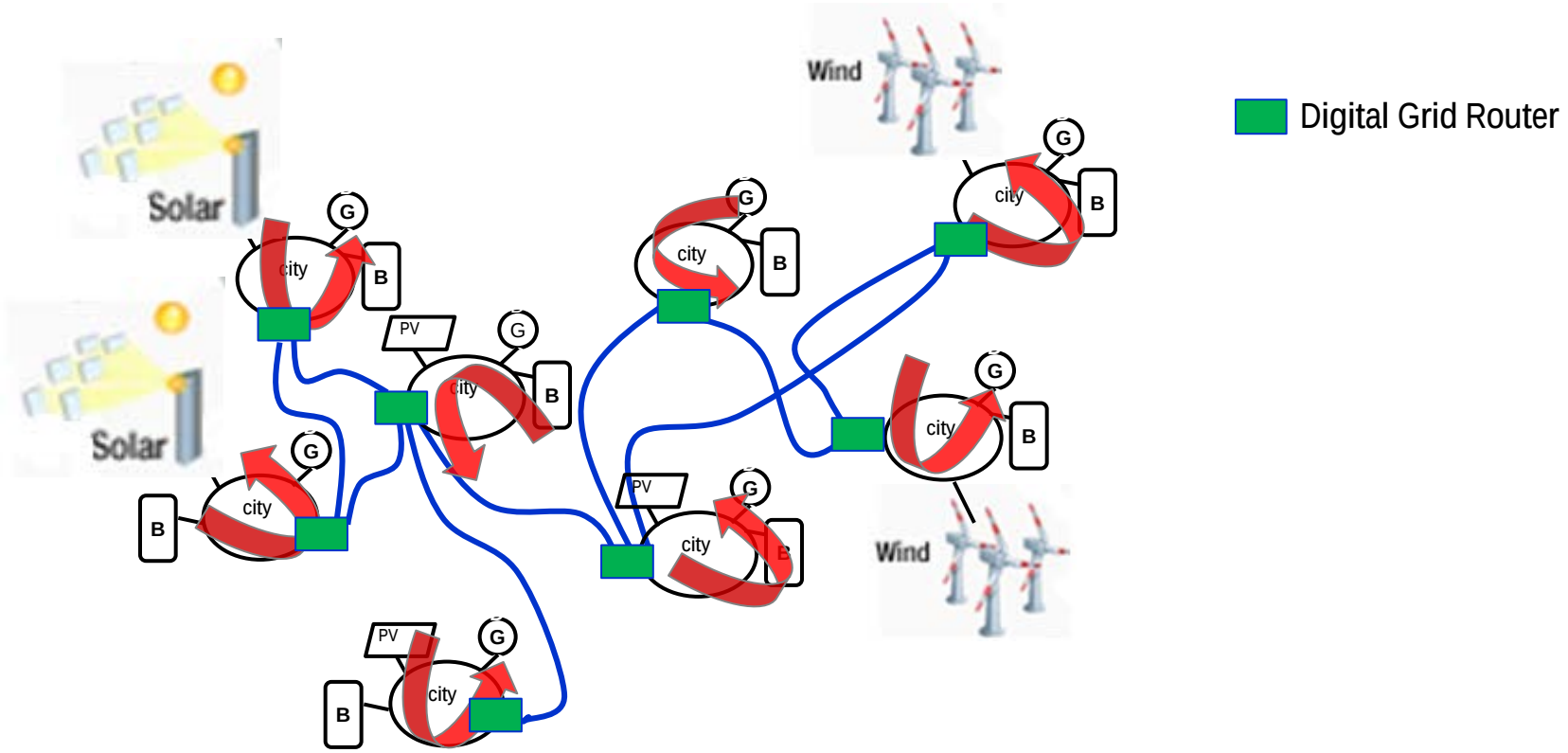
⇒Small failure will be the cause of next failure, cascading into a large scale blackout.

New Procedure to Large Electric System from Distributed Generation

Independent Grid connection via DGR

Independent small grids cannot connect synchronously because of low density demand.

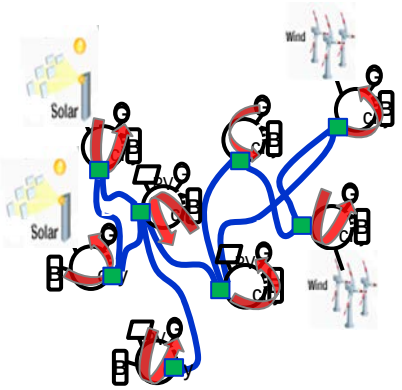
These independent asynchronous grids can be connected when it is necessary via DGR and accommodate power each other.



Digital Grid for developing countries

A new approach to develop electrical grids in developing countries.

- Cell grids already exist as municipal electric power supply.
- In order to connect them, it is not cost effective to install a large power station and long transmission lines to connect those distributed Cell grids as a part of large synchronous grid system.
- The Digital Power Router can be used to connect these cell grids to comprise an asynchronously connected grid system.
- Cell grids can contain a number of PVs and batteries and accommodate an identified energy source among them via the newly designed DPR.

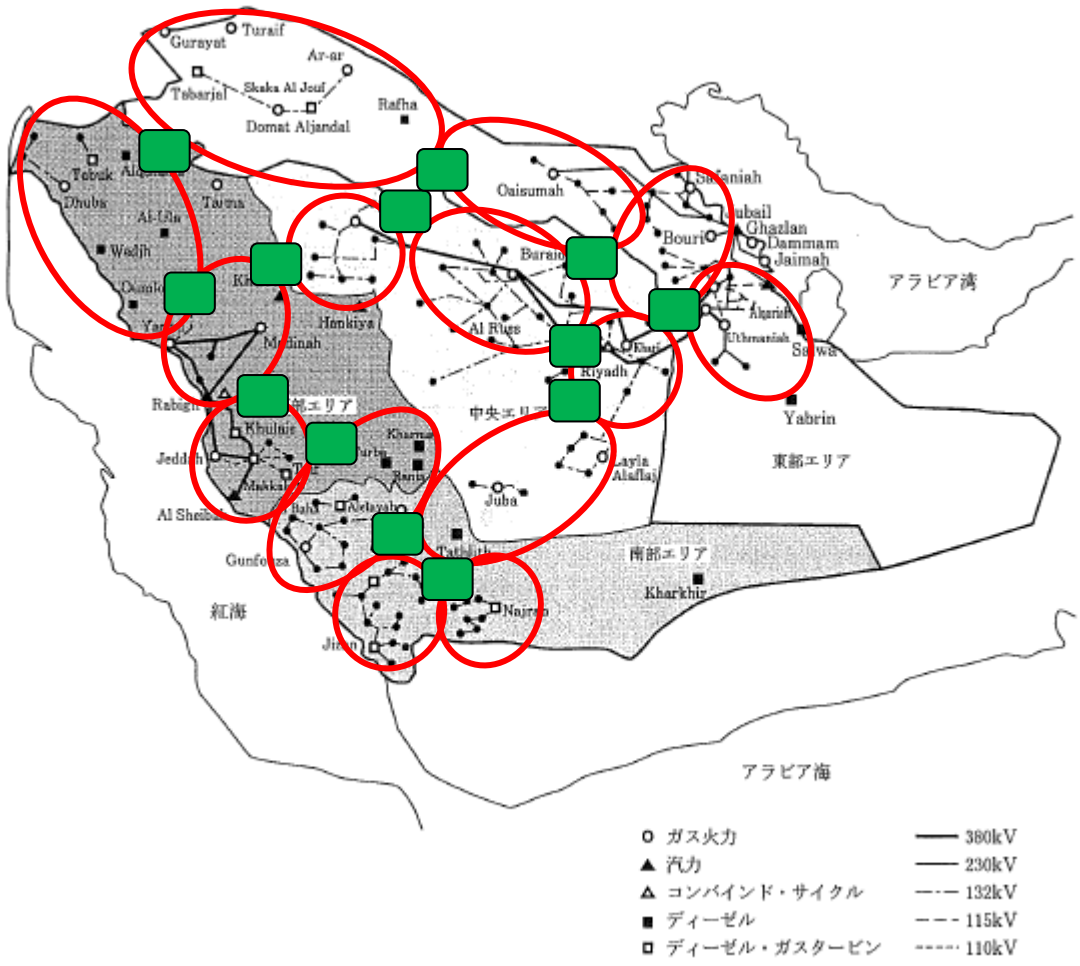


Digital Grid will provide Solar Society

Digital Grid can accept abundant solar energy, which can be called "Solar Society", and provide human beings peace and wealth.

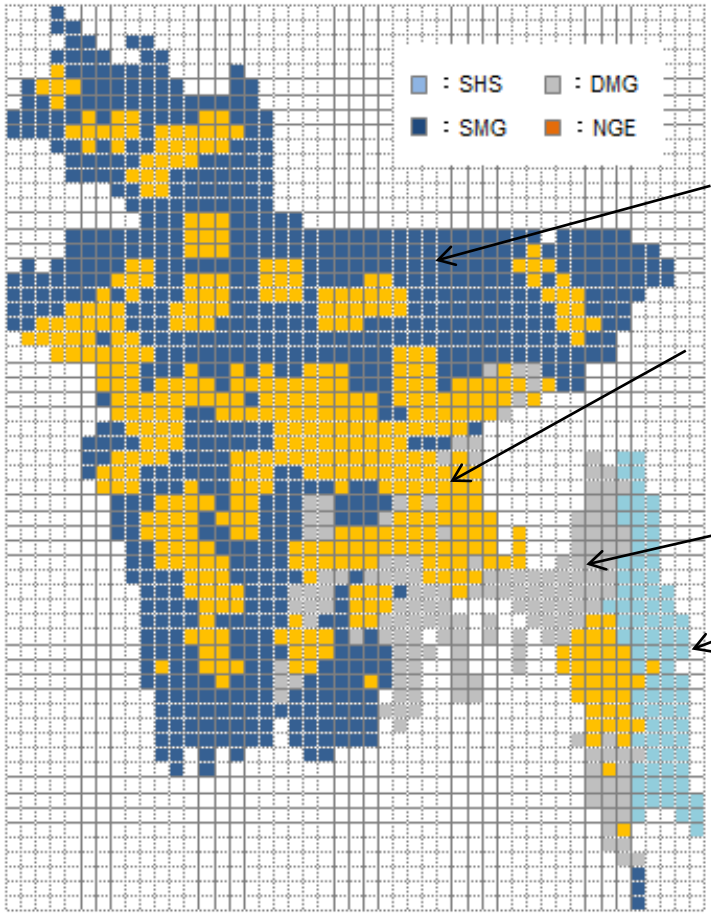
Digital Grid Image in Saudi Alabia

図－2　送電系統図



［出所］　サウジアラビア電力公社.

Bangladesh simulation



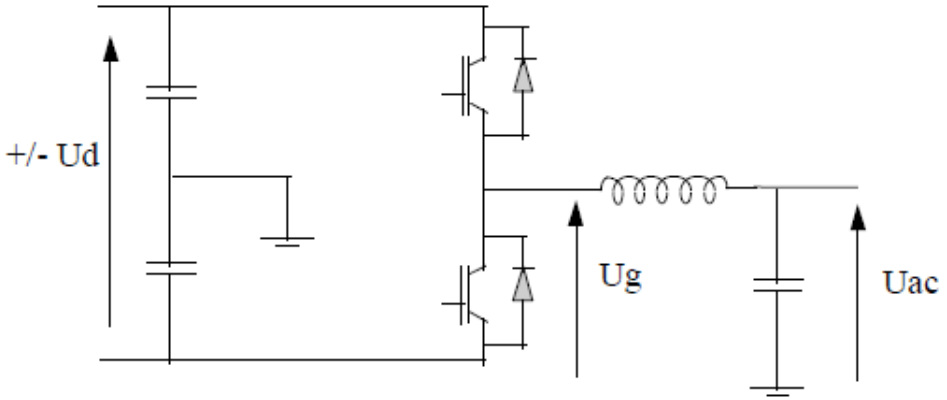
How to control power flow?

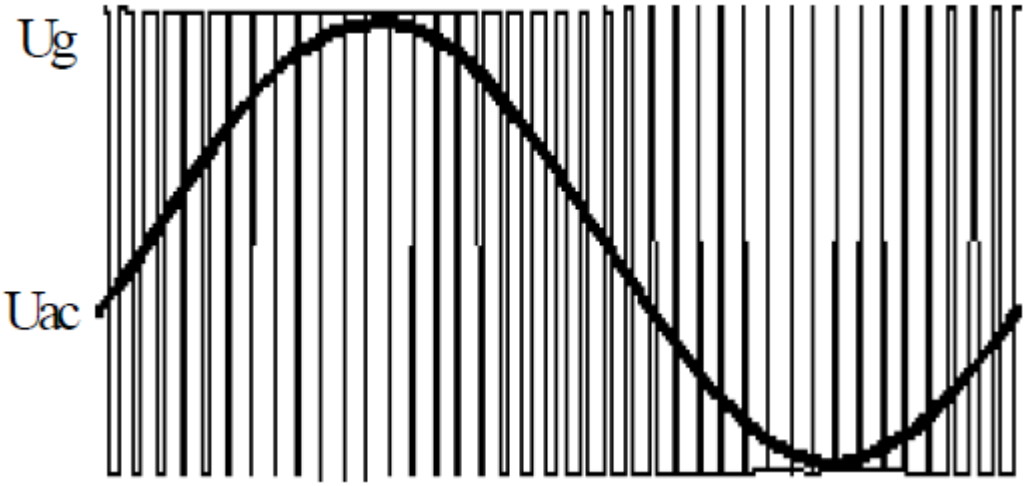
Digital Grid actively controls T&D

	Current Grid	Smart Grid	Digital Grid
Generation	Controllable	Not Controllable	Not Controllable
Transmission & Distribution	Passive	Passive	Active Control
Demand	Not Controllable	Not Controllable	Not Controllable

Demand Response

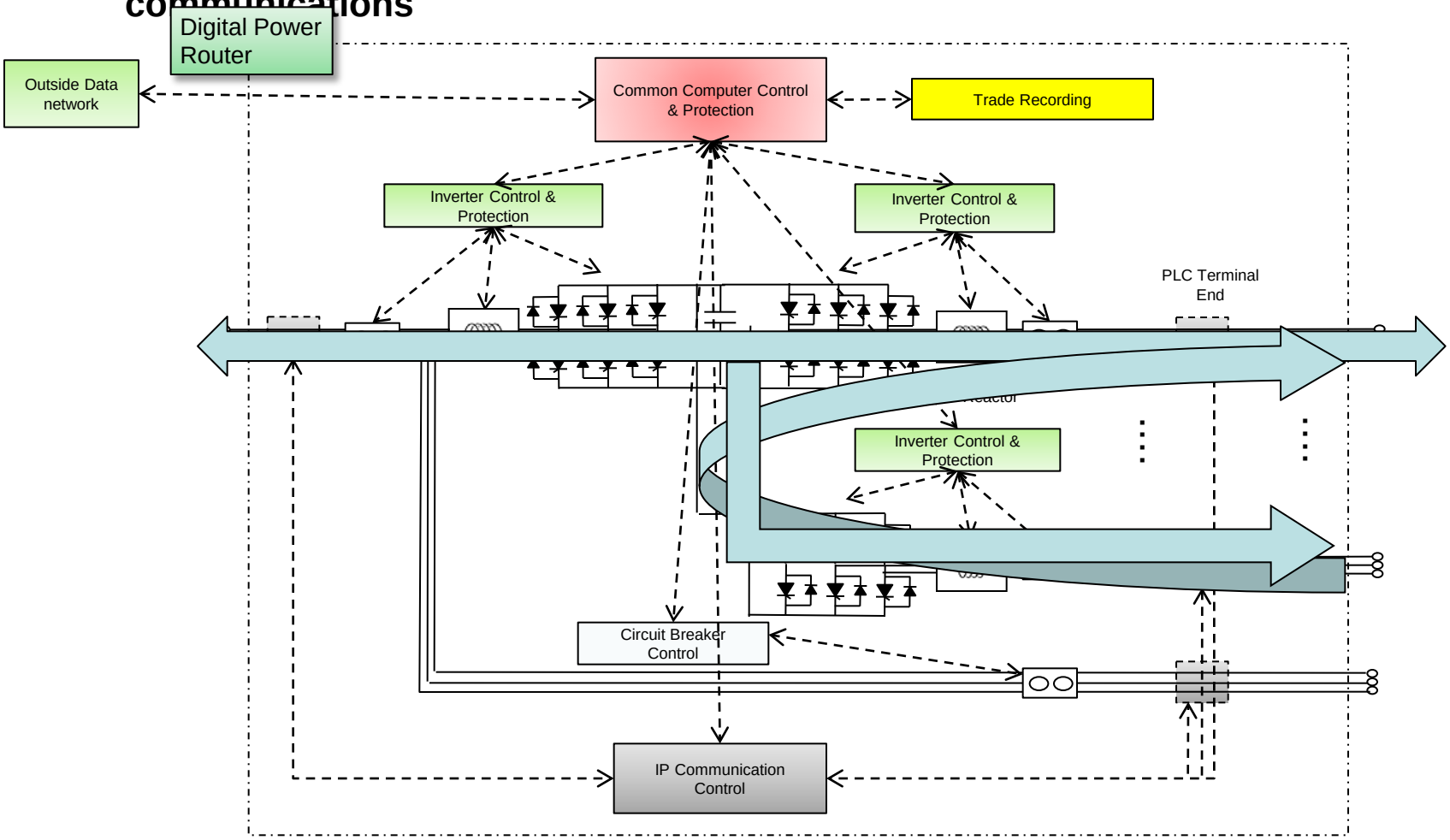
Principle of Voltage Source Converter



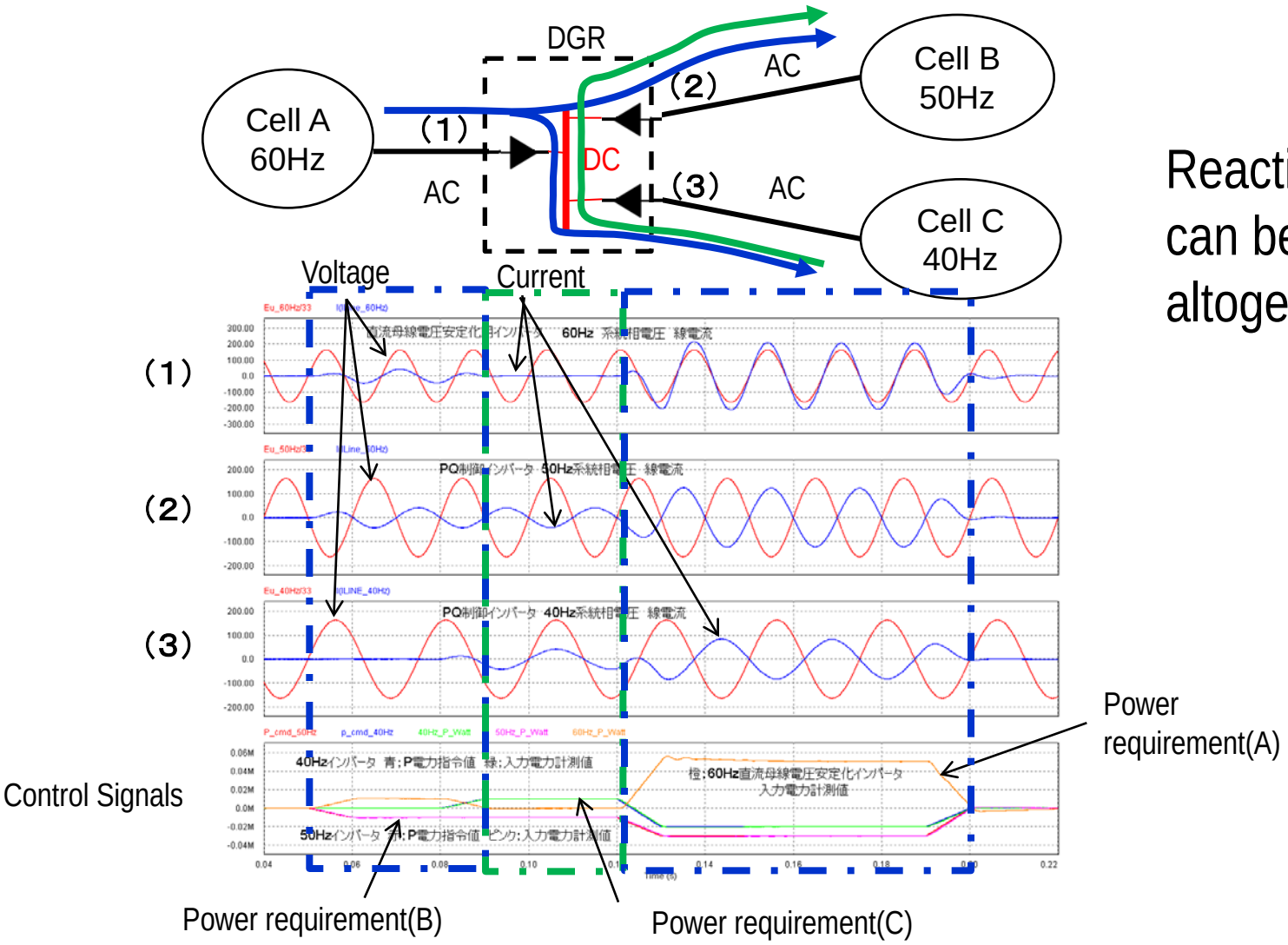


Digital Grid Router™

Computer Controlled Multi-Leg AC/DC converters with Internet communications



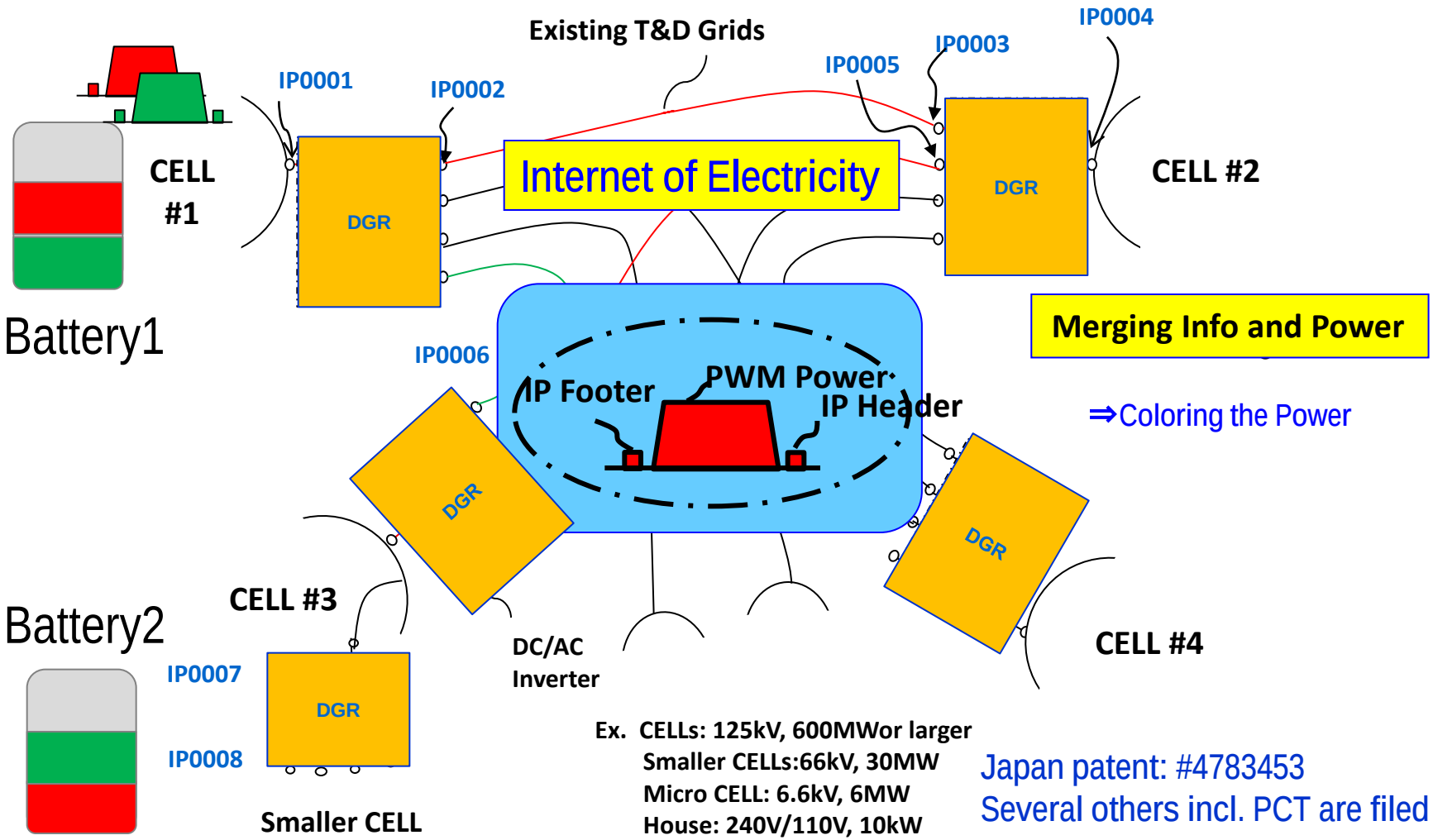
Active Power Control Simulation



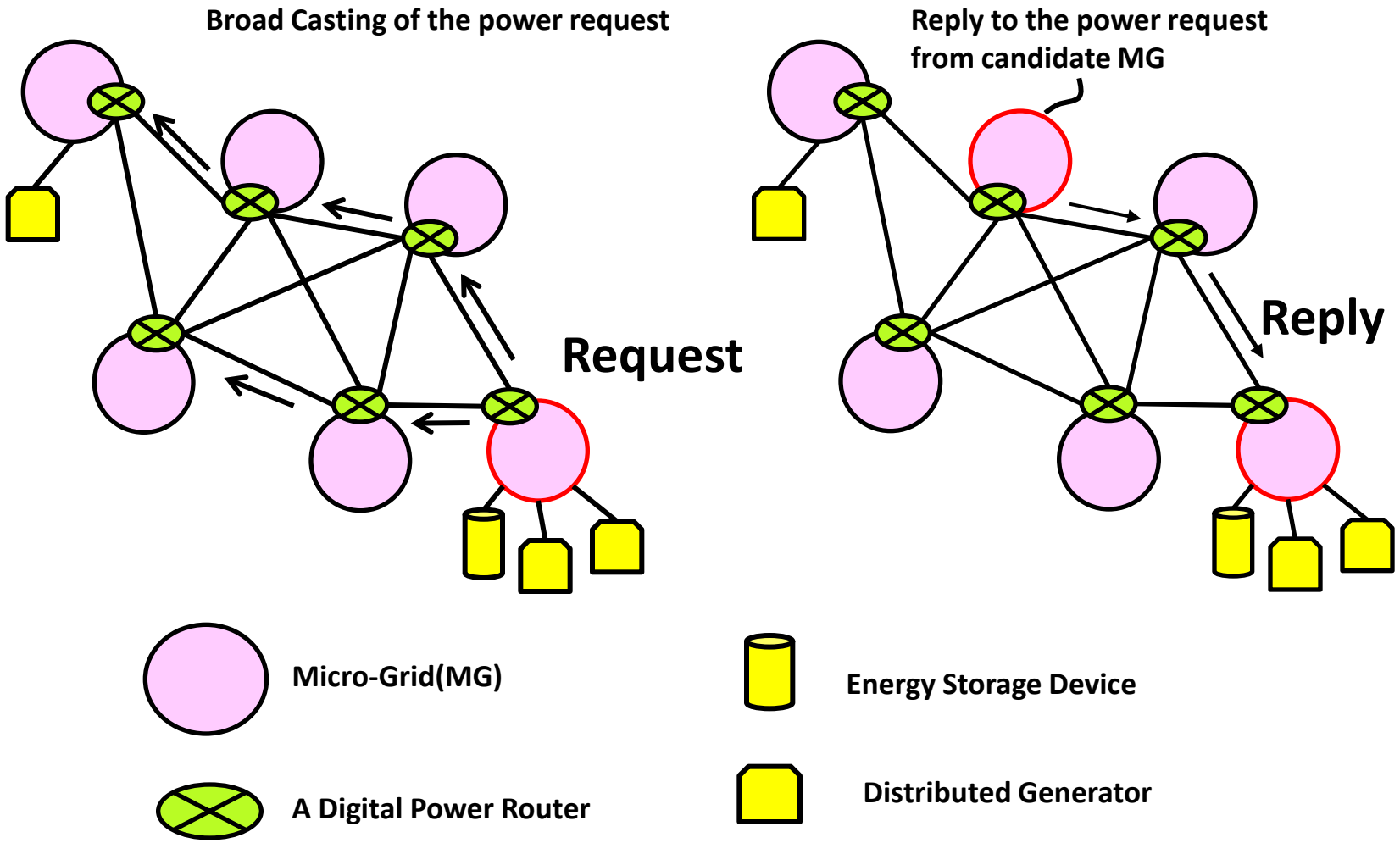
Reactive power can be controlled altogether

Digital Grid Routing

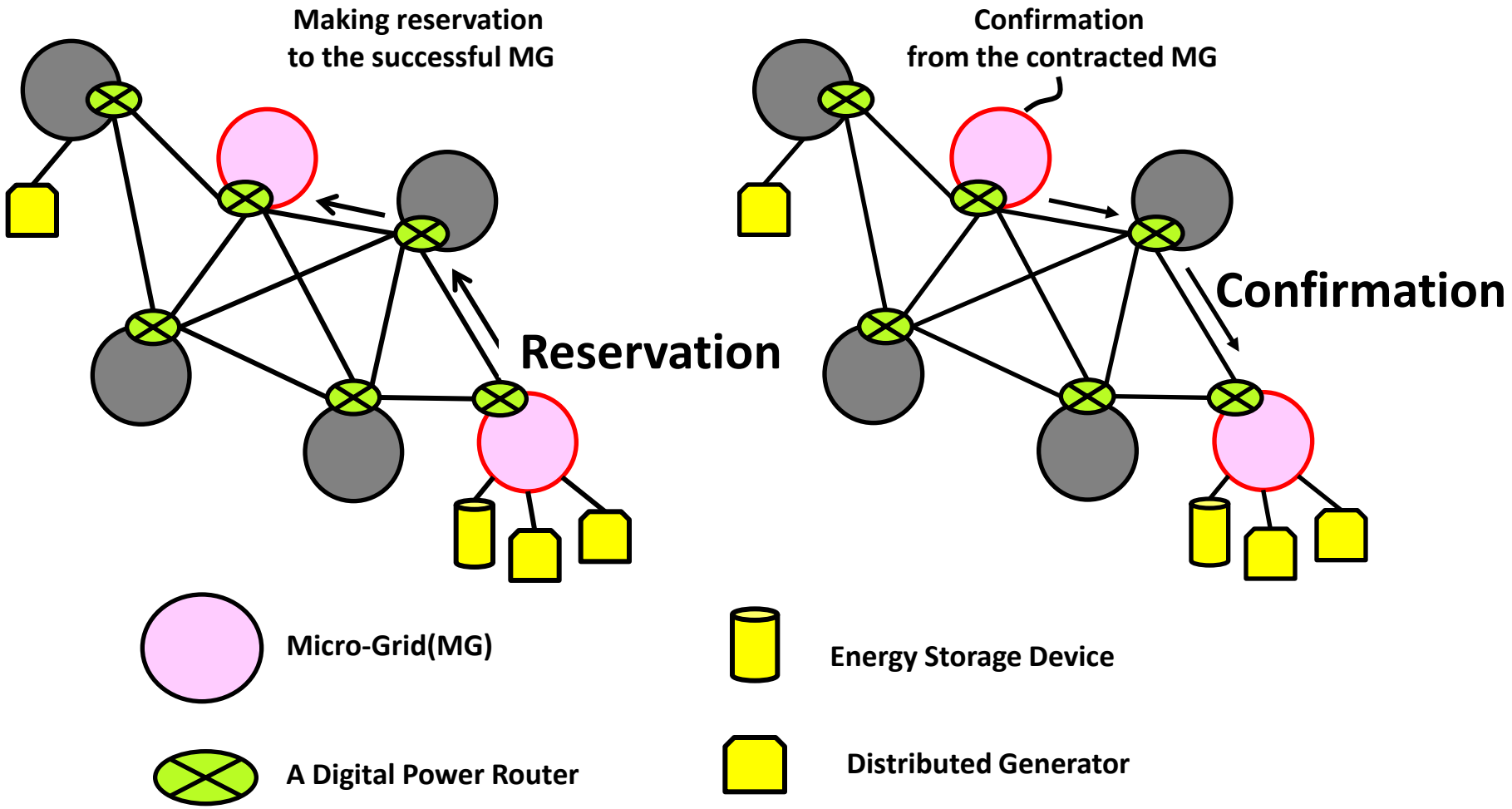
Internet of Electricity



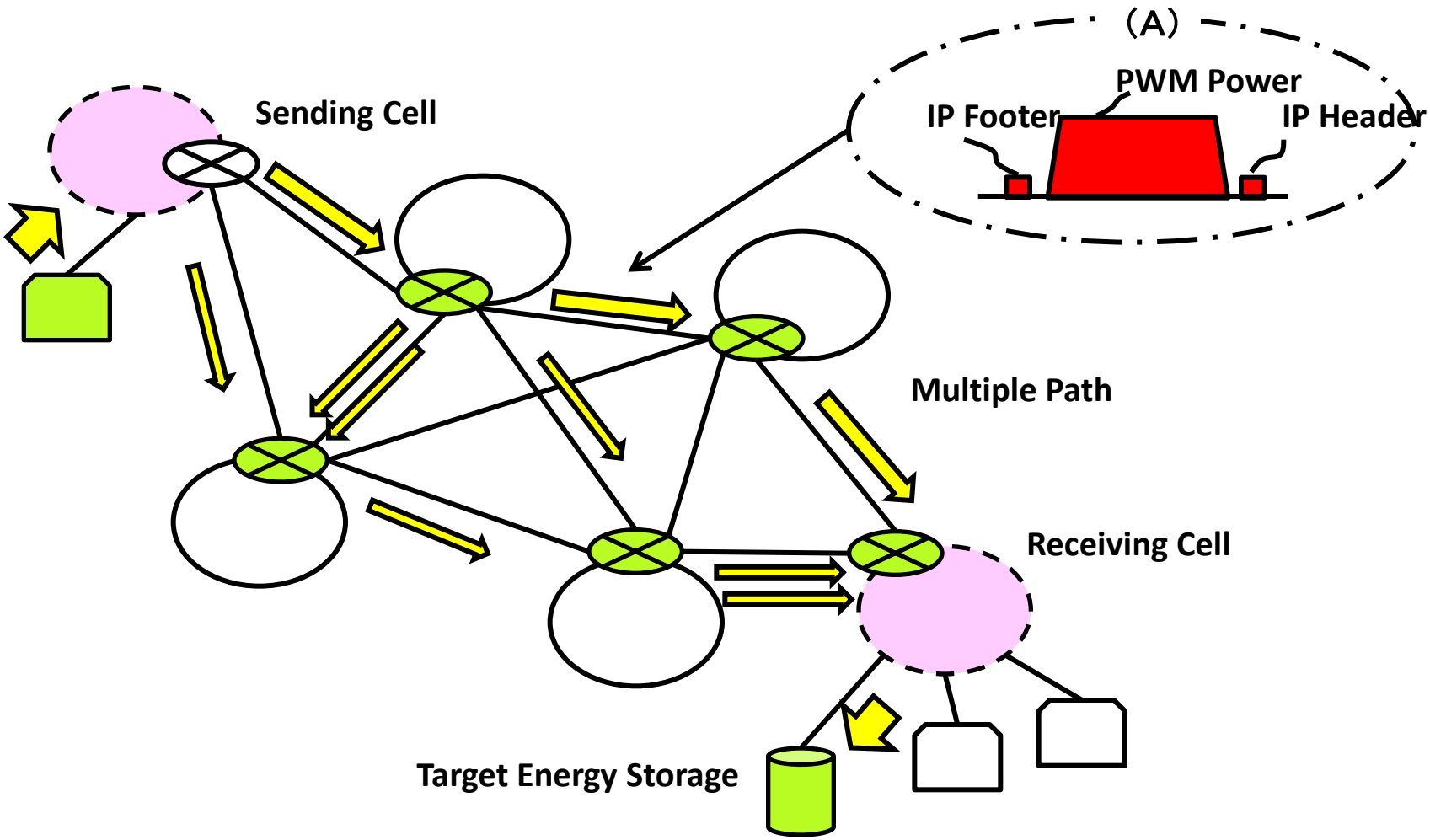
First Stage of Power Request



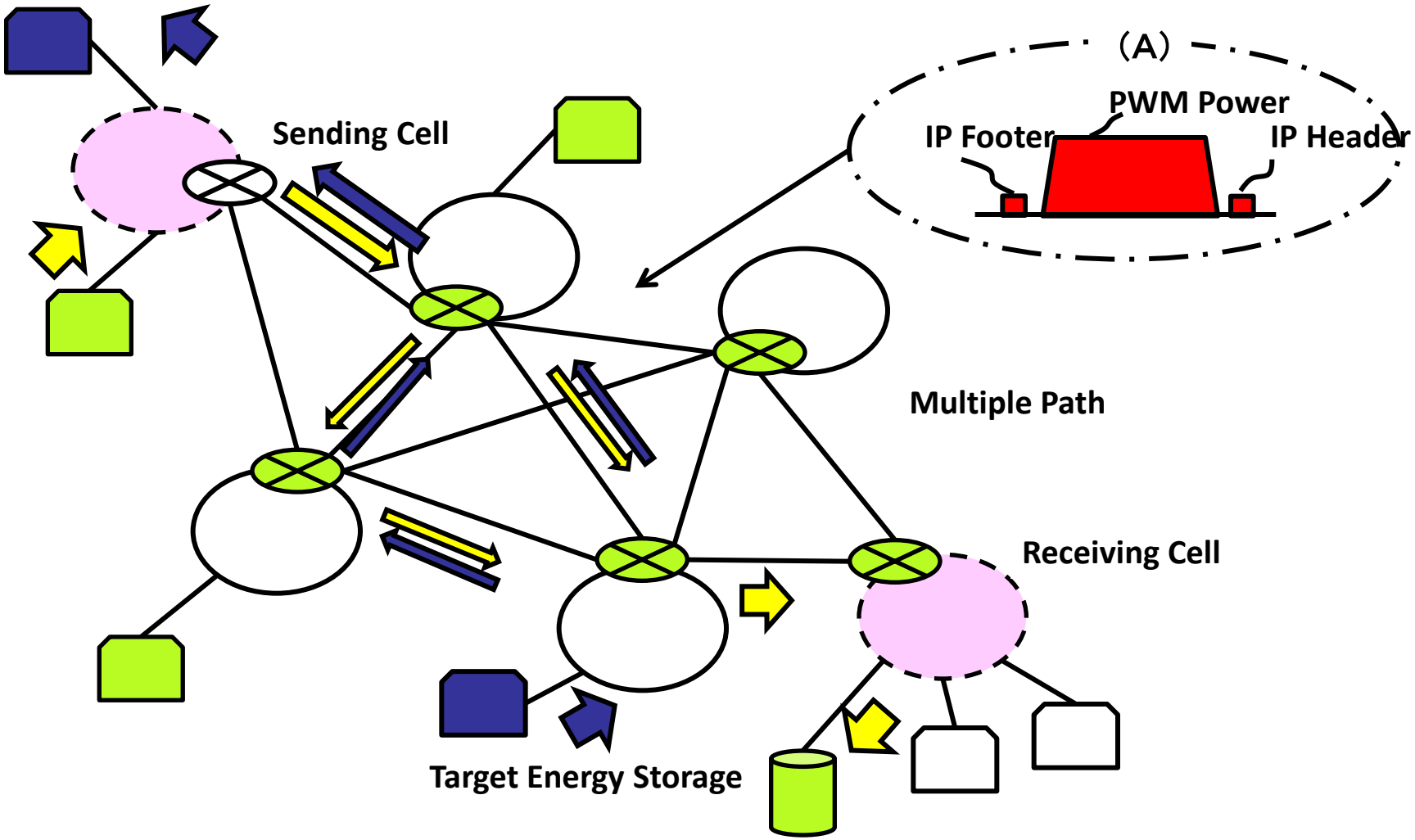
Second Stage of Power Request



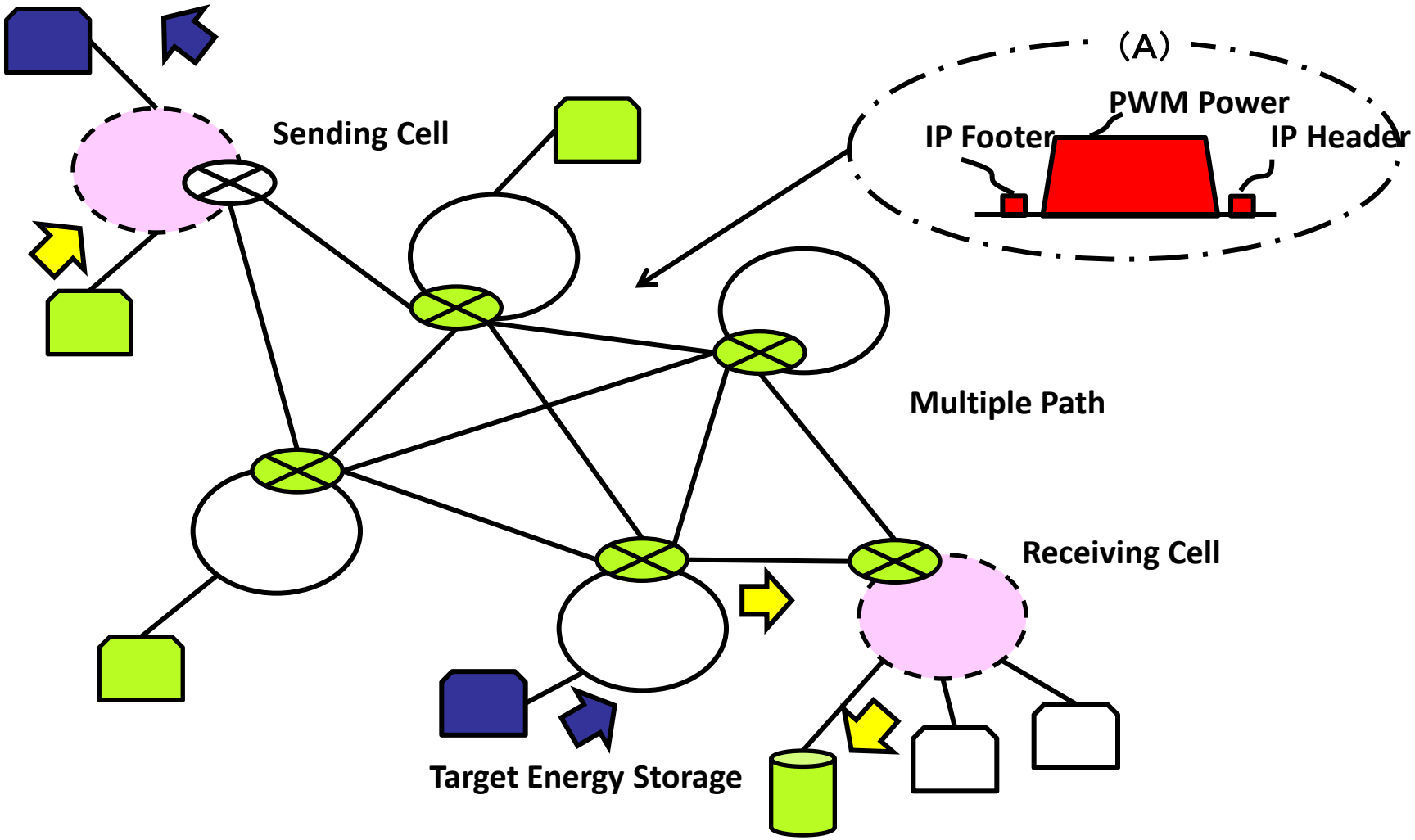
Power Distribution Stage



Counter Flow of Power



Minimum Loss Transaction

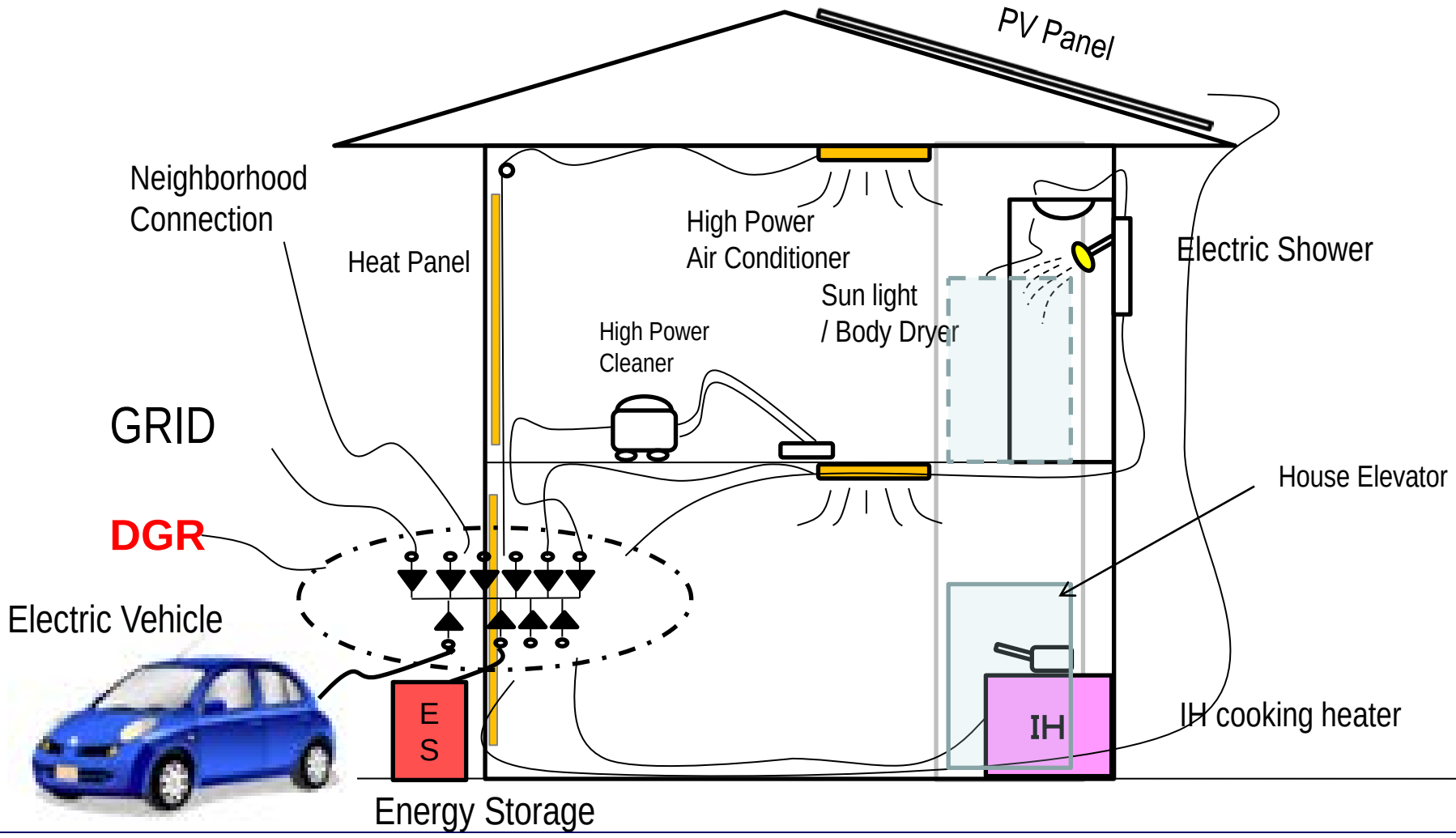


Transaction Record as Bank Book

Date	Start	Stop	From	Buy	To	Sell	Balance
12, May,'99	02:15:40	08:17:20	Grid A9806	2890kWh			10299kWh
14,May,'99	03:07:10	08:55:56			Grid W962	7600kWh	3699kWh
17,May,'99	18:40:12	23:40:12	Grid B547	3455kWh			7054kWh
20,May,'99	10:20:32	16:35:44	Int. PV003	456kWh			7510kWh

- Electricity Transaction will be recorded in DPR as bank book
- Authorized organization to certify those record
- Many features will be add such as CO2 credit, RPS value, Green value, etc

Power House Amenity



FIN