Day-1

Future € 2019 Forum

전력계통 연계와 전력산업의 미래

2019. 9. 18(수)

국회의원회관 대회의실

| 주 최 | 이훈 국회의원실 / (재)여시재 / (사)대한전기협회

AGENDA

일시 : 2019년 9월 18일(수)

장소 : 국회의사당 국회의원회관(대회의실)

DAY 1 9월 18일 : 전력계통 연계와 전력산업의 미래		
13:30~13:50	개회식 [환영사 및 축사]	
13:50~15:10	**Session 1**	
	좌장 Session 1·2·종합토론 문승일 (서울대학교 교수)	
기조연설 1	디지털시대와 전력중심의 사회	손지우 (SK증권 위원)
기조연설 2	국제정치학 관점에서 본 동북아 협력의 중요성	김연규 (한양대학교 교수)
발 표 1	한-중 전력계통연계 추진현황과 전망	강현재 (한국전력 처장)
발 표 2	글로벌 전력망 연계 구상 현황과 과제	Gao Yi (GEIDCO 박사)
15:30~16:50	**Session 2**	
발 표 3	독일 통일과정이 시사하는 전력계통 표준화	서병문 (베를린대 교수)
발 표 4	동북아 전력계통 연계와 산업계 파급효과	이학성 (LS산전 사장)
발 표 5	유럽의 전력계통 연계	Magnus Callavik (ABB Sifang Power System 사장)
발 표 6	ADB의 동북아 전력연계 프로젝트 추진결과	Philippe Linehart (EDF 이사)
16:50~17:30	**폐회 (종합 토론)**	

※ 참석인사 및 주제발표는 변경될 수 있습니다.

개회사

김 종 갑
대한전기협회 회장

반갑습니다.
우리나라의 전력산업 발전을 이끌어 가시는 귀한 분들을 한 자리에 모시고 이곳 국회에서 인사드릴 수 있어, 큰 영광으로 생각합니다.

특히, 오늘 이 뜻깊은 자리를 빛내주시는 국회 산업통상자원중소벤처기업위원회 이종구 위원장님, 항상 큰 힘이 되어주시는 산업통상자원부 정승일 차관님, 그리고 이훈 의원님과 여시재 이광재 원장님, 바쁘신 시간 내주셔서 모두 고맙습니다.

내외 귀빈 여러분, 요즘 주변을 둘러보면 불과 몇 년 전에만 해도 먼 미래라고 생각했던 기술들이 점점 더 빠른 속도로 현실화되는 것 같습니다.

우리의 일상 속에서도 빅데이터가 점점 흔하게 사용되고 있고, 산업현장에서는 인공지능 로봇이 사람을 대신해 어렵고 위험한 일을 수행하기도 합니다. 시장에는 한 달이 멀다 하고 스마트폰과 앱이 출시되고, 속도가 몇 배는 더 빨라진 인터넷 서비스들이 계속 쏟아져 나옵니다.

우리 전력산업계에도 매우 크고 중요한 변화가 이미 시작되었습니다. 그 중 하나인 에너지전환은 전력공급 방식을 근본적으로 바꾸는 혁명적 변화입니다.

화력과 원자력에 크게 의존해 온 지금까지의 전력공급방식을 풍력과 태양광 등 친환경 에너지로 바꿔가는 것입니다. 우리로서는 처음 가보는 길이라 어려움이 많겠지만 국민의 이해와 공감대를 구하면서 힘들고 어렵더라도 세계와 발맞춰 반드시 가야 할 길입니다.

또 하나의 큰 흐름인 디지털변환은 이미 각 산업분야에서 매우 활발하게 진행 중입니다. 정보통신기술로 모든 것이 연결되고 융합하면서, 전기차, 수요자원, 분산전원 등과 같은 에너지신(新)산업이 계속 생겨나고 있습니다.

오늘부터 내일까지 열릴 이번 포럼은 인류의 더 나은 미래를 위해 에너지산업의 지속가능한 발전 방향을 함께 고민하고 토론하는 자리입니다. 기술은 물론이고, 정치, 경제, 사회, 문화 등 전력산업을 둘러싼 복잡하고 다양한 측면을 모두 다룰 예정입니다.

에너지의 지속가능성을 높여가는 이 문제는 특정 국가나 기관 혹은 누구 하나의 힘만으로는 불가능합니다. 기업과 국가의 경계를 뛰어넘어 모든 사람이 지혜와 경험을 모아야 합니다.

다들 어렵게 시간 내주신 만큼, 이틀간 이어지는 주제발표를 관심 있게 들으시면서 평소 생각하고 계신 의견을 활발하게 제시해 주시면 이번 포럼이 더욱 값진 자리가 될 것 같습니다.

참석하신 내외 귀빈 여러분께 다시 한 번 감사드리며, 함께 하신 모든 분들의 건승과 발전을 기원 드립니다. 고맙습니다.

2019년 9월 18일

환영사

이 훈
국회의원

안녕하십니까?
국회 산업통상자원중소벤처기업위원회 더불어민주당 이훈 의원입니다.
'2019년 퓨처E포럼'에 참여해주신 모든 분들을 환영합니다. 이번 퓨처E포럼을 국회에서 개최하게 되어 매우 영광스럽습니다. 이번 포럼행사가 주최되기까지 많은 노고를 쏟아주신 대한전기협회의 회장이자 한국전력공사 사장이신 김종갑 회장님을 비롯해 여시재 포럼의 이광재 원장님 이하 모든 관계자분들께 감사의 말씀을 드립니다.
또한 이번 퓨처E포럼의 성공적 개최를 위해 성원해주신 이종구 산업통상자원중소벤처기업위원회 위원장님과 성윤모 산업통상자원부 장관님을 비롯해 많은 선배 · 동료 의원 여러분께도 감사의 말씀 드립니다.
무엇보다 이번 포럼에 많은 관심을 갖고 참석해 자리를 빛내주신 내외 귀빈 여러분 및 참석자 여러분, 그리고 주제발표와 토론을 위해 각고의 노력을 기울여주신 각계 전문가 및 토론자분들께도 진심어린 감사와 환영의 인사를 드립니다.

지난해 동북아전력포럼을 함께 국회에서 개최한지 1년만에 전기인 여러분들과 다시금 이렇게 포럼행사를 개최하게 되었습니다. 이번 퓨처E포럼은 지난해보다 훨씬 큰 규모에 더욱 풍성한 내용으로 기획됐습니다. 하루 포럼으로 그친 지난해와 달리 올해는 이틀에 걸쳐 진행하는 점에 대해서도 무척 기쁘게 생각합니다.
첫 날인 오늘 논의하는 동북아 전력계통연계 문제는 지난 동북아전력포럼에서도 다루었듯이 단순히 국가 간의 전력연계 이상의 의미가 있습니다. 동북아 전력연계는 국가간의 효율적인 에너지 공유뿐만 아니라 우리나라가 북방지역으로의 새로운 경제지평을 확장하는 신북방정책을 위한 기반입니다. 이는 단순히 경제적 이익뿐만 아니라 세계무대에서 한반도의 잠재역량을 극대화할 수 있는 정책이기도 합니다.
유럽은 경제 · 사회 · 역사적으로 유연하게 통합화할 수 있던 특성에 기초해 전력망 역시 점진적인 연계체계를 구축해가고 있습니다. 물론 유럽의 전력연계도 현재진행형이고, 각국의 전력시장 변화와 운영방식을 두고 계속된 논의가 이어지고 있습니다.
반면 동북아는 유럽에 비해 훨씬 통합과 협력체계 구축이 어려운 환경입니다. 사회 · 문화적인 괴리가 존재할 뿐만 아니라 역사에 대한 올바른 청산이 이뤄지지 못하고, 오히려 역사의 잔재가 동북아의 체제를 끊임없이 긴장 속에 놓으며 괴롭히기 때문입니다.

문재인 정부는 수차례의 남북정상회담을 성사시키고, 북미정상회담도 이뤄지면서 한반도 평화체제를 만들기 위해 부단히 노력하고 있습니다. 비록 현재 크고 작은 마찰도 이어지고 있지만, 이는 70년 분단체제와 냉전구도를 이제 막 극복하려는 시작점에선 겪을 수밖에 없는 과정입니다.
하지만 이러한 과정을 극복해내면 동북아 전력계통연계도 결코 멀리 있는 일이 아닐 것입니다. 그런 시기에 대비해 오늘날 동북아 전력계통의 현황을 진단하고 효과적인 전력연계를 어떻게 준비할 것인지를 논하는 오늘의 포럼이 매우 의미가 있다고 볼 수 있겠습니다.
이 자리를 통해 동북아 주요국가들 사이에서 전력 · 에너지 인프라 및 정책적 상호 협력을 이끌어낼 실효성 있는 방안들이 제시되기를 바랍니다. 저 역시 해당 상임위의 국회의원으로서 지속적인 관심과 노력을 기울이겠습니다.
다시 한 번 퓨처E포럼에 참석해 주신 내외 귀빈과 토론자 및 참석자 여러분께 진심으로 감사의 말씀을 드리며 유익하고 즐거운 시간이 되기를 바랍니다. 고맙습니다.

2019년 9월 18일

축 사

이 종 구
산업통상자원
중소벤처기업위원회
위원장

안녕하십니까.
국회 산업통상자원벤처기업위원회 위원장을 맡고 있는 이종구 의원입니다.

먼저 포럼을 개최해 주신 대한전기협회 김종갑 회장님을 비롯한 관계자분들과 참석해 주신 모든 분들께 감사드립니다.

정부는 2017년 7.6%에 불과했던 재생에너지 비중을 2030년 20%까지 끌어올리겠다는 「에너지전환로드맵」을 발표한 바 있습니다.

물론 인류의 주 에너지원이었던 화석연료가 환경오염과 자원 고갈 등의 문제로 한계에 도달한 상황을 감안할 때, 새로운 미래의 에너지원을 발굴하고 재생에너지 비중을 늘려 가자는 방향성 자체에 대해서는 이견이 없습니다.

그러나 속도에 있어서는 많은 논란이 있습니다.
우리나라 특성상 날씨에 따라 전력 생산량이 좌우되는 풍력, 태양광 등의 재생에너지로는 안정적인 전력공급이 어려울뿐더러 효율도 떨어집니다.
국익에도 도움이 되지 않고 정작 환경에도 좋지 않다는 말도 나오고 있습니다.

국민 부담도 커집니다. 탈원전을 급격하게 추진한 결과 매년 수천억 원의 이익을 내던 에너지 공기업은 적자더미에 올라앉았고, 관련 업체들은 일감 절벽으로 도산 위기에 내몰렸습니다.

세계적인 경쟁력을 자랑하는 원전기술은 사장되게 생겼습니다. 뿐만 아니라 한전의 적자가 지속되면 이를 충당하기 위해 전기료 인상이 불가피합니다.
에너지 전환은 효율성과 경제성을 따져 신중하게 추진되어야 합니다.

모쪼록 이번 포럼이 급격한 에너지 정책의 부작용과 문제점을 짚어보고, 현실에 맞도록 정책을 재검토하는 기회가 되기를 바랍니다.
국회에서도 여러분들의 목소리를 더욱 귀담아 듣고 정책에 반영되도록 노력하겠습니다.

다시 한 번 오늘 참석하여 주신 모든 분들께 감사드리며, 모두 건승하시길 기원합니다.
감사합니다.

2019년 9월 18일

치 사

정승일
산업통상자원부 차관

안녕하십니까. 산업통상자원부 차관 정승일입니다.
에너지 전환의 시대를 맞아 장기적인 전력산업의 정책 방향을 논의하는 '퓨처 E 포럼'을 개최해 주신 이훈 의원님과 대한전기협회 김종갑 회장님, 여시재 이광재 원장님께 감사드립니다.

아울러, 바쁘신 가운데서도 전력산업 정책에 많은 관심을 가져주시는 국회 산업통상자원중소벤처기업위원회 이종구 위원장님께도 감사의 말씀을 드리며, 오늘 귀한 시간 내어 참석해 주신 많은 국내외 귀빈 여러분, 모두 반갑고 환영합니다.
그리고, 이 자리를 빌려, 올 여름도 무더위로 인한 전력수요 급증에도 여기 계신 전력산업 관계자 여러분들의 노고 덕분에 안정적인 전력공급을 이뤄낼 수 있었던 점, 깊은 감사와 격려를 보냅니다.

전력산업은 다른 어떤 분야보다도 기후변화 대응에 있어 핵심적인 역할을 해야 할 위치에 있고, 4차 산업혁명, 미세먼지, 지진 등 그 주변을 둘러싸고 중요한 사회적 이슈들도 지속적으로 제기되고 있습니다.

따라서, 전력산업계는 깨끗하고 안전하면서도 사용이 편리한 전기를 안정적으로 공급해야 하는 숙제를 풀어나가야 합니다.
이에, 우리 정부에서는 장기적으로 지속가능한 에너지전환 정책을 추진해 나가고 있습니다.

원자력, 화력 등 전통적 발전설비 중심에서 벗어나 신재생에너지 등 친환경 설비를 확대하며 국가 에너지믹스를 최적화하고, 에너지효율을 높이는데 주력하고 있습니다.
그런데, 이 거대한 정책적 흐름이 원활히 진행되기 위해서는 사회적 합의와 국민 분들의 공감대를 확보하는게 제일 중요합니다.

특히, 이번 포럼의 주제인 '전력계통 연계'나 '지속가능한 전력정책의 방향'과 같이 미래세대들에게 영향을 미치는 전력산업 정책은 더욱 소통과 협의에 주력해야 합니다.
그런 의미에서, 저는 오늘 포럼이 공감대 형성을 위한 논의의 시작을 알리는 동시에 현재 추진되고 있는 정책을 점검할 수 있는 매우 중요한 자리라고 평가하고 싶습니다.

전력산업이 처한 현실을 정확히 분석하고 우리 국민들께서 요구하시는 사항을 바탕으로 충분한 논의를 거쳐 합리적 미래가치를 도출해 내는 자리가 되었으면 하는 바람입니다.

정부에서도 오늘 논의되는 내용에 귀 기울여 사회적 동의와 지속가능한 전력산업의 발전을 동시에 만족시키는 전력정책을 수립하는데 적극 반영하도록 노력을 다하겠습니다.
오늘 참석해 주셔서 감사드리며, 모든 분들의 발걸음을 계속해서 응원하겠습니다.
항상 고맙습니다.

2019년 9월 18일

목 차

Session 1

Session 2

기조연설 1

디지털시대와 전력중심의 사회

손 지 우
(SK증권 위원)

Future e-Forum

디지털 시대와 전력 중심의 사회

SK증권 리서치센터 손지우
SMART City TFT Manager

Contents

與時齋 Yeosijae Future Consensus Institute × SK securities research center

- 4차 산업혁명과 스마트시티
- 스마트시티는 전력부족이다
- ESS, 그리고 전고체배터리

01 4차 산업혁명과 스마트시티

4차 산업혁명과 스마트시티

CES

2014 Audi
2015 Mercedes-Benz
2016
2017 NISSAN
2018 Ford

2014 Audi Rupert Stadler

자동차의 1세대는 달리는 것 → 2세대는 길들이는 것
→ 3세대는 안정/효율/기술/고급이었는데, 4세대는 연결(connectivity)

그 중 2014년 아우디의 전(前) 회장 Rupert Stadler는
4세대 자동차 시대의 '연결(connectivity)'을 언급하며
사실상 자율주행차의 서막을 알렸죠.

4차 산업혁명과 스마트시티

1차 산업혁명
증기기관차 by James Watt
기존 운송수단 대비
화물수송 시간·공간↓ : 생산성 급증

2차 산업혁명
내연기관차 by Henry Ford
기존 운송수단 대비
여객운송 시간·공간↓ : 생산성 급증

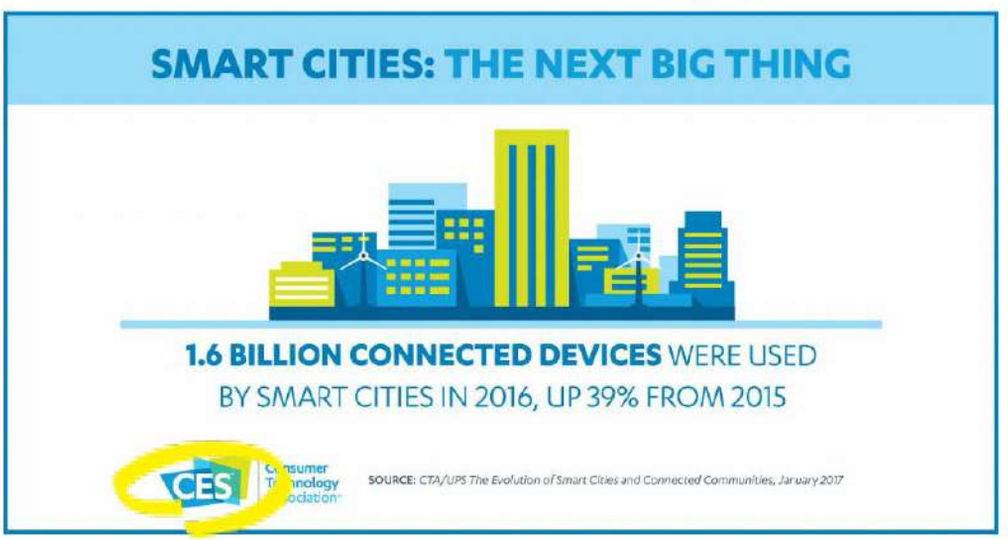
Automobile
"What we called as a Killer Application"

늘 산업혁명은 자동차로 인한 생산성 급증이 뒷배경이었기에, 이런 자동차의 변화는 단연 눈에 들어옵니다.

3차 or 4차 산업혁명
Smart Car by whom? ✓
connectivity
mobile vital space
autonomous driving
electronic vehicle
.....

4차 산업혁명과 스마트시티

그런데 CES의 관심도가 자동차에서 이제 도시, 즉 SMART CITY까지 넘어갔습니다.

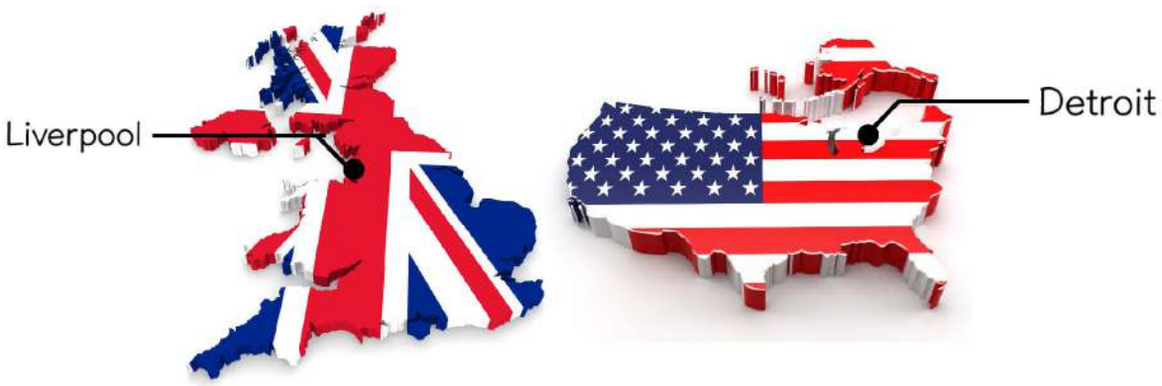


4차 산업혁명과 스마트시티

저희는 이 현상도 또 다른 산업혁명의 징후로서 눈 여겨 보는 것이,
산업혁명마다 늘 새로운 국가와 도시가 등장했기 때문이죠.

1st Industrial Revolution

2nd Industrial Revolution



4차 산업혁명과 스마트시티

Liverpool

선박 대형화 대응 미비
제 2차 세계대전에서 독일의 표적

Detroit

오일쇼크 이후 일본의
고연비 소형차에 완패

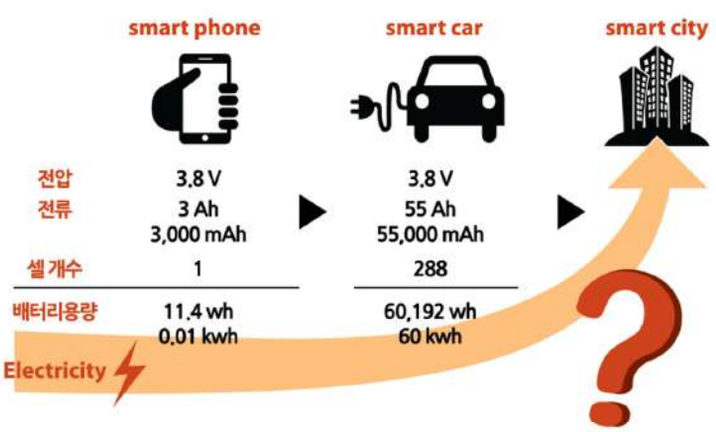
새로운 산업혁명을 견인할
새로운 도시의 필요, SMART CITY

요인	1차 산업혁명	2차 산업혁명	3차 산업혁명 혹은 4차 산업혁명
도시	리버풀, 영국	디트로이트, 미국	???
1. 운송(Transportation)	항구도시 머지(Mersey)운하	미국 중북부의 대지 5대호(Great Lakes)	
2. 엔진(Engine)	증기기관(외연기관)	내연기관	인공지능(Artificial intelligence)
3. 에너지(Energy)	석탄 맨체스터(Manchester)	석유 클리블랜드(Clevelend)	가스 신재생에너지
4. 철강(Iron&steel)	쉐필드(Sheffield)	피츠버그(Pittsburgh)	
5. 핵심기기(Application)	직물 / 증기기관차	내연기관차(자동차)	자율주행 기반의 스마트카

02 스마트시티는 전력부족이다

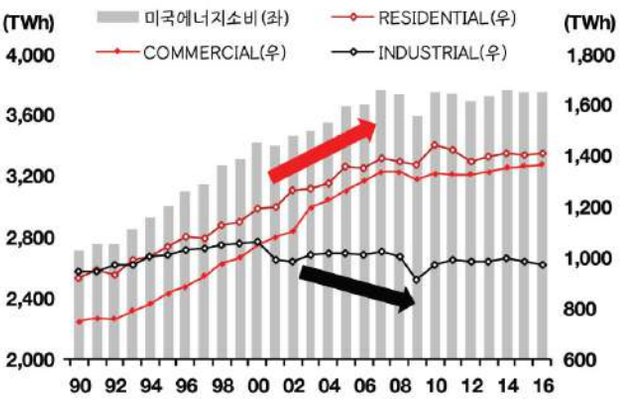
스마트시티는 전력부족이다

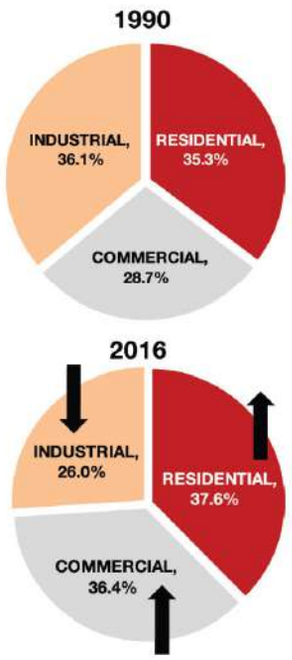
다만 이런 첨단을 바라봄에
있어서 초기에 인프라(infrastructure) 구축이
문제가 될 수 있다는 걱정은 거의 안 하는 것
같습니다. 특히 전기부족 같은 사태를 말이죠.



스마트시티는 전력부족이다

4차 산업혁명에서 전력소비의 문제는 미국을 보면 파악이 가능합니다. 그들은 이미 가정용과 상업용의 전력소비가 크게 증대 중인데, 그 이유는 바로 ICT 기술의 발전 때문입니다.



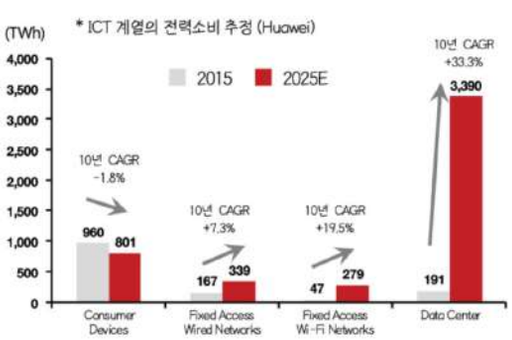


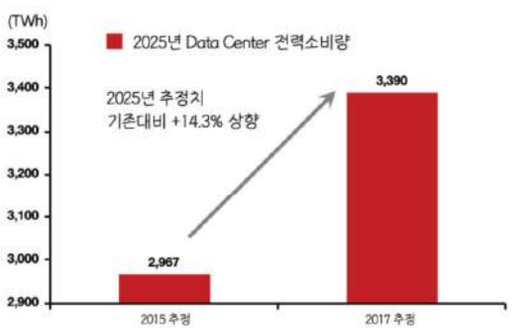
스마트시티는 전력부족이다

그렇기에 스마트시티 플랫폼 주도업체 중 하나인 화웨이(Huawei)는 이미 이런 분석을 내놓은 바 있습니다.

"Data Centers will use around 3–13% of global electricity in 2030 compared to 1% in 2010."
"데이터센터 전력소비는 2030년이면 전체 전력소비의 3~13%를 차지할 것이다.
2010년은 1%에 불과했다"

자료 : 스트레이트뉴스(2018년 10월 30일), SK증권



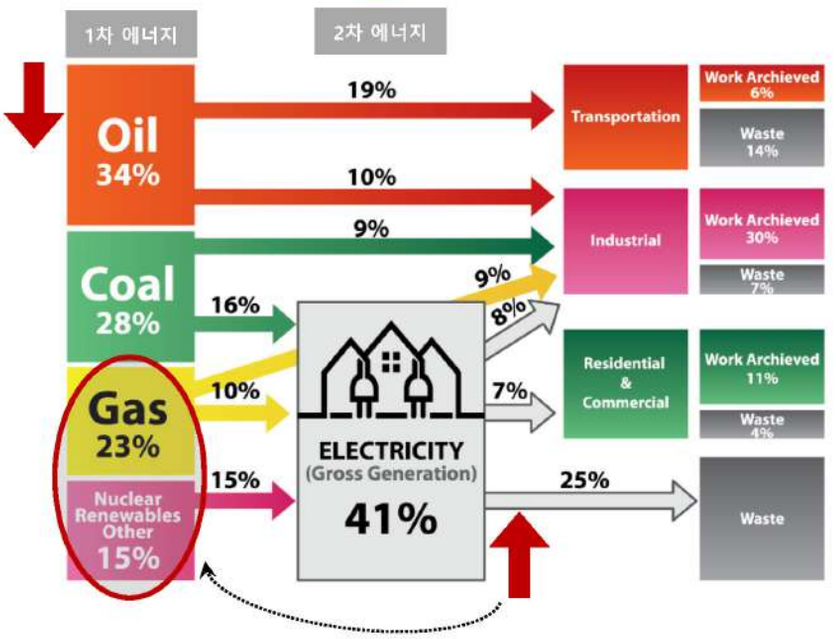


스마트시티는 전력부족이다

또 하나 간과할 수 없는 것이 전기차입니다

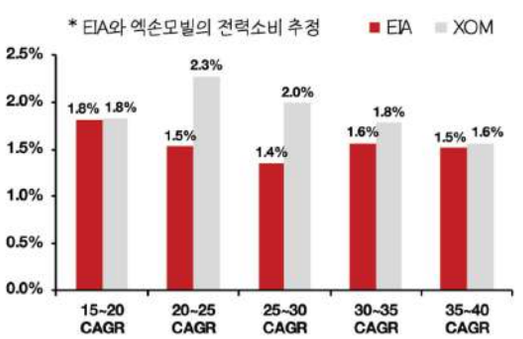
전기차는 1차 에너지 소비의
증대요인이 아닙니다
2차 에너지, 즉 전기소비의
증대요인으로 작용합니다

따라서 앞으로는
전기생산에 쓰이는
1차 에너지원(석탄 제외)에
관심 높아질 수밖에 없겠죠



스마트시티는 전력부족이다

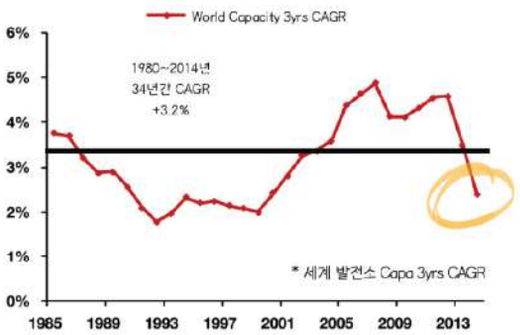
문제는 글로벌 유력 분석기관, 그리고 대한민국 정부도
이와 같은 4차 산업혁명 및 스마트시티의
전력소비 효과에 대해서는 간과하고 있다는 부분입니다.

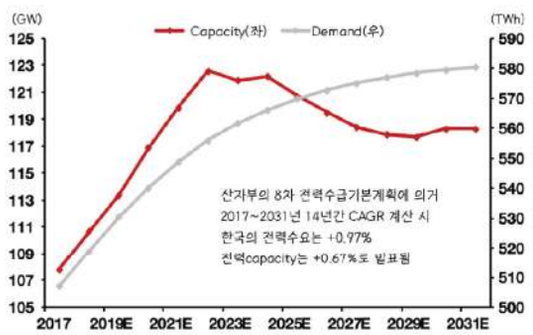


스마트시티는 전력부족이다

진짜 문제는 결국 전력소비가
줄어든다라는 글로벌 컨센서스 때문에
발전소 건설 자체가 세계적으로 많이
안 이뤄진다는 것이죠.

특히 한국 같은 경우는 수요가 안
늘어날 것이라는 가정에 기반하여 전력
capacity 자체가 2020년 이후면 오히려
줄이는 것을 계획 중입니다.

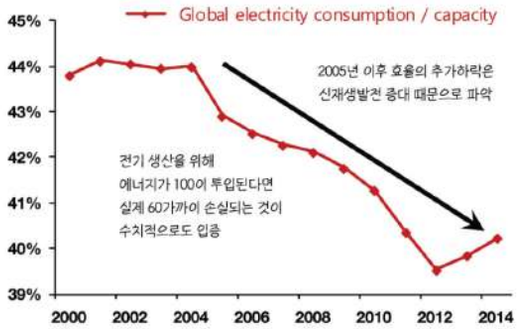




03 ESS, 그리고 전고체배터리

ESS, 그리고 전고체배터리

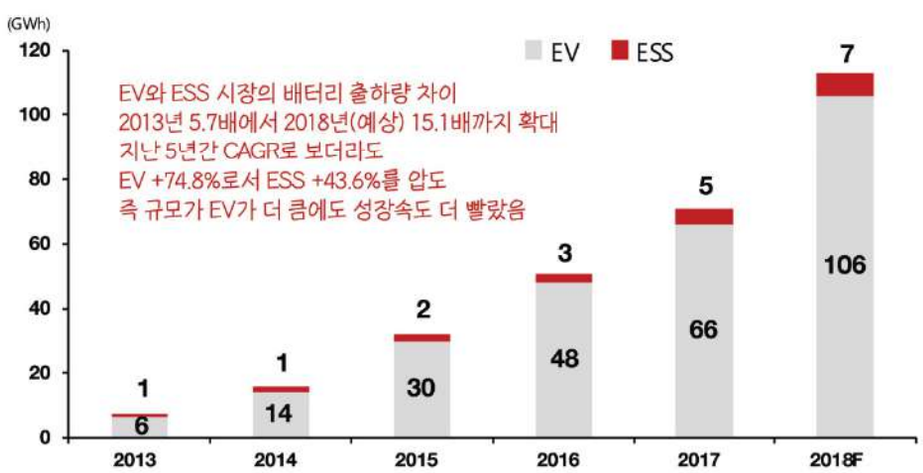
현재 전력 시스템은 비효율적인 부분이 꽤나 많습니다. 성수기와 비수기의 전력소비가 다르고, 뿐만 아니라 원천적으로 전력손실이 많이 발생하는 만큼 유휴설비가 꽤나 크게 계산되죠. 이를 효율적으로 바꿀 수 있는 방법은 없을까요?



현실적으로 하나 볼 수 있는 것이 ESS입니다.

ESS, 그리고 전고체배터리

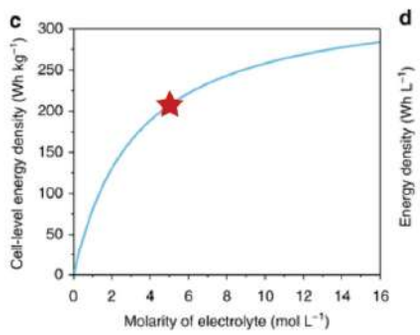
시장 규모는 전기차에 비해서 1/10도 안 되는 수준이지만, BESS의 가능성은 전기차에 뒤지 않을 것입니다. 배터리 시장은 앞으로도 계속 각광을 받겠네요.



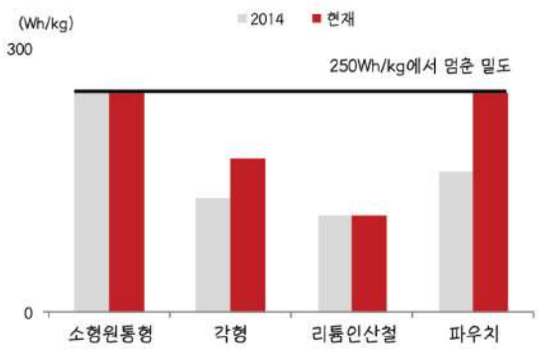
ESS, 그리고 전고체배터리

지금부터 주목해야 할 Game Changer가 등장합니다. 바로 전고체 배터리(Solid-state battery)입니다.

* 리튬이온배터리의 에너지 밀도는 리튬이온전지 이론적 추정치: 최대 300Wh/kg 제시

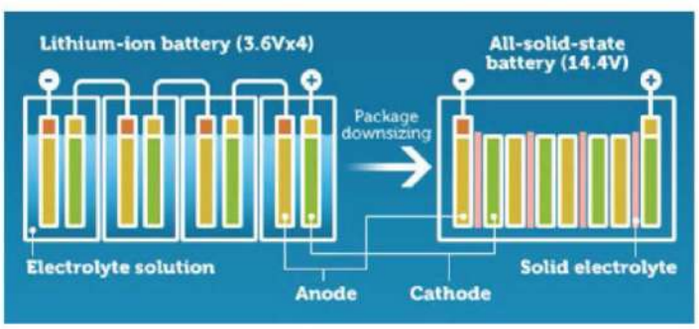


* 250Wh/kg에서 추가밀도 상승을 못 이뤄내



ESS, 그리고 전고체배터리

이 에너지 밀도를 해결해 줄 수 있는 유일한 방법이 바로 전고체 배터리입니다

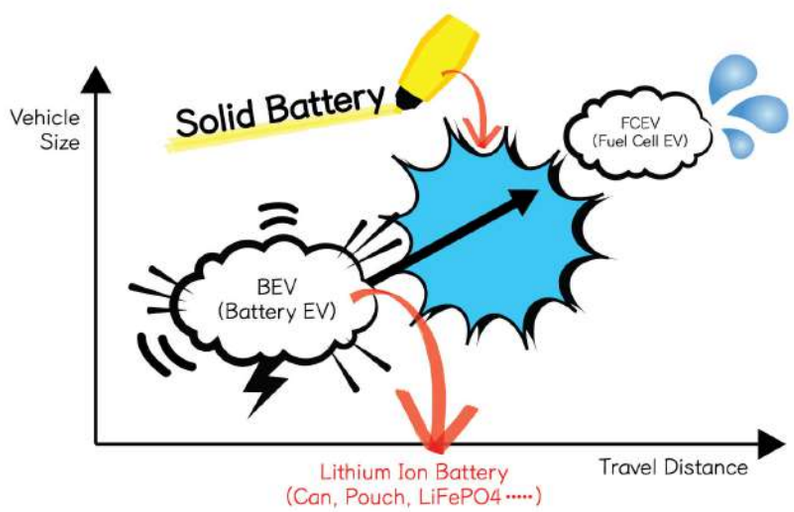


단전지화가 핵심: 분리막, BMS, packaging 사라짐. 그만큼 밀도증대여력 증대

ESS, 그리고 전고체배터리

그런데 이 전고체 배터리 시장을 선도하는 기업이 어디인지 아시나요? 바로 자동차 업체, 도요타입니다.
이미 Panasonic과 51:49 합작회사 설립을 하고 2020년부터 전고체 배터리를 생산한다는 군요.
자체적으로 2017년부터 이미 기술개발팀이 물러나고 양산팀이 들어선 상황이랍니다.

ESS, 그리고 전고체배터리



결국 앞으로 배터리에서는 파괴와 융합이 동시에 나타날 것으로 보입니다.
전고체는 등장할 경우 기존 리튬이온배터리 시장 뿐만 아니라 수소차 시장에도 큰 타격을 줄 것입니다.


Thank you!
End of document!
×
SK securities research center

기조연설 2

국제정치학 관점에서 본 동북아 협력의 중요성

김 연 규
(한양대학교 교수)

Center for Energy Governance & Security
Hanyang University

국제정치학 관점에서 본 동북아 협력의 필요성

김 연 규
한양대학교 국제학부 교수
한양대학교 에너지거버넌스 센터장
2019.9.18
2019 Future E Forum 발표자료
국회의원회관 대회의실

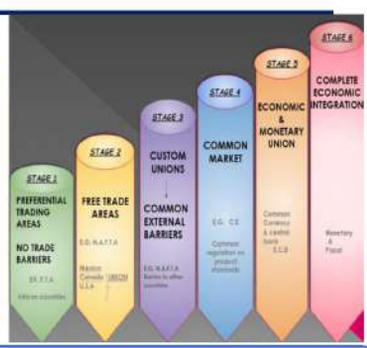
목 차

지역협력의 정의와 동북아지역협력의 특수성

동북아 지역내 다자협력체 구축

역내 지역협력의 정의

- 지역협력은 역내 자원의 효율적 배분과 초국경 문제해결을 위해 필요
- 협력의 주요분야: 인프라, 에너지공급, 자유무역협정, 금융, 통화협력, 사회 이민, 군사안보 협력
- 지역협력은 정치군사 등 경성이슈 보다는 기능분야의 에너지, 인프라 등 연성이슈 협력에서 시작



EU와 동북아 지역협력의 비교

- 2차례의 세계 전쟁을 겪은 유럽은 20세기 하반기 에너지공동체에서 출발 무역 통화 금융 분야 지역협력. 군사안보 분야에서 좌절
- 동북아 지역은 역내 인프라와 연계성 부족과 자원의 비효율적 배분의 문제 심각하여 지역협력의 혜택이 예상되나 역내협력 수준 매우 낮아
- 동북아 지역 내 모든 국가(한, 중, 일, 몽, 러)들이 참여하는 동북아에너지협력과 인프라 구축을 위한 정부간협의체 형성 절실

동북아지역 협력이 부진했던 원인은 무엇인가?

동북아 역내 협력이 부진한 이유

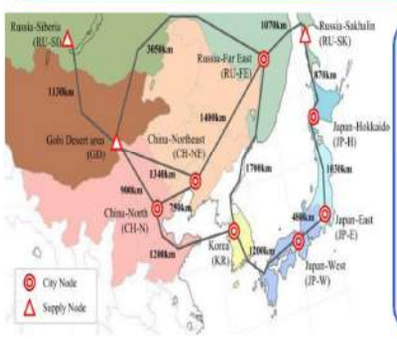
- 동북아는 에너지자원의 매장 분포와 역내 각국의 에너지수급구조의 차이를 감안할 때 지역 에너지협력을 확대할 수 있는 엄청난 잠재력. 그러나, 미국 에너지패권체제로의 편입.
- 러시아는 아직까지도 동북아지역에 부존되어 있는 에너지 자원을 적극적으로 개발하여 공급하고 있지 못해. 따라서 동북아의 에너지 수입국은 동북아보다 다른 지역의 수입에 크게 의존. 한국과 일본에게는 석유의 전량을 海路로 도입하고 중동의존도가 80%에 달해 생명선이나 마찬가지.
- 동북아는 러시아 에너지 인프라와 단절, 걸프지역에 의존. 미-일 동맹에 의해 러시아아시아 남진 차단. 중-러 대립은 더더욱 동북아에서의 러시아 입지 약화. 극동 시베리아 낙후의 결과. 러시아 태평양함대 약화와 무역 차단
- 동북아 지역에는 EU의 EC 와 같은 국가간 기구의 부재. 동북아에너지협력 정부간협의체 형성에 대한 필요성이 제기되었지만, 현재까지 에너지분야의 역내 정부간에 정례 양자회의는 있지만, 다자회의는 없는 상황
- 동북아지역에서는 에너지 다자간협의체 결성이 ASEAN 방식, 또는 EU방식이 적절한가?
- 동북아지역 전체 회원국이 참여하는 지역협의체 결성이 가능한가?

최근 동북아지역 협력이 다시 주목 받는 배경은 무엇인가?

1990년대-2000년대 동북아 지역 협력

1990년대 동북아 협력

- 1990년대 동북아 협력은 중-러 화해 배경으로 에너지협력과 중-러 무기거래 중심
- 한-중 한-러 수교로 한-중-러 연결 북방협력. 한중일의 러시아에너지 개발 경쟁
- 미국의 동남아 신남방 지역 철수와 중국의 동남아 진출 확대
- 1997년 아시아 금융위기로 ASEAN+3 아시아 지역협력 공감대



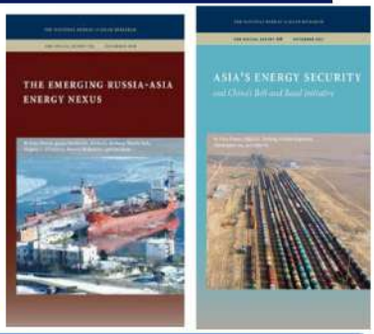
2000년대 동북아 협력

- 2000년대 고유가로 러시아 재부상. 에너지수입으로 국방력강화. 러시아-유럽 관계악화로 러시아 본격적으로 아시아지역으로 에너지수출
- 러시아는 전체에너지재정수입의 35%, 전체가스수출의 67% 차지하는 유럽에 의존하는 리스크 인식
- 유럽은 2030년이후 가스보다는 재생에너지 주로 의존가능성. 따라서 아시아시장 수출 필요.

2010년대 동북아 협력의 전개

2010-2016년 동북아 협력의 전개

- 러시아의 아시아 시장 진출은 쉽지 않아!
- 현재로서는 중국만 연결. 한국/일본은 연결 안되!
- 석유는 한중일 수입시장의 30% 차지. 아시아가스시장 진출은 훨씬 더디게 진행.
- 이유는 중국은 2000년대 가스수요 급증했으나 수입비중이 크지 않았고, 한일은 대부분 미국주도 중동 LNG와 동남아 LNG 수입. 중국은 주로 PNG 구축



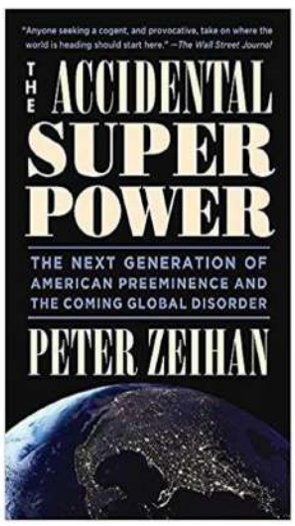
2017년 이후 변화

- 2014-2016년 중러 가스관계약은 더디게 실행. 유가하락으로 $55 billion 투자한 러시아가 $5 하락한 PNG 가스가격에 수지 맞추기 힘들어 서두르지 않아. 당시 $7 정도의 LNG 가격과 차이 별로 없어.
- 2017년 말부터 상황급변. 중국 가스수요 급증. 러시아 협상력 우위.
- 러시아 중국과 3개의 PNG 노선 (PoS1, PoS2. Far East PNG)과 2개의 북극 LNG 사업 추진.
- 한국의 신북방, 신남방 정책으로 중러 협력에 한국 참여

21세기 미-중패권 경쟁과 동북아 협력

21세기 미-중 신냉전과 동북아 협력

- 20세기는 미국에 의한 글로벌 자유무역, 안전한 에너지 공급에 의존하는 시대
- 21세기의 가장 큰 특징은 보호무역주의 대두, 에너지란, 그리고 심각한 새 이슈는 고령화.



- 보호무역에 의해서 미국시장으로의 수출에 제약이 걸리고 수많은 원자재 수입이 어려워지면 중국 한국 일본(?) 경제에 빨간불.
- 중국의 바닷길의 대부분은 미국 우방 세력에 의해 둘러쌓여. 21세기 중국이 헤게모니를 쥐고 해상을 장악하고 글로벌 무역을 하기에는 다양한 제약조건

THANK YOU !

Center for Energy Governance & Security
Hanyang University

발 표 1

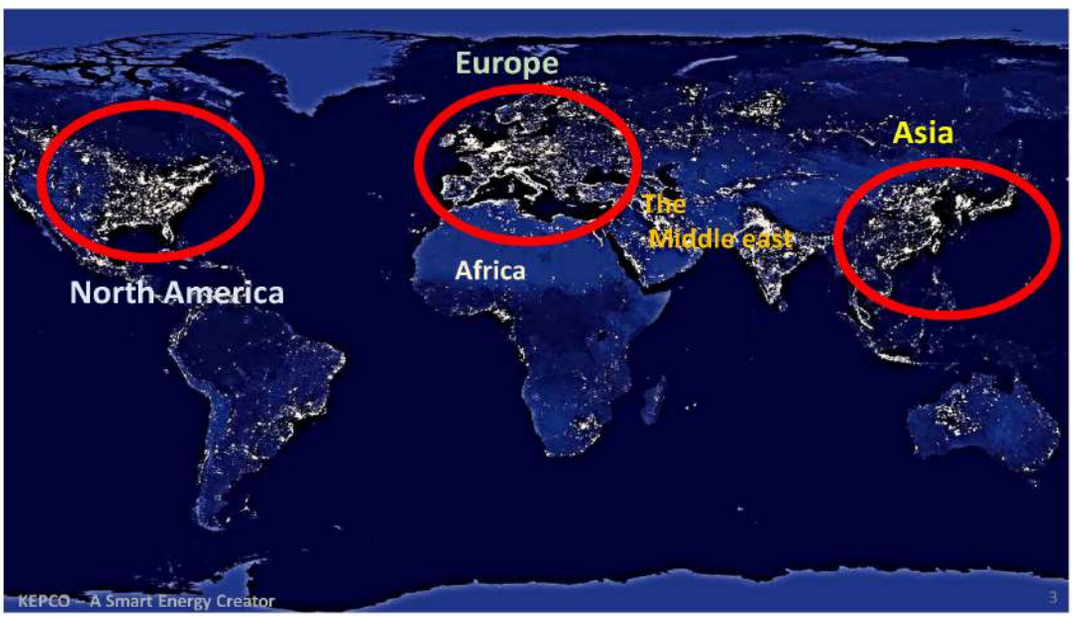
한-중 전력계통연계 추진 현황과 전망

강 현 재
(한국전력 처장)

CONTENTS

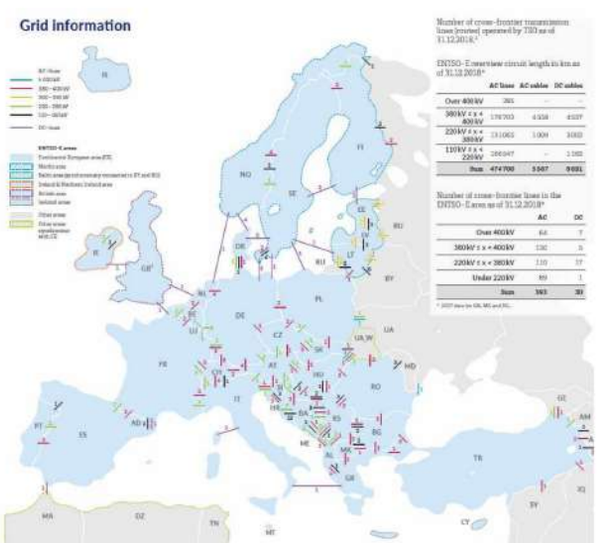
1 Cross-border Interconnection

Electricity Demand



1 Cross-border Interconnection

Interconnection in Europe



European Commission

entsoe
Reliable Sustainable Connected

36 countries
43 power utilities

EU and ENTSO-e drive cross-border interconnections

Now 2018,
423 interconnectors('18.12)
467 TWh Exchanged('18.12)

Until 2040,
100 more interconnectors

KEPCO – A Smart Energy Creator

source : ENTSO-e 4

1 Cross-border Interconnection

Interconnection in North America

First interconnector in the world (1901)

Now 37 interconnectors between U.S. and Canada

74.5GWh Exchanged in 2018

Further 6 interconnectors(5GW) until 2025

"Enhanced flexibility and reliability of North America power grid"

* USA, Canada, Mexico summit('16)

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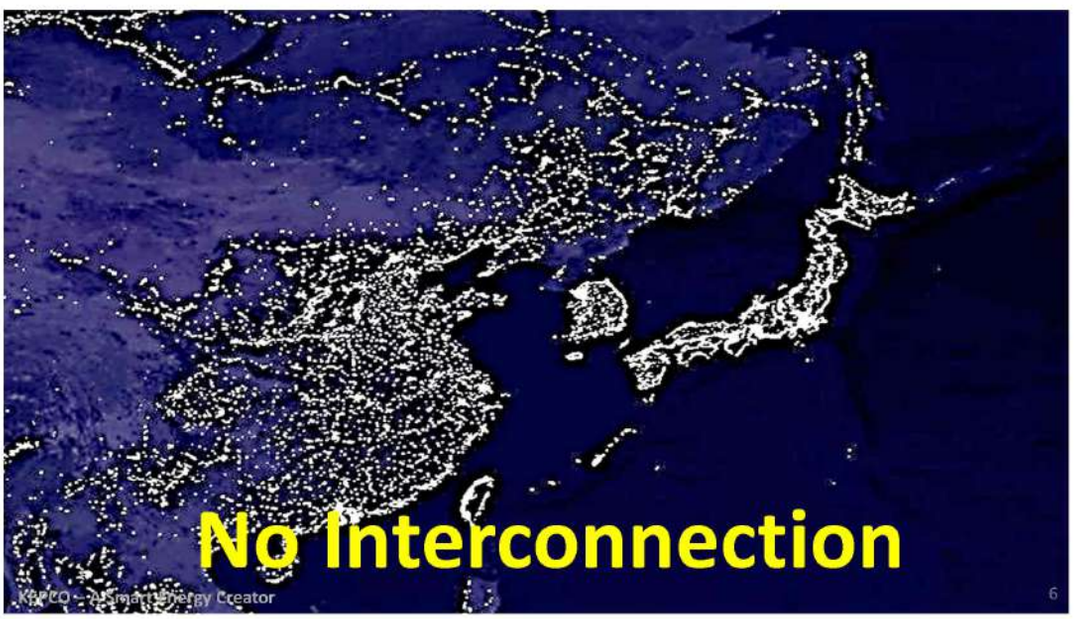
source : Canadian electricity association 5

1 Cross-border Interconnection

Northeast Asia



KEPCO – A Smart Energy Creator 6

2 C-K project Progress

Major Progress (2016~2017)

'16.03	MOU on Joint Promotion of Power Grid Interconnection between SGCC(China) - KEPCO - SoftBank(Japan) - Rosseti(Russia)
'16.06 ~ '17.03	Joint Pre-F/S on China-Korea-Japan Power Interconnection between SGCC – KEPCO - SoftBank
'17.12	MOA on Joint development of China-Korea Power Interconnection between SGCC-KEPCO-GEIDCO ※ MOU between Korea-China

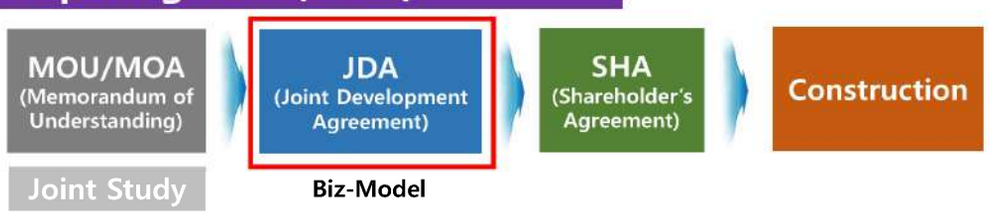


2 C-K project Progress

Review Study (2018)




Preparing JDA (2019)



2 C-K project Progress

Example of Project Development

elia nationalgrid

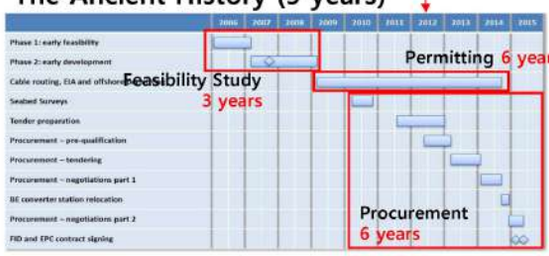
50% 50%

Nemo Link

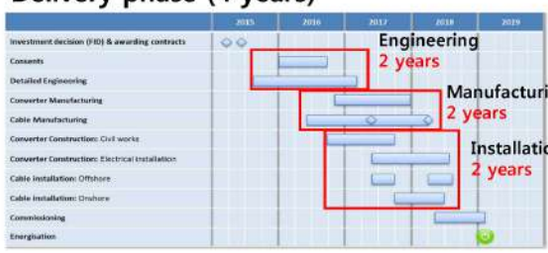
HVDC 400kV – 1,000MW
140km (130km submarine cable)

The Ancient History (9 years)

JV Incorporated



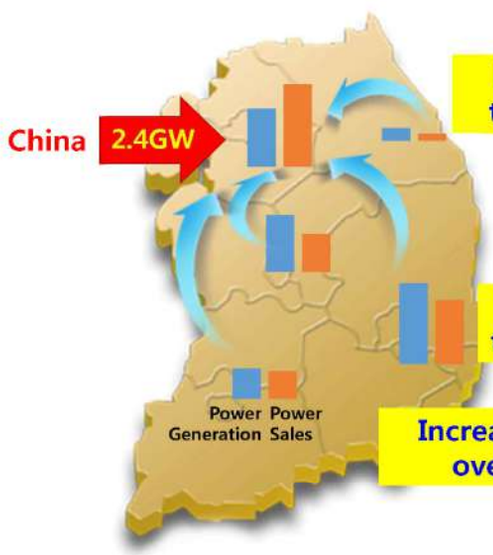
Delivery phase (4 years)



source : Nemo Link

3 Project Effectiveness

Stability of Power Supply



Reduced power flow toward northern area

with 2.4GW direct access to northern(metropolitan) area

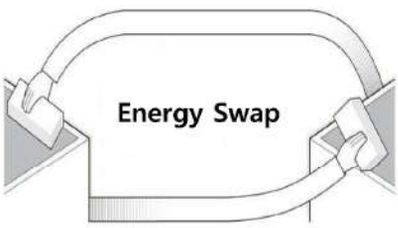
The larger the total grid, the larger the renewable energy accommodation

Increased grid reliability through overcoming of "Grid Island"

source : KEPCO, KEEI

3 Project Effectiveness

Social Benefit



- **Price reduction effect with low-cost generation**
  (EU saves annual generation costs €2bn to 5bn in 2030)
- **Elevated Cooperative Tie among Northeast Asia**
  (Effectiveness of Energy Swap)
- **Technical development and Creation of jobs**

source : WEC, ENTSO-e 11

4 Issues

Inter-governmental Support

- ***Enhanced cross-country reliability of Northeast Asia***
- ***Establishment of inter-governmental commission***

ENTSO-e(Europe)

ASEAN(Southeast Asia)

ECOWAS (Southwest Africa)

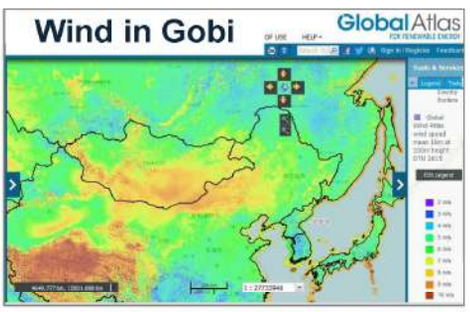
source : ENTSO-e, ASEAN, ECOWAS 12

4 Issues

Co-developing Renewable Energy

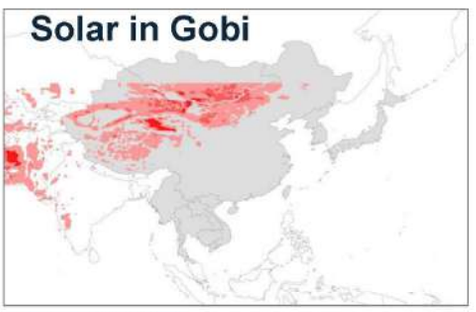
- *Renewable Energy Development of Gobi Desert*
- *Interconnection between China and Mongolia*

Wind in Gobi



Wind : more than 8m/s

Solar in Gobi



Solar : 270-300 sunny days in a year, 4.3-4.7 kWh/meter or higher per day

source : Mongolia government 13

4 Issues

Revision of Law and Regulation

***First* Business in Korea**

***First* Definition in Korean law**

Electric Utility Act & KEPCO Act

New Definition

- **Oversea power supplier**
- **Cross-border interconnection business**
- **Expansion of transmission line concept**
- **Legal basis of PPA contract**

Prior Assignment for Interconnection Business

source : KEPCO 14


Thank you
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15

발 표 2

글로벌 전력망 연계 구상 현황과 과제

Gao Yi
(GEIDCO 박사)

Status and Challenges for Global Power Grid Interconnection

Global Energy Interconnection Development and Cooperation Organization (GEIDCO)

Korea

Sept. 18, 2019

GEIDCO

Global Energy Interconnection Development and Cooperation Organization
全球能源互联网发展合作组织

- Established: March, 2016
- Mission: Promote Global Energy Interconnection (GEI) to meet the global energy and power demand with clean and green alternatives.

GEIDCO members 602 from 86 countries/regions

1

발 표 2. 글로벌 전력망 연계 구상 현황과 과제 35

Global Energy Interconnection
Development and Cooperation Organization
全球能源互联网发展合作组织

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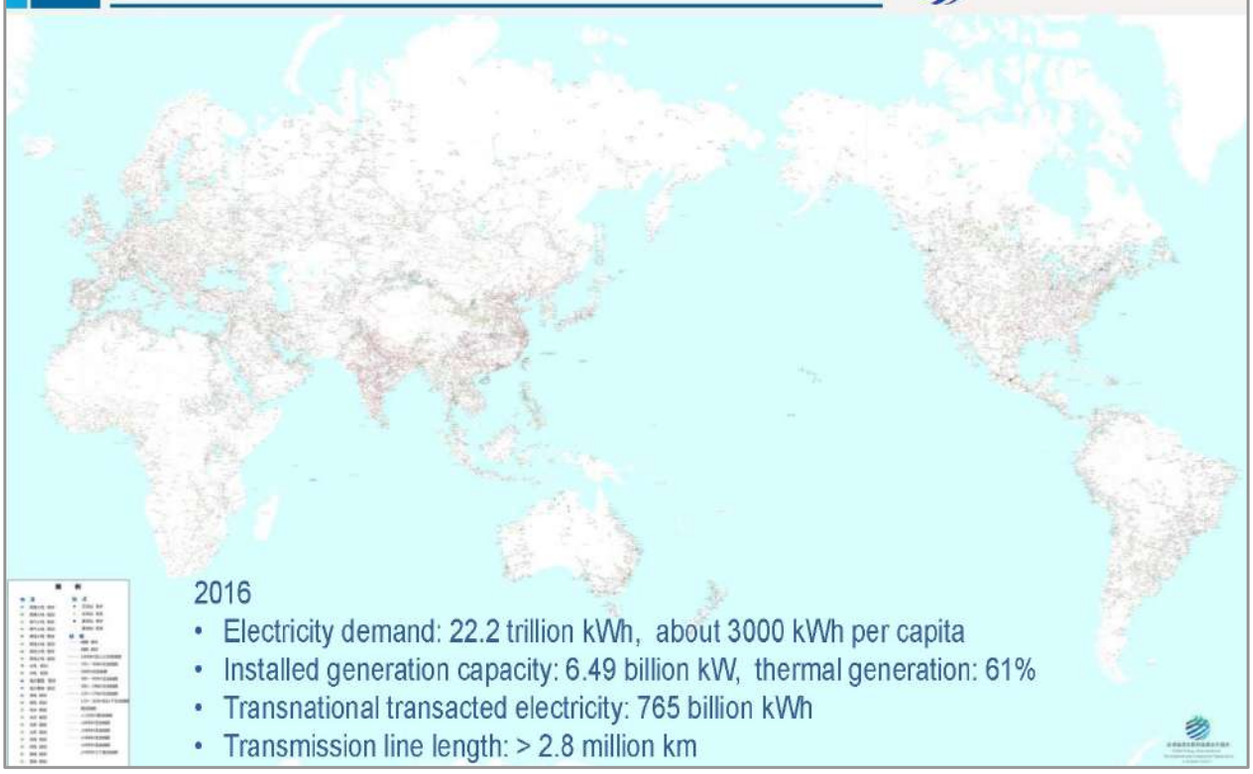
Global Power Grid

Global Energy Interconnection
Development and Cooperation Organization
全球能源互联网发展合作组织



2016

- Electricity demand: 22.2 trillion kWh, about 3000 kWh per capita
- Installed generation capacity: 6.49 billion kW, thermal generation: 61%
- Transnational transacted electricity: 765 billion kWh
- Transmission line length: > 2.8 million km

Europe

Global Energy Interconnection Development and Cooperation Organization
全球能源互联网发展合作组织

Power grids are interconnected in Europe to promote closer cooperation to support the implementation of EU energy policy and achieve Europe's energy and climate policy objectives.

By the early 20th century, most countries built their power grids.

↓

1920s to the 1960s, cross-border network received more and more attention.

↓

1970s to the late 1990s, the interconnection scale further expanded and formed the European continent unified synchronous network comprising 24 countries.

↓

Now, the ENTSOE-E cover 36 countries, including the world's largest interconnected cross-border power grid.

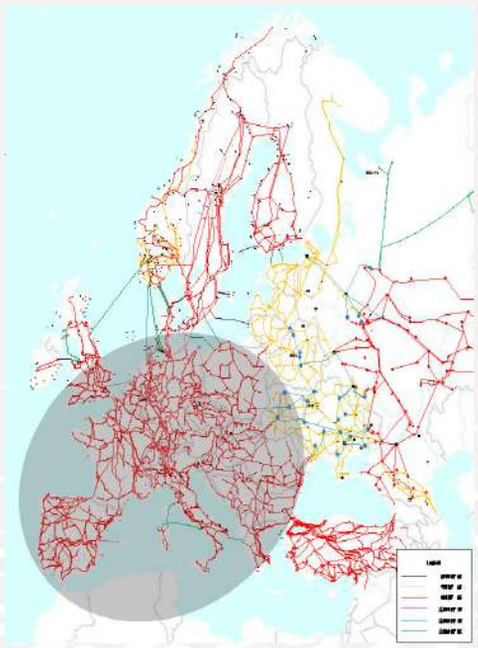


Diagram of Power Grid Interconnection in Europe

4

North America

Global Energy Interconnection Development and Cooperation Organization
全球能源互联网发展合作组织

Along with synchronous interconnection, the power grid capabilities are enhanced in terms of mutual support and backup between hydropower and thermal generation sectors, and between wet and dry periods.

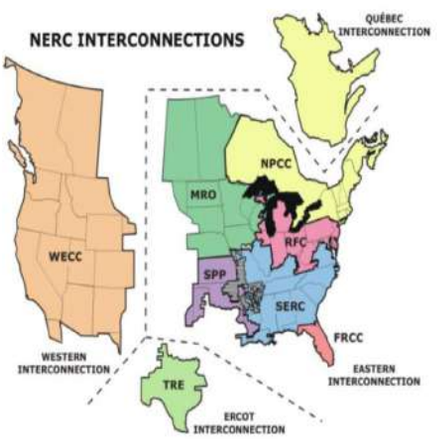
By the early 1900s, isolated AC systems were formed according to the load and power supply requirements.

↓

1920s to the early 1960s, isolated systems began to interconnect across the states and borders.

↓

By the 1980s, four synchronous power grid were in operation, including the eastern, western, Texas and Quebec power grids.



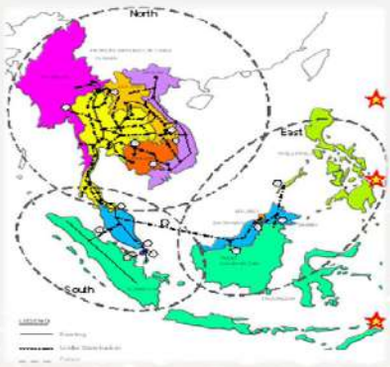
NERC Interconnections

5

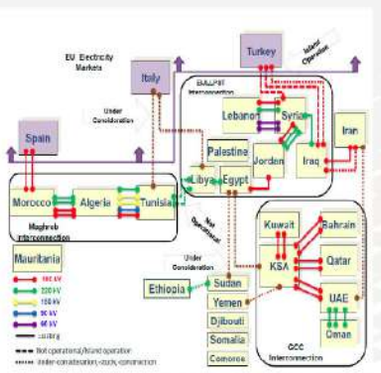
Subregions

Global Energy Interconnection Development and Cooperation Organization
全球能源互联网发展合作组织

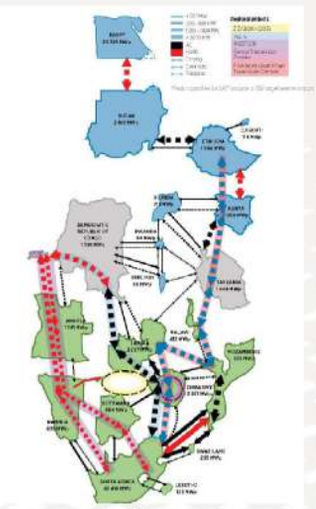
With the regional economic integration accelerating, regional power grids are gradually achieved to ensure adequate power supply, reduce investment and operating cost, and obtain benefits of power grid interconnection.



ASEAN



Pan-Arab



Africa

Driving Forces for Grid Interconnection

Global Energy Interconnection Development and Cooperation Organization
全球能源互联网发展合作组织

Although the structure of a grid is closely related to energy resources distribution, electric power balance manner, and political system, etc., the way of interconnection is chosen to expand grid scale.

- Meet electricity demand requirement
- Uneven distribution of energy resources
- Diversification of power supply & a dynamic capacity
- Regional economic integration
- Promote competitive power trading and pooling policies

Global Energy Interconnection
Development and Cooperation Organization
全球能源互联网发展合作组织

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I. Status of Power Grid Interconnection

II. Study on Global Energy Interconnection

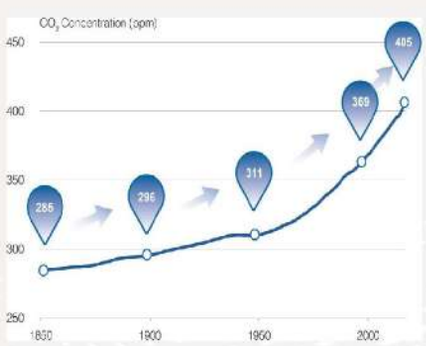
III. Challenges and Initiatives

Sustainable Development

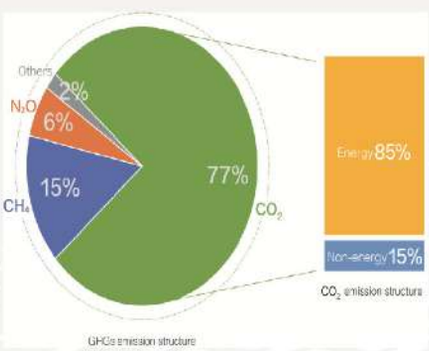
Global Energy Interconnection
Development and Cooperation Organization
全球能源互联网发展合作组织

- The Paris Agreement on climate change
- The core of sustainable development lies in clean development

Clean Replacement



Variation of Atmospheric Concentration of CO2



Compositions of Global Greenhouse Gases Emission in 2014

Electricity Replacement

9

The Essence of GEI

Global Energy Interconnection Development and Cooperation Organization
全球能源互联网发展合作组织

GEI is a modern energy system featuring higher proportion of clean energy integration, global energy dispatch and allocation, and smarter, more robust and reliable power network with higher electrification level.

Smart grid + **UHV grid** + **Clean energy**

Foundation *Key* *Priority*

10

Constructing GEI

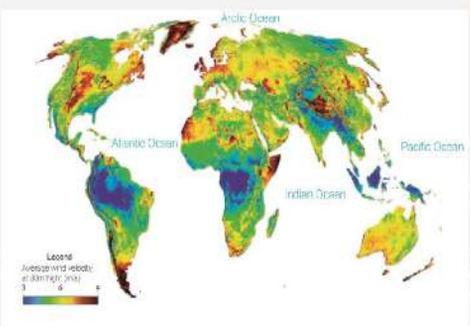
Global Energy Interconnection Development and Cooperation Organization
全球能源互联网发展合作组织

Main Procedure:

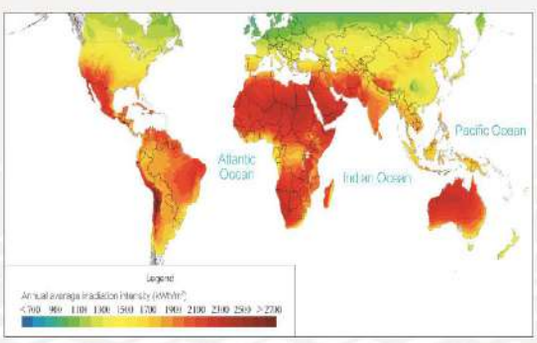
Demand---Resource---Generation---Power Exchange Direction & Scale ---

---Interconnection Scheme---Investment---Benefit

- Global wind and solar energy resources are abundant but not evenly distributed.
- Wind and solar power are intermittent and fluctuating. The large-scale exploitation, allocation and efficient utilization of clean energy resources worldwide shall be achieved only by integrating clean energy generation into a globally interconnected grid.

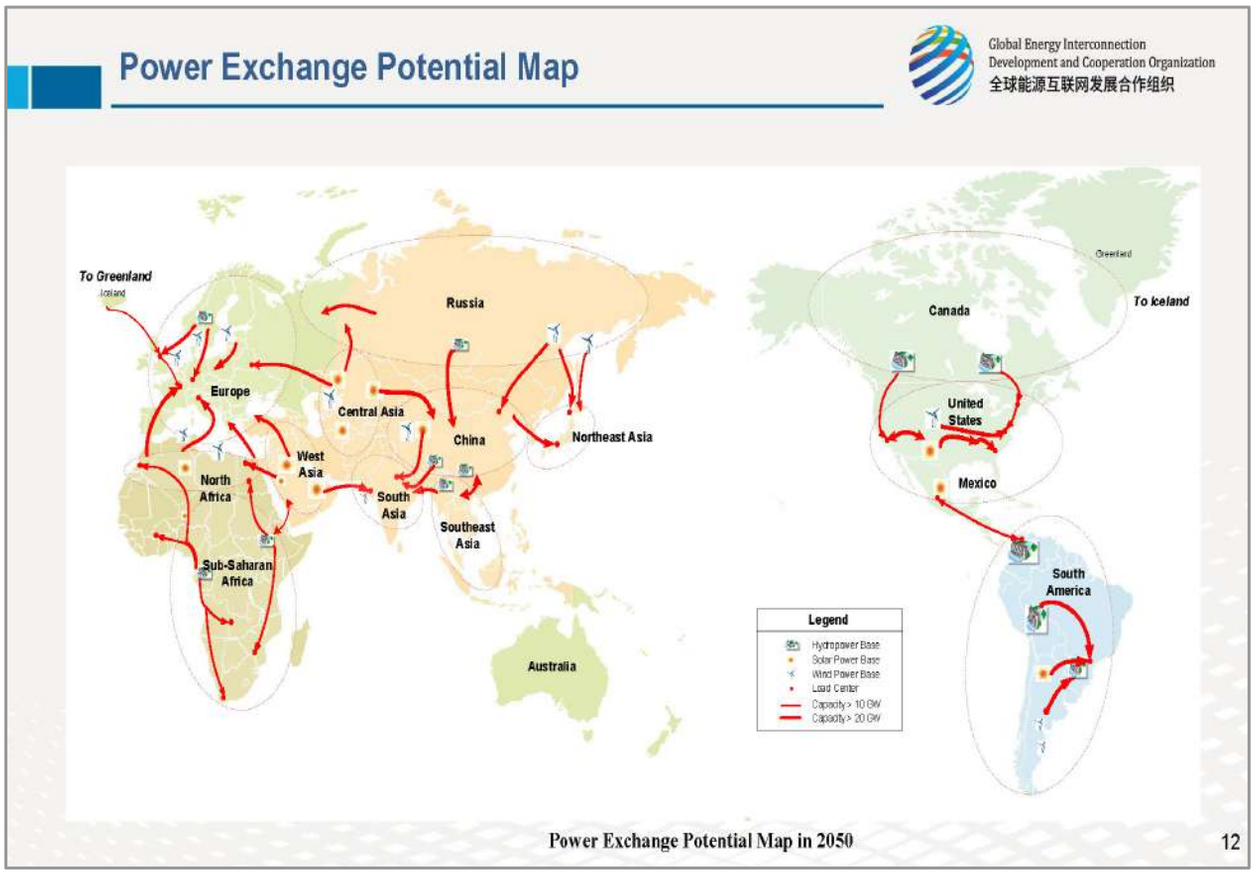


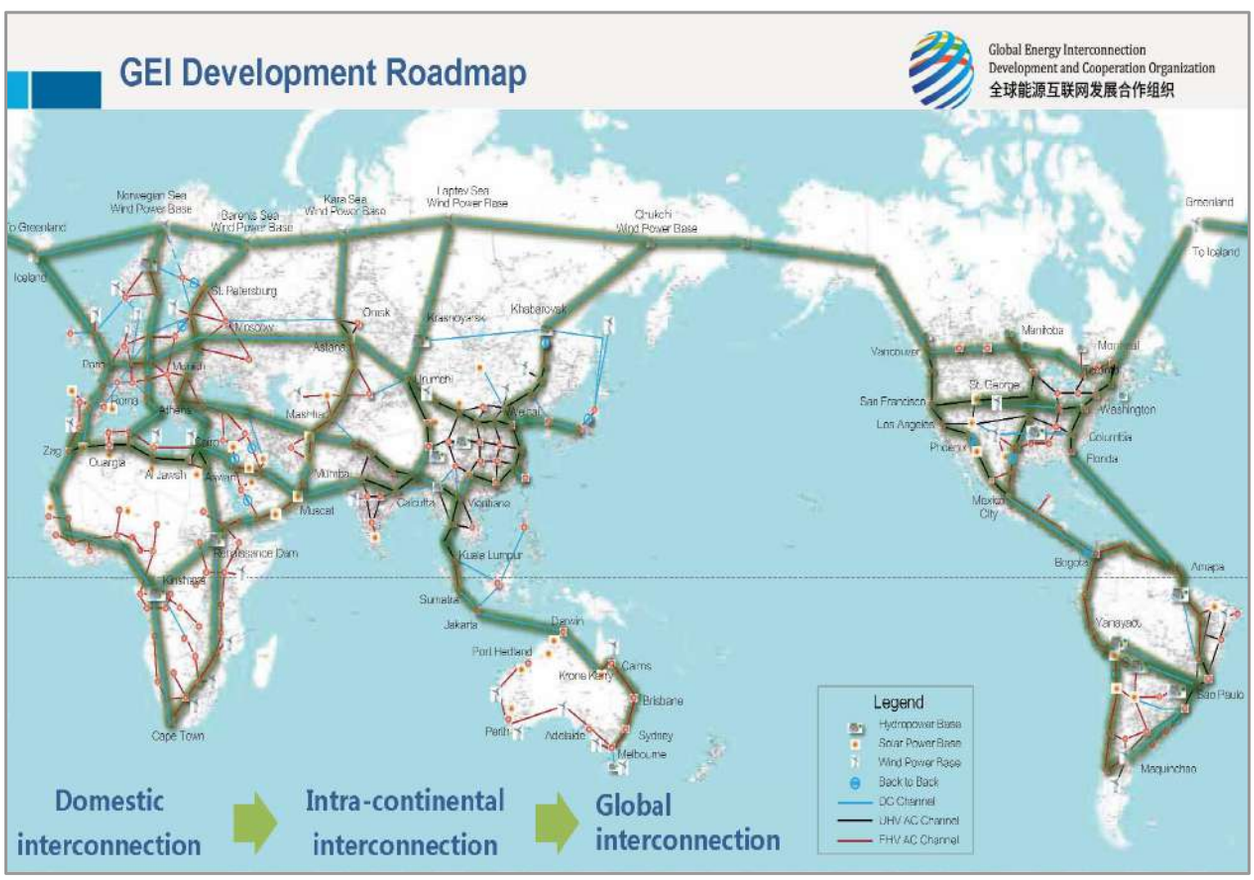
Global Distribution of Wind Energy Resources



Global Distribution of Solar Energy Resources

11





발 표 2. 글로벌 전력망 연계 구상 현황과 과제 41

Research under GEI Scenario

Global Energy Interconnection
Development and Cooperation Organization
全球能源互联网发展合作组织

Asia
North America
South America
...

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Global Energy Interconnection
Development and Cooperation Organization
全球能源互联网发展合作组织

➢ Europe

Overall Pattern of Europe Power Grid Interconnection in 2050

➢ Africa

Overall Pattern of African Grid Interconnection

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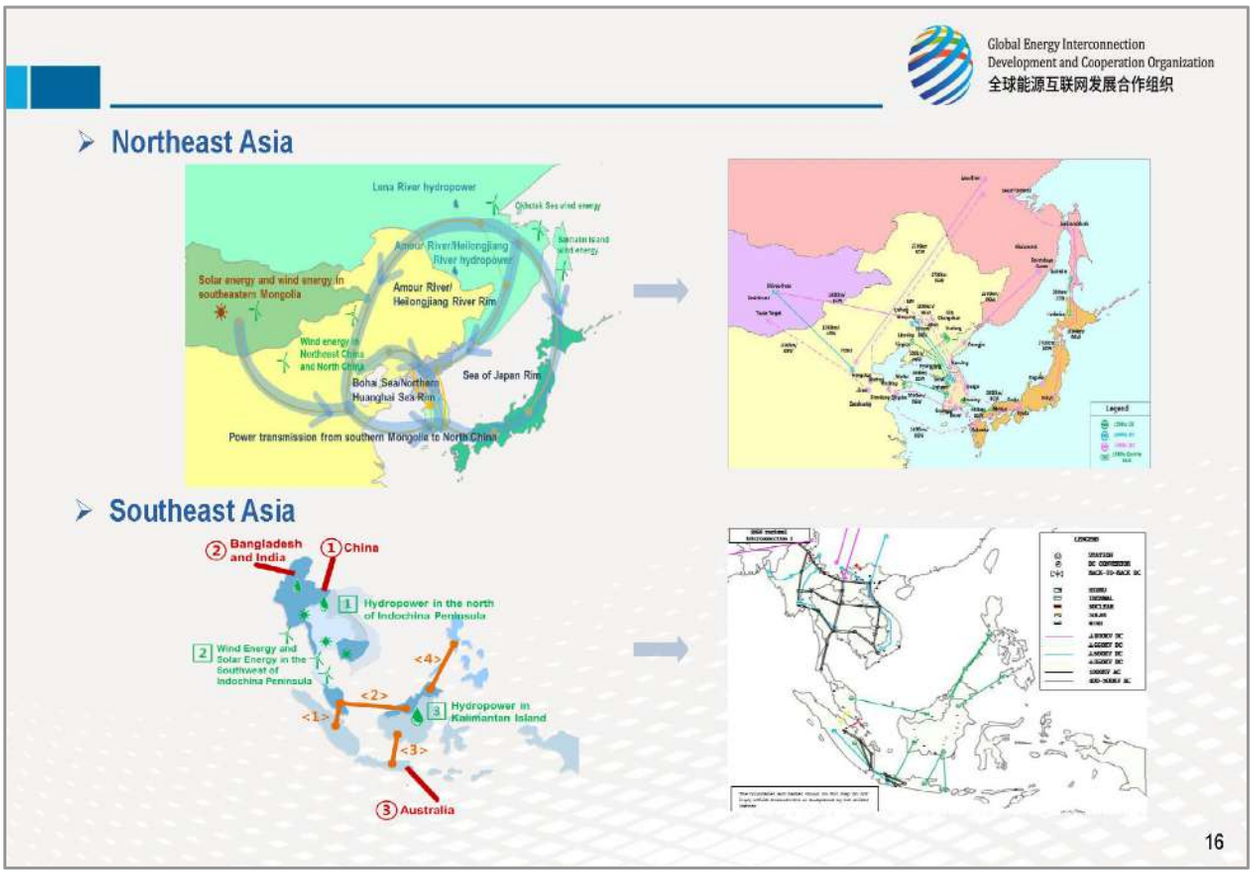
Global Energy Interconnection
Development and Cooperation Organization
全球能源互联网发展合作组织
Northeast Asia
Lena River hydropower
Amour River/Heilongjiang River hydropower
Solar energy and wind energy in southeastern Mongolia
Amour River/ Heilongjiang River Rim
Wind energy in Northeast China and North China
Bohai Sea/Northern Huanghai Sea Rim
Sea of Japan Rim
Power transmission from southern Mongolia to North China
Southeast Asia
Bangladesh and India
China
Hydropower in the north of Indochina Peninsula
Wind Energy and Solar Energy in the Southwest of Indochina Peninsula
Hydropower in Kalimantan Island
Australia
16


Research Reports
Global Energy Interconnection Action Plan
Global Energy Interconnection Backbone Grid Research 2018
Global Energy Interconnection Development Index 2018
White Paper on Global Energy Interconnection Development Strategy
Global Energy Interconnection Development and Outlook 2017
Global Energy Interconnection Technology & Equipment Innovation Outline 2018 - 2025
Global Energy Interconnection Standard System Research 2018
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Global Energy Interconnection
Development and Cooperation Organization
全球能源互联网发展合作组织

Contents

Global Energy Interconnection
Development and Cooperation Organization
全球能源互联网发展合作组织

Challenges

Electricity is an inherently strategic commodity and the efforts to engage in deep integrated trading thus faces political, regulatory, technical, and economic/financial challenges

Energy policy

Under the condition of regional power grid interconnection, how to promote each government to formulate energy policies in line with the overall trend of the region development and combing with the characteristics of energy development in each country.

Regulatory system

Considering each country condition, how to propose appropriate legal framework and regulatory system to meet the needs of regional power supervision, and promote the coordination among the national electricity regulatory.

Electricity market

How to study and propose schemes of an unified electricity market from aspects of the organization, mechanism and regime in order to form a harmonious cross-boundary electricity market pattern in a region.

Technical standard

How to establish GEI specification and standard based on power grid interconnection safety and operation efficiency, which will be used to guide technology from power grid planning to operation in the future.

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Initiatives

Global Energy Interconnection Development and Cooperation Organization
全球能源互联网发展合作组织

Jointly Promoting planning coordination

Give full play to the leading role of the government, to strengthen policy support, jointly conduct planning studies, incorporate planning results into sustainable energy development plans of various countries, promoting and accelerating cross-border energy and power interconnection.

Jointly Promoting Technological Innovation

Give full play to the advantages of universities and scientific research institutions, to strengthen cooperation in areas such as large-capacity submarine cables, VSC-HVDC, high-efficiency clean power generation technology, fostering innovative breakthroughs.

Jointly Promoting Project Implementation

Give full play to the role of energy enterprises and financial institutions to innovate business models, and promote the construction of a number of clean energy and cross-border interconnection projects with high economic efficiency and good demonstration effect, so as to bring project implementation as soon as possible.

Jointly Promoting Mechanism Construction

Give full play to the coordination role of international and regional organizations, to promote greater cooperation among countries, establish bilateral and multilateral cooperation mechanisms such as project development, electricity market and power grid operation, achieving coordinated development.

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Creating a Better Future for Sustainable Regional Economic, Social and Environment Development

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발 표 3

독일 통일과정이 시사하는 전력계통 표준화

서 병 문
(베를린대 교수)

Energy Policy of Germany before and after unification

Dr. Mark B. M. Suh
International Council
Pugwash Conferences on Science and World Affairs

2019 Future E Forum, Seoul, 18. 9. 2019

Germany 1945-1949

4 Military Zones:
American,
British, French
and Soviet Zones

German 1990-present

16 Independent States
form the Federal Republic
of Germany

West German Energy System, 1949-1990

- Free Market oriented Energy System
- Based on Coal and Nuclear Power Plants
- Strong economy and growing demand for stable energy supply
- Strong Nuclear industry: growing resistance against it after the Chernobyl(1986) and Fukushima(2011) accidents
- All nuclear power plants will stop operation by 2023
- Enormous problems with the nuclear waste, still unresolved

East German Energy System, 1949-1990

- Centrally planned and controlled system
- Cooperated only with the Soviet Union and other socialist countries
- Based on Brown Coal and conventional energy sources
- Serious environmental damages and pollution
- Chronic shortages of electricity and heavy pollution, unstable but cheap
- Sought technical Cooperation with West Germany to reduce pollution in the 1980s

Energy Cooperation of East and West Germany, 1989.11-1990.2

- East and West German governments started to liberalize East German Energy market from 1 November1989 to February 1990 and decided to abandon the East German Energy System
- From February 1990 German government decided to integrate East German system into the West German Energy System and focused on solving mainly serious environmental problems

Privatization of East German Energy Market

- Two Germanies agreed in June 1990 that West German companies Preussen Elektra, Bayernwerk and RWE will provide electricity to East Germany. Already in January 1991 these three companies owned 75% of East Geman energy market and the remaining 25% were also sold to West German utility companies.
- The Swedish Group Vattenfall is now dominating the North Germany including Berlin, own many power plants including nuclear reactors
- Former East Germany is now fully integrated in the German and European Energy Market and enjoy stable supply and improved environment

Energy Market after the Unification, 1990-1994

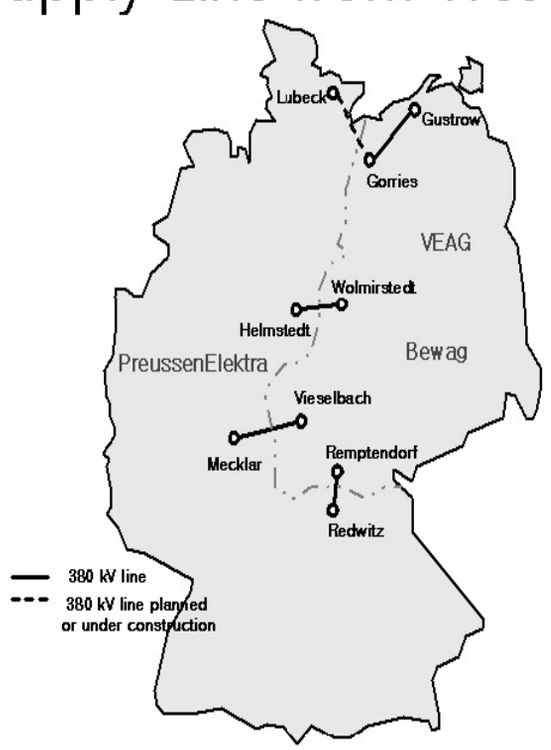
- Privatization by the Treuhandanstalt (Trusteeship Institution)
- all East German state enterprises and companies on sale
- Mostly bought by West German companies or investors cheaply
- Privately owned and market oriented energy system like Western Germany

Dissolution of East Germany (Treuhandanstalt),1990-1994

- 15102 State/public Enterprises: More than 4 Million workers employed
- More than 2,22 Mio. Ha farmland
- Some 2,07 Mio Ha. Forestland

- 1990. 2: East German authority estimated some 130 billion E Mark
- 1990.10: West German authority estimated some 60 billion W. Mark
- When Treuhandanstalt took over on July 1,1990 all enterprises had total 270 billion Mark debts
- Until 1994 some 14000 enterprises were privatized and Treuhandanstalt was dissolved
- In 1995 were some 3.3 million unemployed in former East Germany

Energy Supply Line from West to East, 1991-

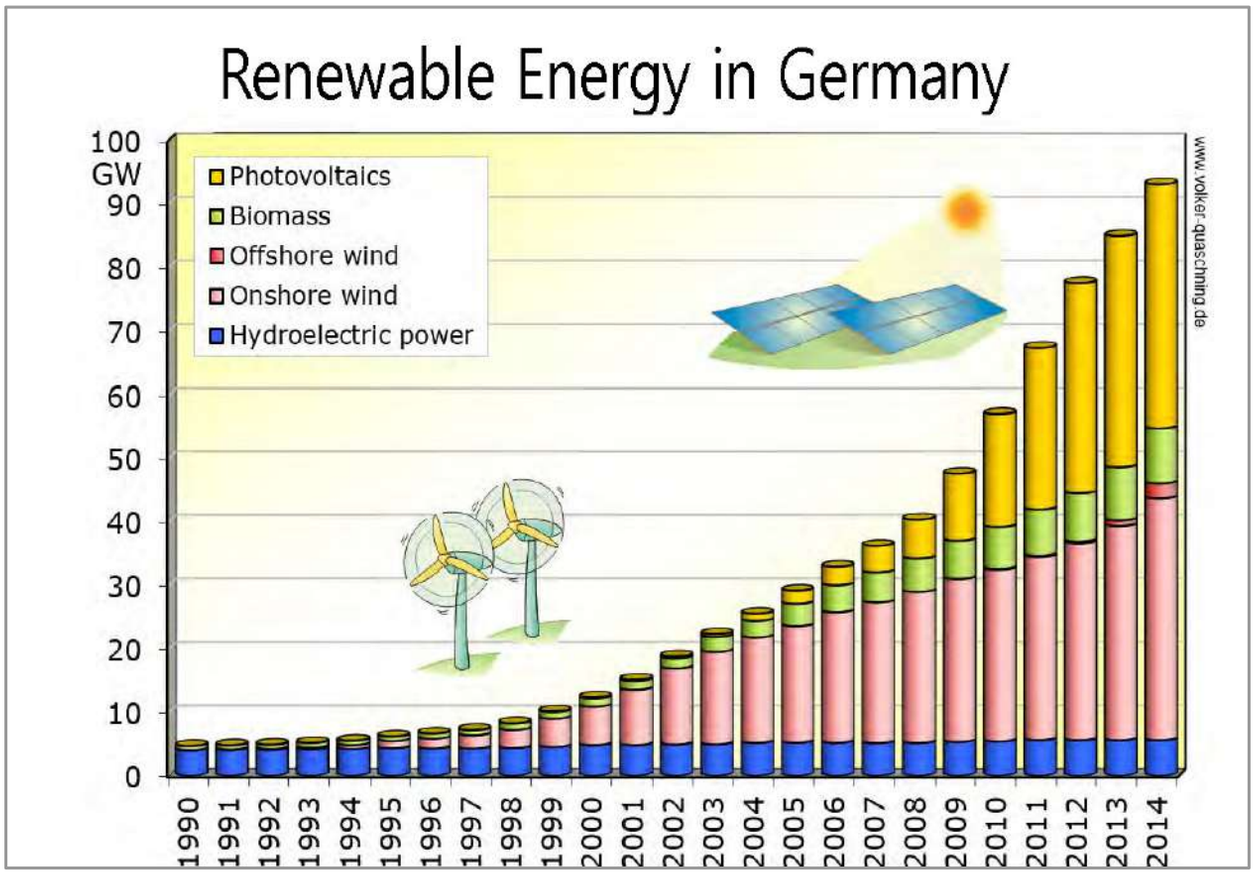


Renewable Energy Revolution

- The Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz; EEG) 2014
- EEG promotes the development of energy generated from renewable resources.
- The proportion of renewable energy in the electricity supply is to be increased to at least 65% by 2030
- 2050: Independent Energy Sources, Renewables
- To save the environment and to stop Climate Change
- Final Goal: Creation of the European Energy Union
- Challenges: Long and difficult Process
- Some people in Germany and a few countries are against it
- Energy Revolution made Germany already strong and independent: Other countries should follow and make Europe strong and independent

Energy Transition in Process

- Germany has been the global pioneer in applying renewable energy and environmental technologies.
- The energy transition continues to be an integral part of Germany's energy landscape with ambitious goals to cut CO2 emissions by 60% and increase the share of renewable energy in total energy consumption to 80% by 2050.
- Investments in offshore wind, photovoltaics, grid expansion and energy storage projects are expanding
- implementation of a new, smart energy infrastructure needed to balance the fluctuating supply of renewable sources.
- Energy efficiency and saving will play a central role.



Energy Transition in Progress 2015-2050

- Gradually switching to renewables up to 80% by 2050
- At present about 40% are from renewable sources
- More needs to done: strong pressure from the public
- All remaining 8 nuclear power plants are scheduled to shut down by 2022
- Electric companies are suing the government for billions Euros compensation
- All coal fired power stations are planned to be closed before 2037: depend on political decision and demand for new jobs in the mining region

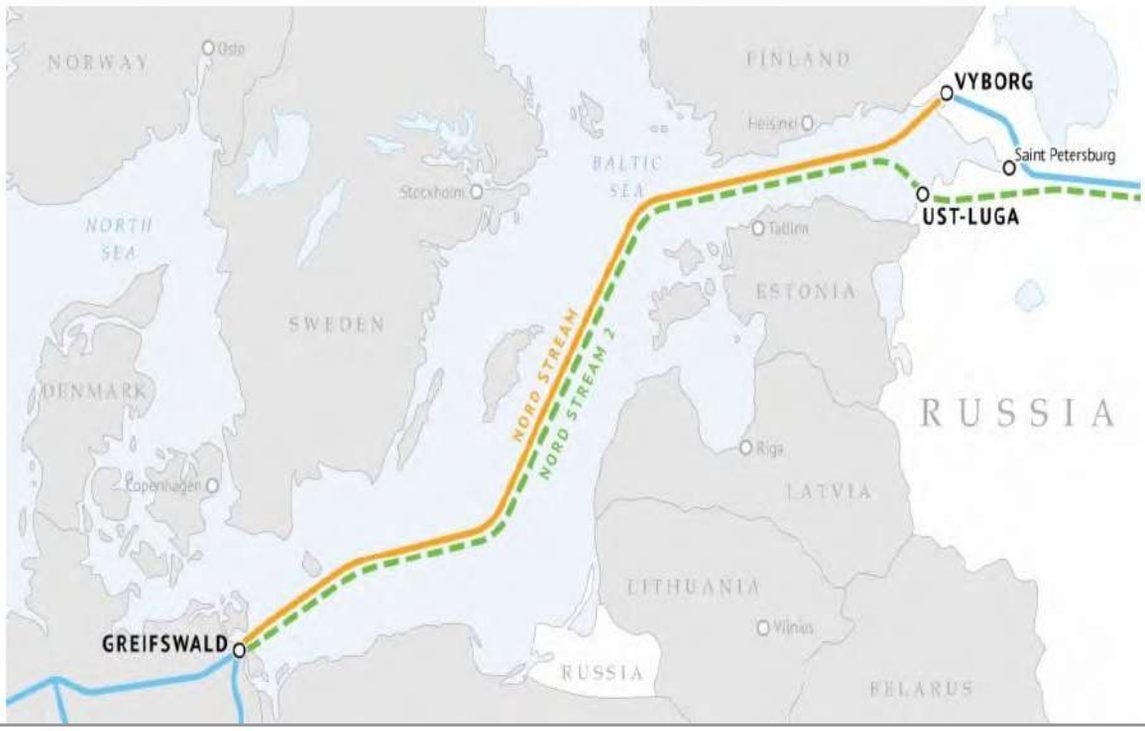
Networks

existing extra-high voltage GRID-35000km
Optimization of existing lines-3100 km
new construction-1800-2550 km

Russian Natural Gas pipelines: A Solution to the European Energy and Environmental Problem?

- Nord Stream 1
  - Russia and Germany agreed on the project in 2006
  - Russia provides Gas to Germany through Nord Stream 1 since 2011
- Nord Stream 2 to be completed in November 2019
  - Russian Gas will help Germany to achieve its Energiewende goals
- Natural Gas: Clean and efficient energy source
  - The US and France are against it; US hopes to provide LPG to Europe
  - Germany will make Europe dependent on Russia

Nord Stream 1 and 2



Russian Natural Gas Promises

- Nord Stream 1 and 2 will supply 110 billion cubic meters annually to Europe
- Europe can reduce CO2 emission by 40%
- Cheap and clean, but political risk?
- Would American LPG be safer or cheaper?
- Germany is not worried about dependency and political risks

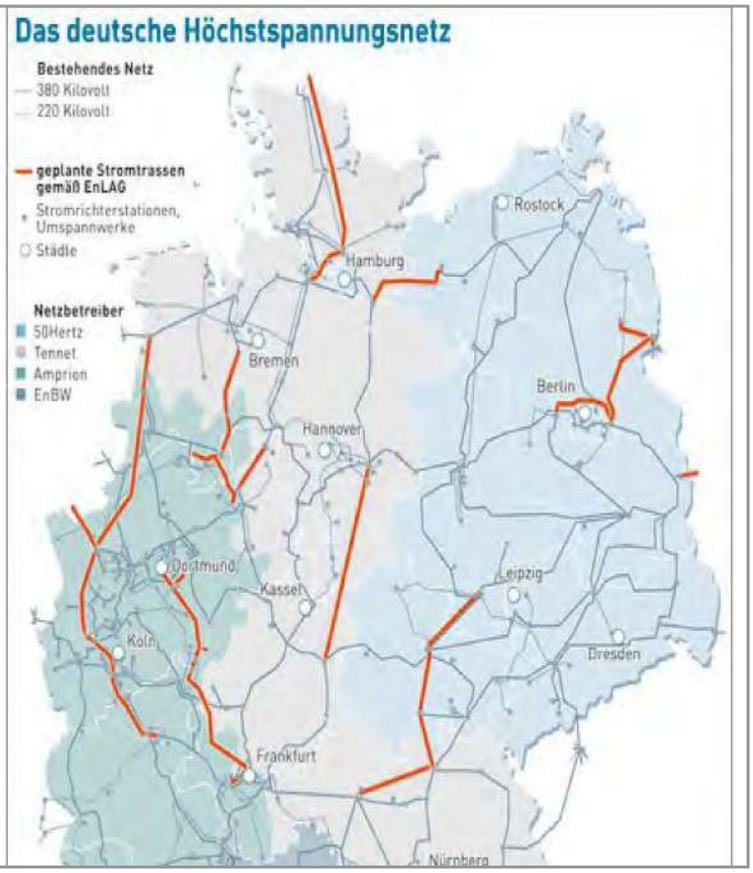
Building A European Energy Network

- Creation of the European Energy Union envisioned: 27 member states are already interconnected
- Cheaper and stable green energy supply should be fostered and guaranteed
- European Energy Market price need be stabilized
- Constructing of 7000 km extra-high voltage grid is moving slowly, due to too many law suites, high costs making green energy expensive
- In order to protect environment and climate change the energy transition is urgent and necessary

Future Energy Strategy of Germany

- To create the European Energy Union for sustainable green energy supply
- Utilize Excess Energy: Use to pump water to the mountain in Norway and run Hydropower plants in the evening: underwater cable is already constructed
- Produce solar energy in Spain or Africa and connect to the European networks: some pilot projects in deserts of Spain and Northern Africa
- To store excess electricity in batteries: big battery houses are being built in former mining areas

Extra-Voltage
Grid lines in
construction
and in Operation



발 표 4

동북아 전력계통 연계와 산업계 파급효과

이 학 성
(LS산전 사장)

Northeast Asia(NEA) Super-Grid and Its Effects on Industry

Contents

1. NEA Super-Grid
2. LSIS Technology
3. HVDC in Korea
4. Suggestions

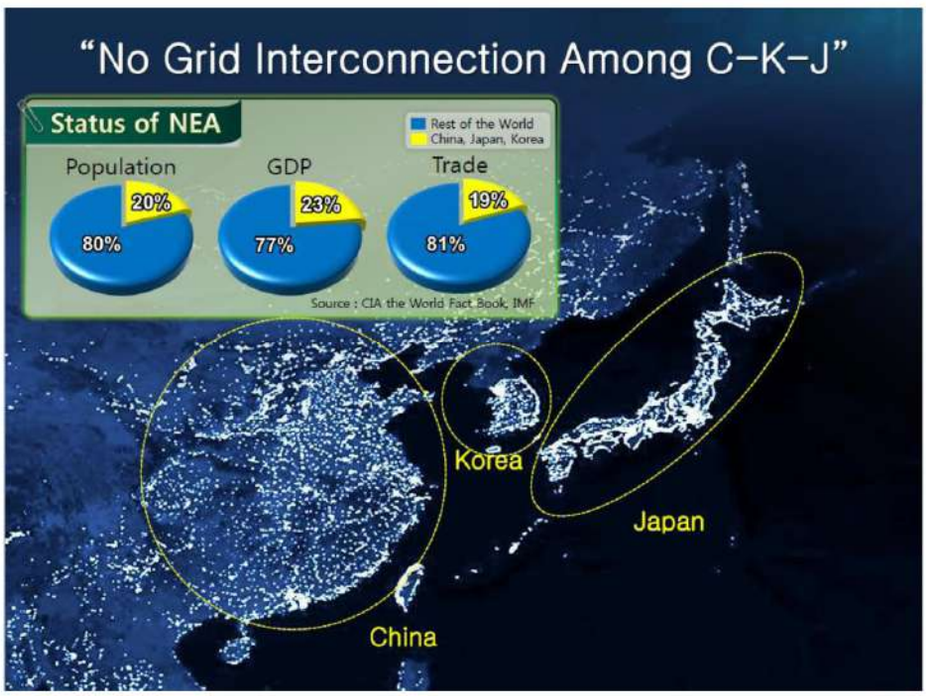
Dr. Hahk Sung Lee
CTO & CDO
of LSIS
2019.09.18

NEA Super Grid

Power Trading Begins in NEA

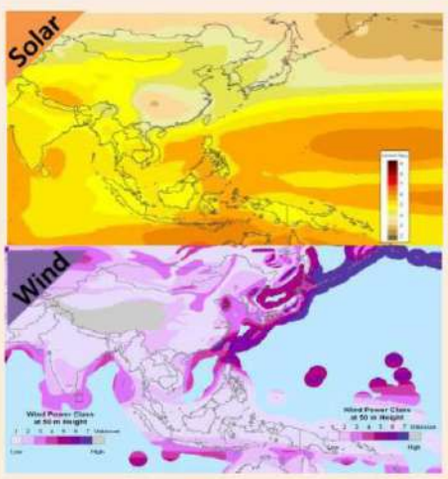
발 표 4. 동북아 전력계통 연계와 산업계 파급효과 63

1. Power Systems in NEA



Ref: Dr. G.S. Jang, 2018 Super-Grid Forum in GwangJu

2. Renewable Energy Resources vs. Power Demand in NEA



- Separation and Long Distance between the RES site and Load Center

Ref: Dr. G.S. Jang, 2018 Super-Grid Forum in GwangJu

3. NEA Super-Grid

Ref: Dr. G.S. Jang, 2018 Super-Grid Forum in GwangJu

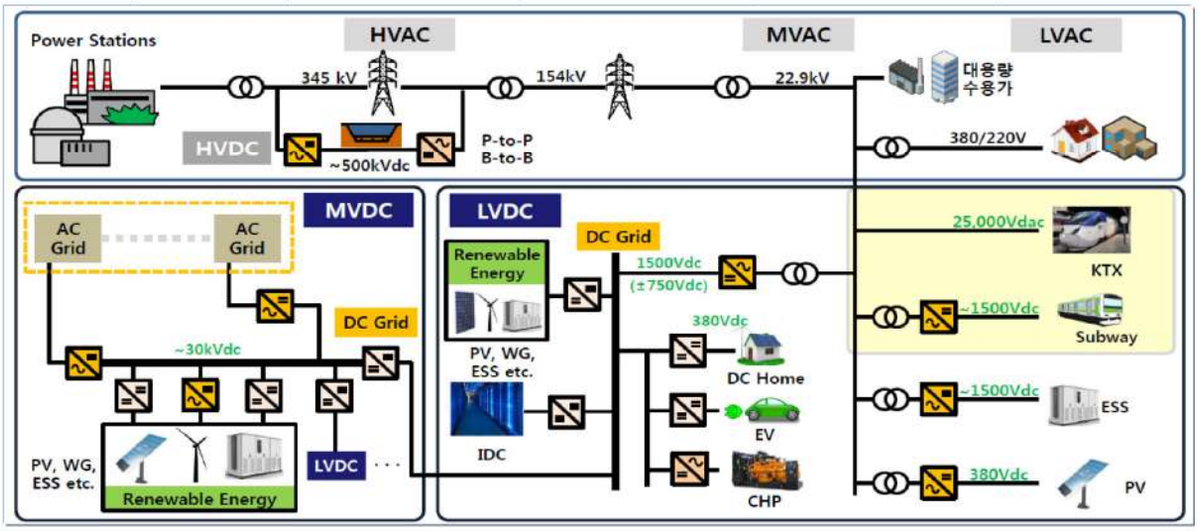
발 표 4. 동북아 전력계통 연계와 산업계 파급효과 65

◆ Classifications of DC

(Provided by LSIS)

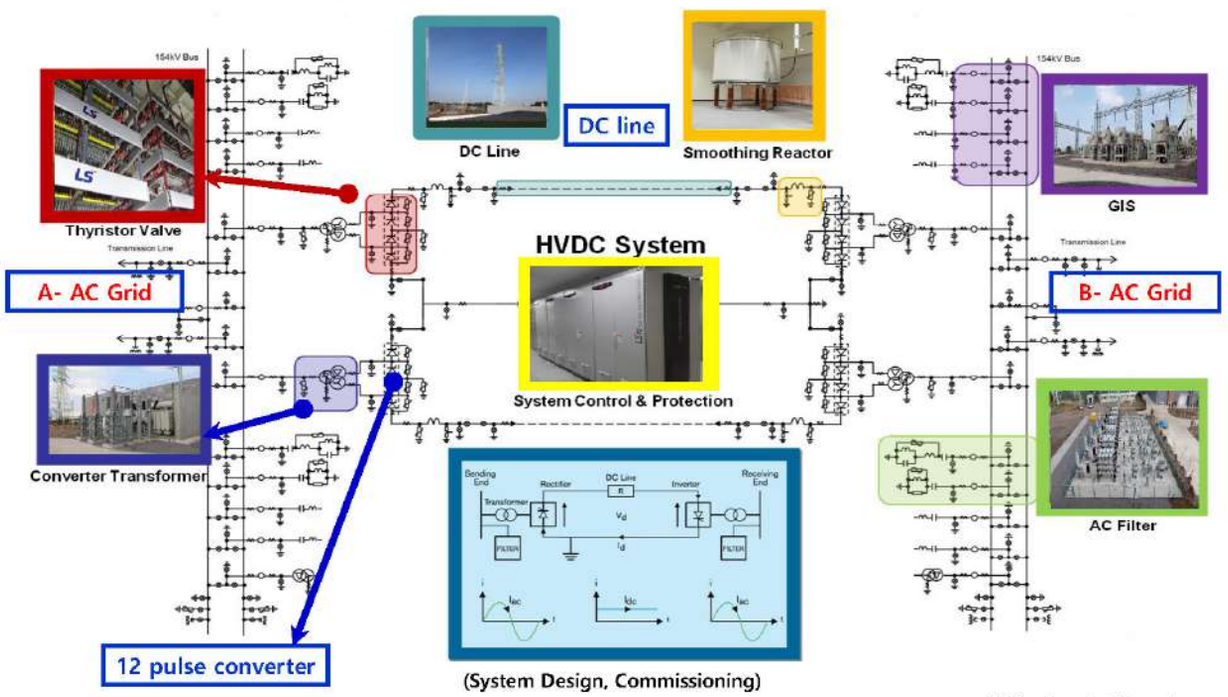
DC Grid solutions in HVDC, MVDC and LVDC.

Class	LVDC	MVDC	HVDC
Voltage	0.1~1.5 [kV]	1.5 ~ 100 [kV]	100 ~ 800[kV]
Applications	Micro-Grid, Digital Center	Renewable Energy	High Power, Interconnection



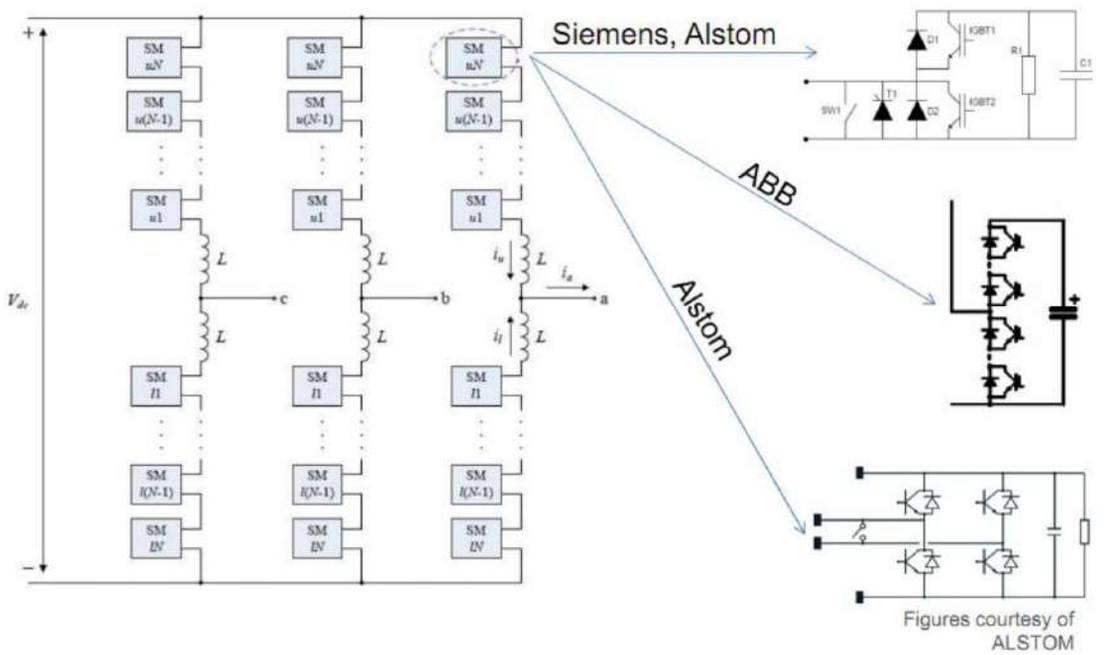
◆ LCC HVDC Configuration Diagram

(Provided by LSIS)



LCC: Line-Commutated Converter

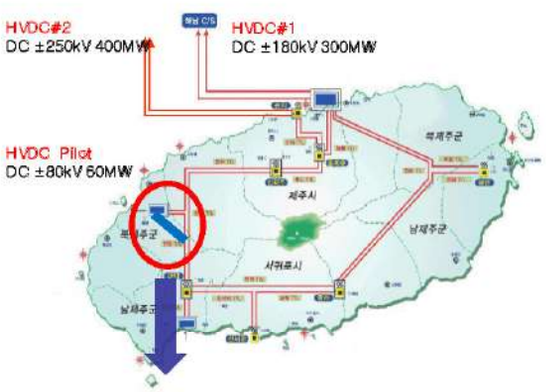
◆ VSC HVDC Block Diagram

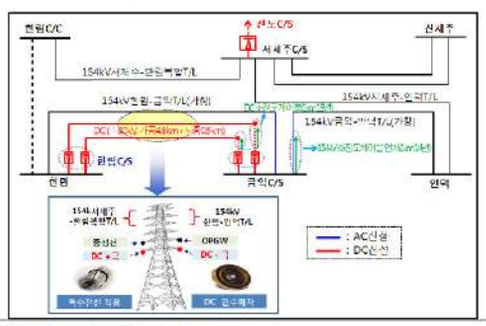


VSC: Voltage Sourced Converter

◆ LSIS Technology

(Pilot Project of LCC HVDC)





Converter Station

- Erection of converter station
- Bi-pole operation (DC ±80kV/60MW)

Hallim

GeumAK

Replacement

- Replacement of Valve, VBE and C&P panels
- Mono-pole operation (DC ± 80kV/30MW)

LSIS Valve

LSIS C&P (Control & Protection)

(*) VBE: Valve Base Electronics

LSIS

발 표 4. 동북아 전력계통 연계와 산업계 파급효과 67

◆ LSIS Technology

(Valves of LSIS)

LCC HVDC
60MW – 500MW rating

DC250kV
LCC HVDC Valve

DC500kV
LCC HVDC Valve

HVDC

VSC HVDC
50MW - 500MW rating

MMC Sub-Module

DC200kV
MMC HVDC Valve

FACTS
~100Mvar – 675Mvar rating

100Mvar
SVC Valve

675Mvar
SVC Valve

300Mvar
MMC Valve

FACTS

FACTS: Flexible AC Transmission System,
SVC: Static Var Compensator,
MMC: Modular Multilevel Converter

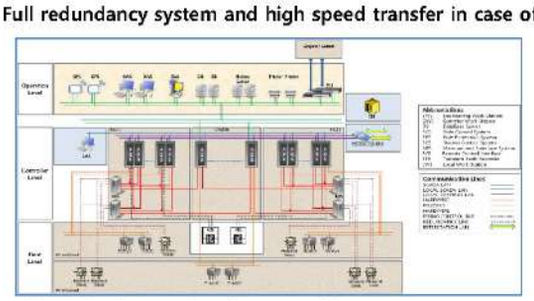
◆ LSIS Technology

(Control Platform of LSIS)

control and protection(C&P) platform for LCC HVDC, VSC HVDC and FACTS

C&P system

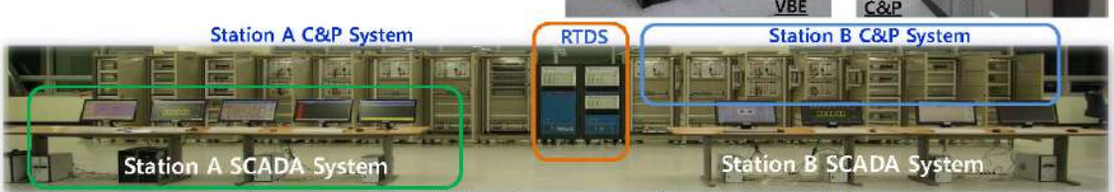
- Three layers structure: operation level, control level, field level
- Full redundancy system and high speed transfer in case of critical problems (less than 1ms)



Control and Protection System Architecture

VBE

C&P



(*) RTDS: Real Time Date Simulator / C&P: Control & Protection / SCADA: Supervisory Control And Data Acquisition

◆ LSIS Technology

(Converter Transformer)

DangJin MP#1 HVDC PJT

CTR

Future 2019 Forum

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LSIS

◆ LSIS Technology

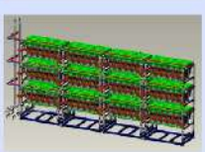
(MVDC Solutions)

LS can provide a Total Solutions for MVDC.

- MMC Valve, DC System Design, Control Platform, MG EMS and Hybrid DC Circuit Breaker.

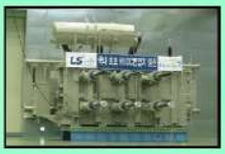
MMC Valve

- Ratings: Up to 300MW
- Building type
- Container type
- Applicable for HVDC and STATCOM



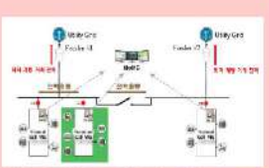
System Design

- MVDC System
  - Valve/Transformer
  - Control Platform
  - System Design



EMS

- Micro-Grid EMS
  - Campus MG
  - Island DC MG



DC Circuit Breaker

- DC 80kV Hybrid Circuit Breaker

STATCOM: Static Synchronous Compensator, MG: Micro Grid, MVDC: Medium Voltage DC, EMS: Energy Management System

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LSIS

발 표 4. 동북아 전력계통 연계와 산업계 파급효과 69

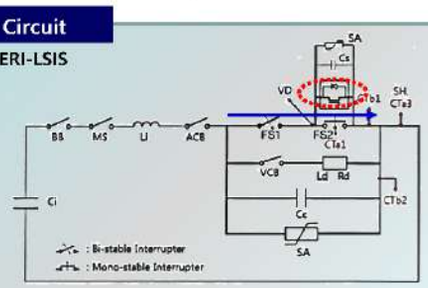
◆ LSIS Technology

(DC Circuit Breaker)

▪ LS has a DC80kV Hybrid DC Circuit Breaker

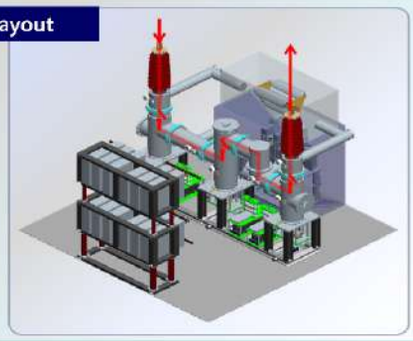
Circuit

• KERI-LSIS

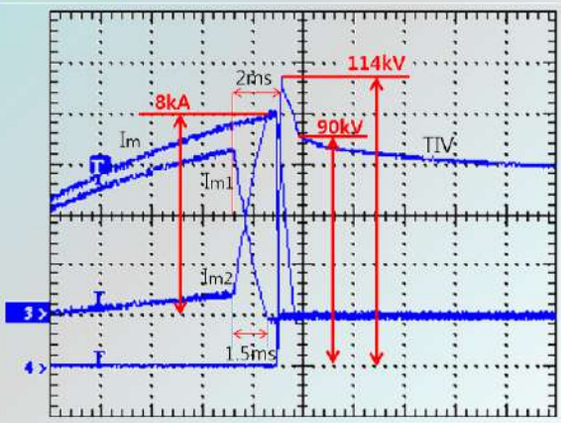


▪ No power losses during normal operation

Layout



Test



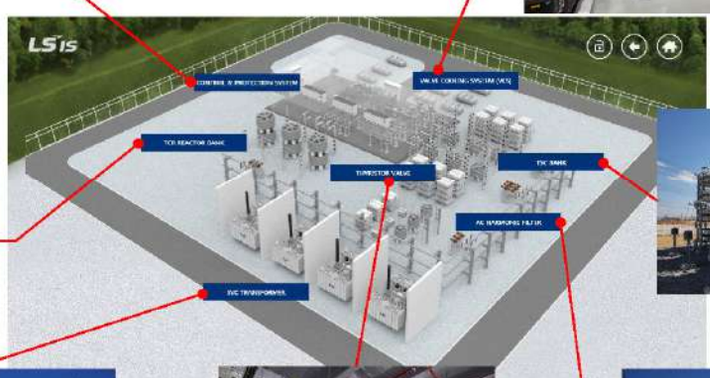
- Transition time from FS to Solid Switch : 1.5ms @ 8kA
- Breaking time : about 2ms
- Max. TIV : 114kV
- Breaking Current : 8kA

◆ LSIS Technology

(SVC)

Site: Shin-Je-Cheon Sub-Stattion

Power rating: -225Mvar ~+675MVar



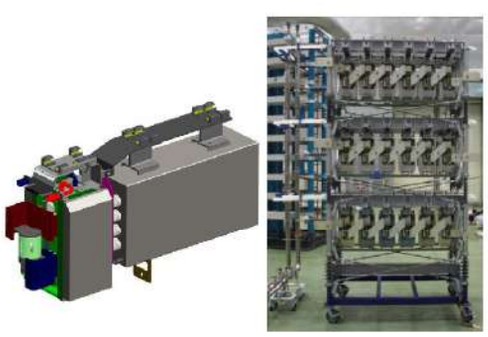
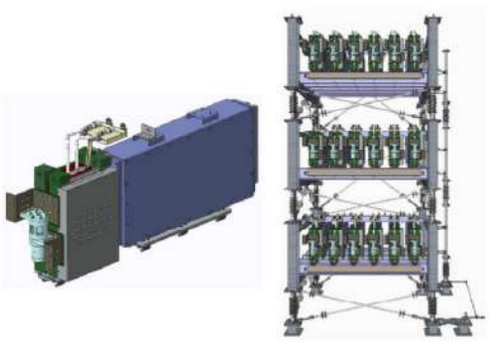
◆ LSIS Technology

(Shin-Je-Cheon SVC site)

Shin-Je-Cheon Site, Korea

◆ LSIS Technology

(MMC STATCOM)

Class	1st Generation MMC Valve	2nd Generation MMC Valve
Picture		
Upgrade	▪ System power rating: 300MVar ~ 500MVar ▪ Sub-module DC voltage: 2400V ▪ Reliability: ultrafast bypass switching speed : less than 2.6ms ▪ Safety: explosion-proof design ▪ Easy maintenance: Sliding Connection to DC Capacitor	

◆ LSIS Technology

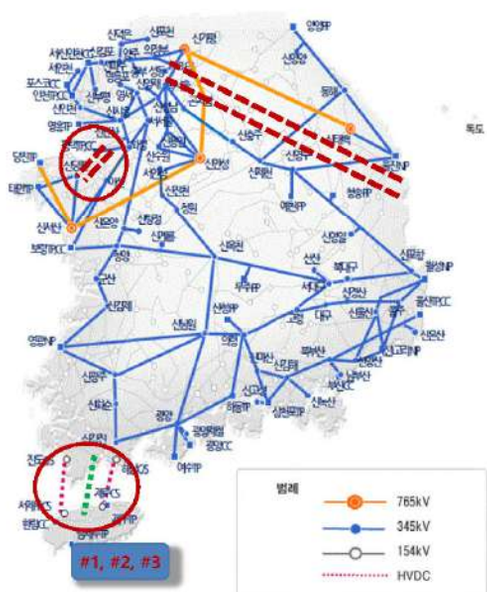
(MMC STATCOM Test)

MMC: Modular Multilevel Converter

◆ HVDC in Korea

- Two LCC HVDC are operating.
- LS developed a 60 MW Pilot HVDC at 2014.
- LS is supplying Valve, Converter Transformer and C&P to Dangjin PJT and EP PJT.

Project	Capacity	Type	Commission	Supplier
Jeju #1	300MW	LCC	1998	Areva
Jeju #2	400MW	LCC	2013	Alstom
Jeju #3	200MW	VSC	2021	ABB
Jeju Pilot	60MW	LCC	2014	LSIS
Dangjin MP1	1500MW	LCC	2021	GE+LSIS
Dangjin MP2	1500MW	LCC	2023	GE+LSIS
EP #1	400MW	LCC	2022	GE+LSIS
EP #2	4000MW	LCC	TBD	TBD



◆ Recent HVDC PJT in Korea

(Converter Transformer supplied by L난)

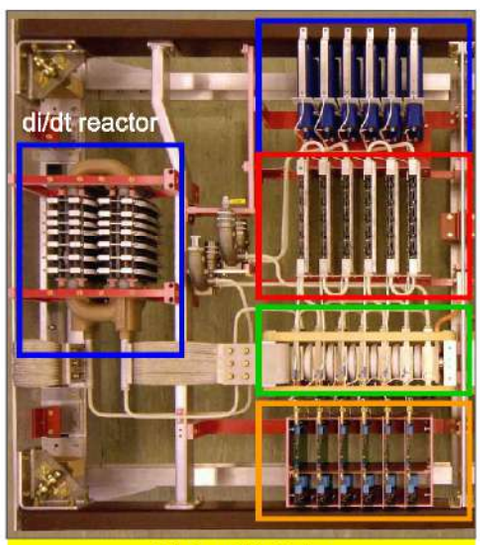
DangJin MP#1 HVDC PJT

CTR

◆ Recent HVDC PJT in Korea

(LCC Valve supplied by LSIS)

DangJin MP#1 HVDC PJT



Valve Module

Damping Capacitors

Damping Resistors

Thyristor Clamped Assembly
- Clamping Force 135kN
(App.15T) for 5" Thyristor

Gate Electronics

Valve Tower

◆ Recent HVDC PJT in Korea

(Control & Protection supplied by LSIS)

DangJin MP#1 HVDC PJT

Control & Protection

4. Suggestions

1. Grid interconnections between country are absolutely necessary for the power and energy trading and the optimum use of electrical energy. HVDC is critical system for the grid interconnection.

2. Government should keep to support KEPCO and company to develop HVDC system. It requires a huge investment, and takes a long time to develop HVDC system.

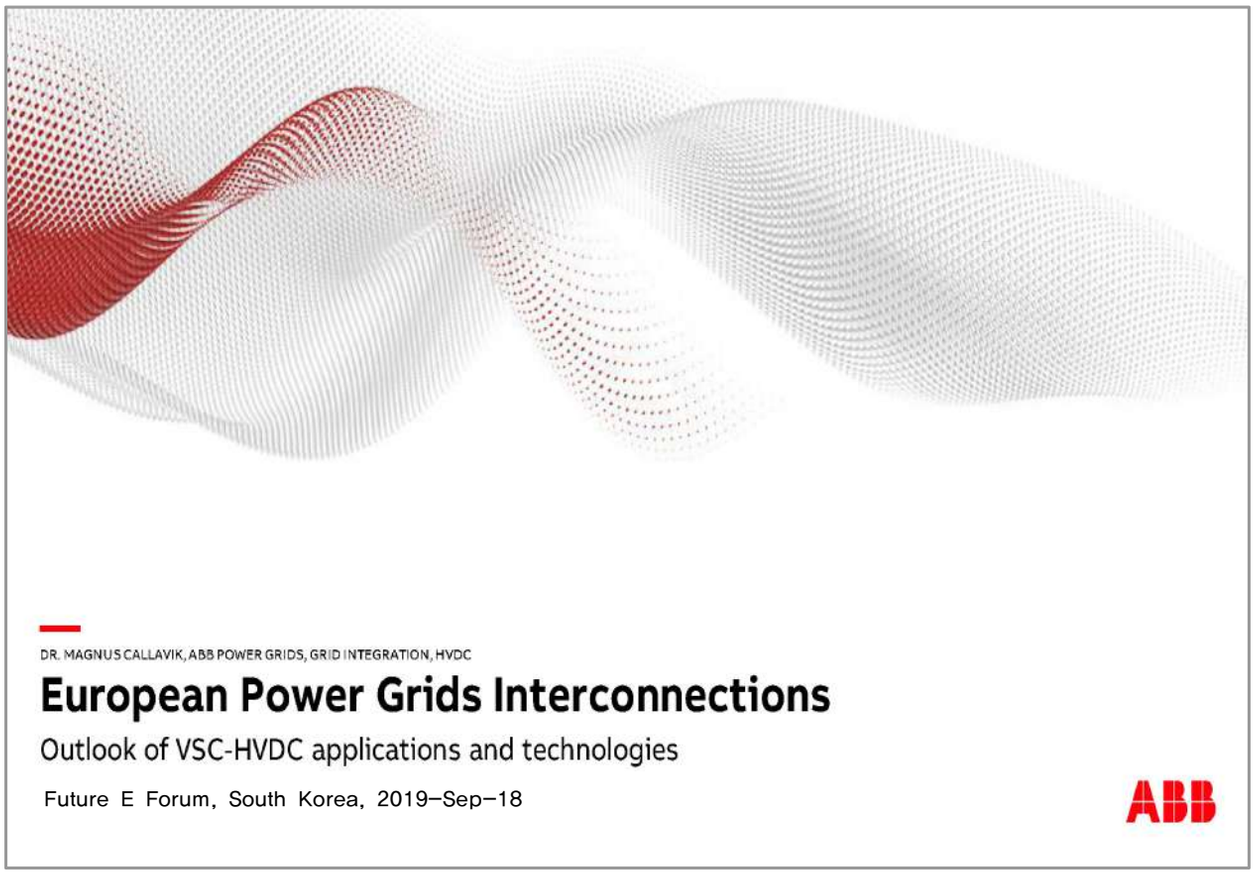
3. For the localization of the HVDC technology, KEPCO or Government should increase the supply scope of local company in HVDC system through the bidding process.

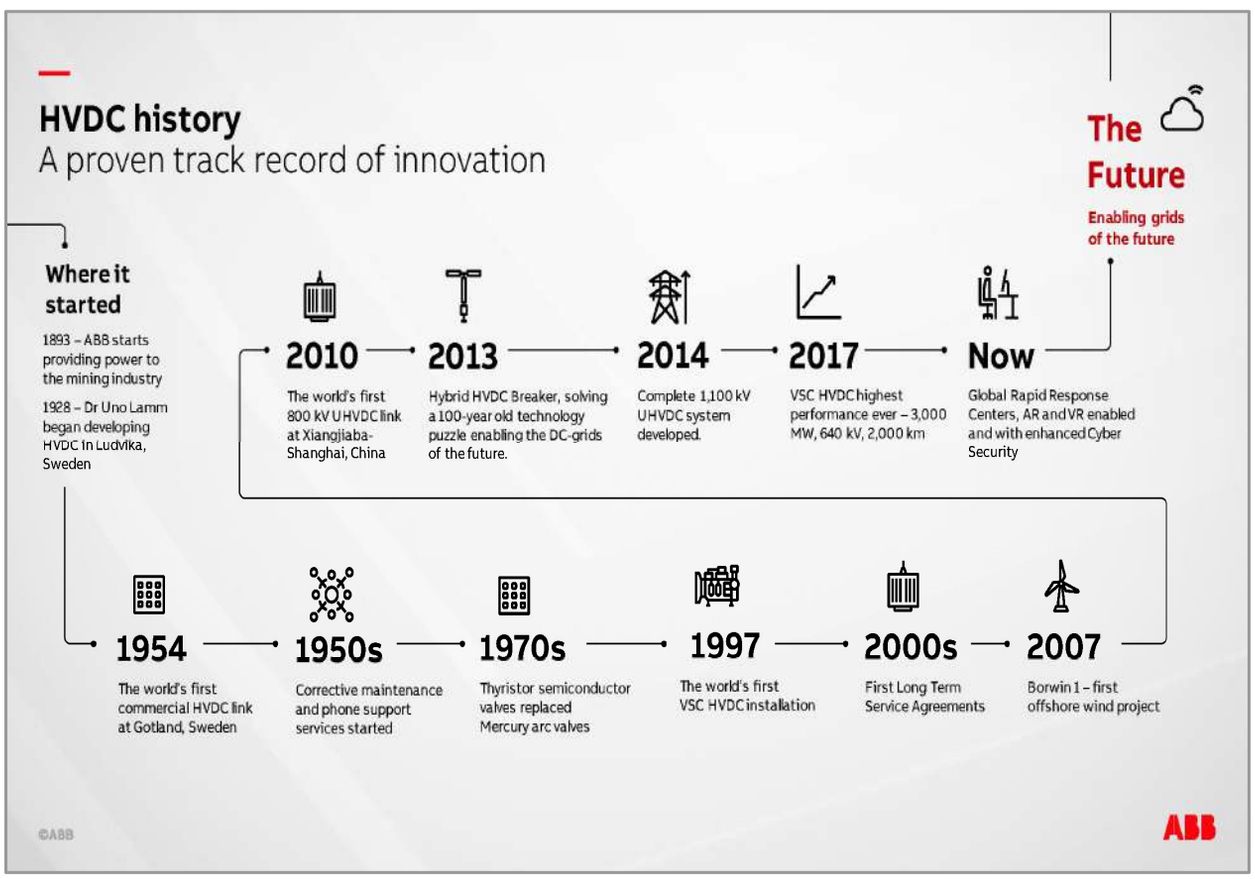

Thank You

발 표 5

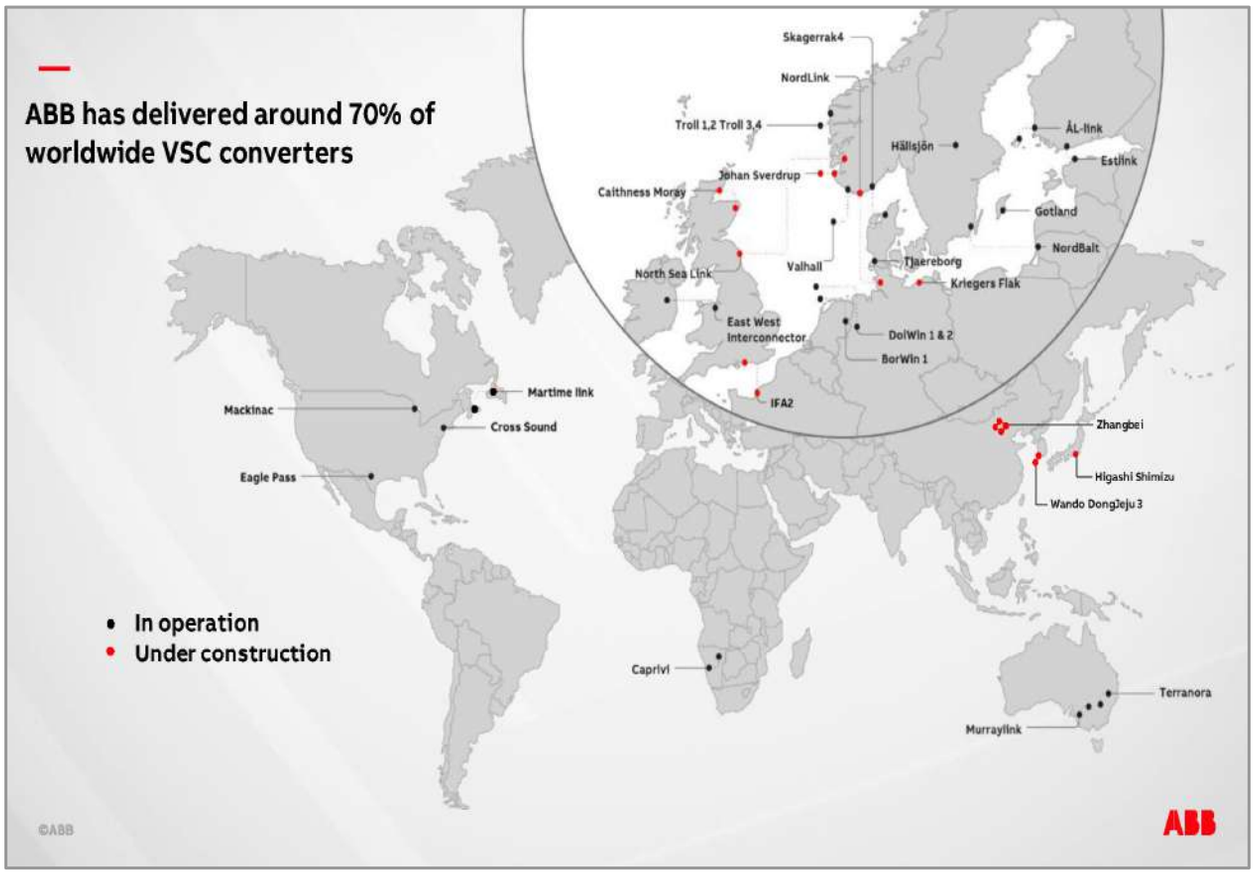
유럽의 전력계통 연계

Magnus Callavik
(ABB Sifang Power System 사장)



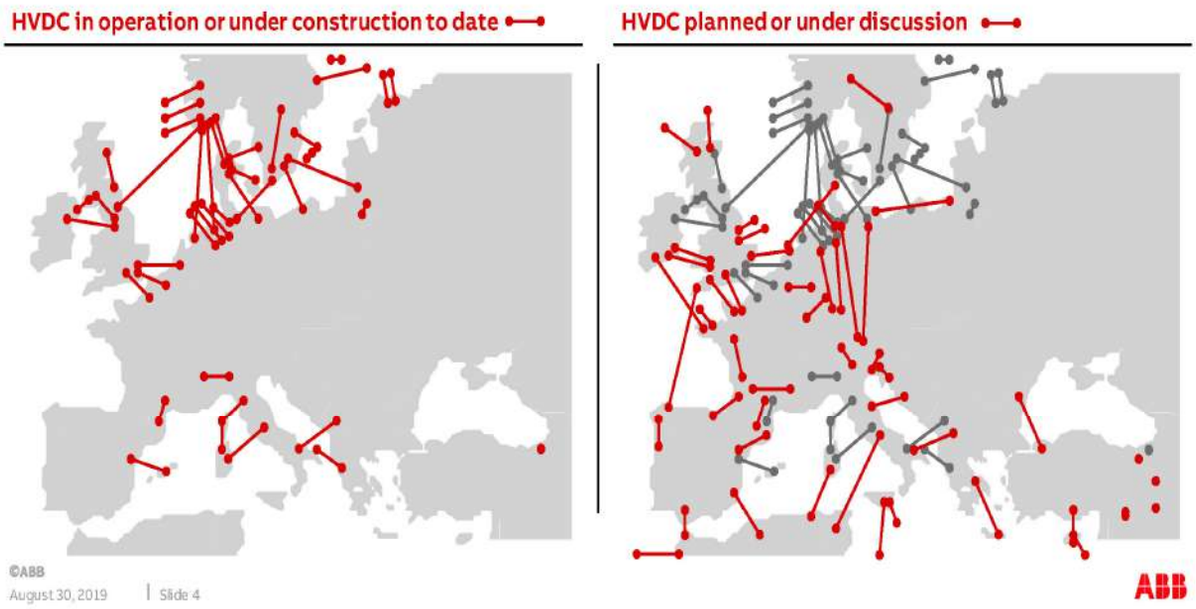


발 표 5. 유럽의 전력계통 연계 79



European Energy Policy drive interconnection and renewable integration

Market need excellence in Technology & Project execution of low-loss long transmission connections over sea and land, in-between unsynchronized network



European energy policy and interconnector targets

HVDC links in active development. HVDC is key enabler for integration of energy markets

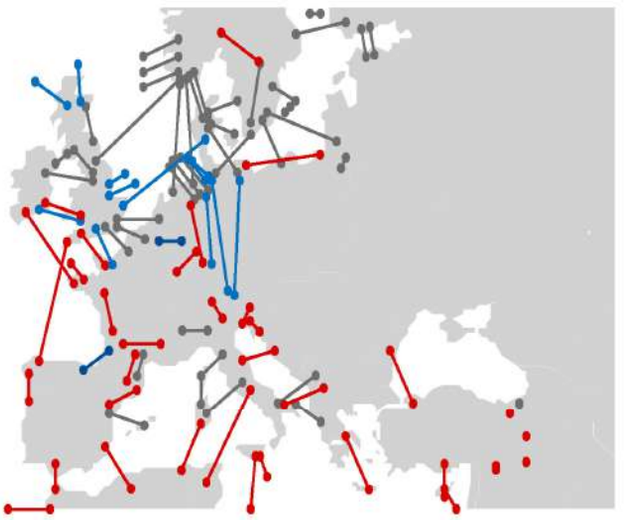
Most active HVDC projects in development

Key applications

- Many Offshore wind projects in Germany & UK
- Many Interconnectors under development
- Large DC in AC links in Germany

Drivers

- One common market nevertheless with occasional high price differences between regions and countries
- Too low cross border transmission capacity *vs* peak load due to history and geographical constraints
- Too low export interconnection capacity *vs* excess renewable generation capacity
- Transmission is most competitive compared with excess generation and/or large scale storage



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Our customer's applications drive our offering

In all HVDC Applications, HVDC Light is the dominating technology in new projects except bulk power

Connecting remote generation

Interconnecting grids

Offshore wind connections

DC links in AC grids

Power from shore

City center infeed

Connecting remote loads

Upgrades / Life cycle services

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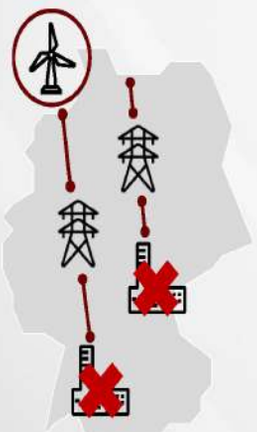
발 표 5. 유럽의 전력계통 연계 81

HVDC systems at the heart of the energy transformation

Integrating Renewables

Re-balancing power

Energy corridors, e.g. Germany



Offshore Wind Connections

Offshore Wind installed base to grow 16% until 2030, from 17GW to 115GW installed

Europe
Mainly UK, DE, DK, with growth in FR, PL,..

2015 - 11.2 GW
2020 - 24.4 GW
2025 - 42 GW

Asia
Mainland CN with fast growth as of '18.
KR, TW and JP emerging

2015 - 1.1 GW
2020 - 9.6 GW
2025 - 46 GW

Compact and Efficient Connection

Up to 2GW of power connected with one HVDC station

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Example of HVDC Light installations

Troll Power from Shore (Norway, 2015)

Artistic impression of future project

Dolwin 2 Offshore wind connection. Offshore and onshore stations (Germany, 2016)

August 30, 2019 | Slide 8

ABB

DC in AC Grid - Case study
Caithness Moray – Scotland

Strengthening Northern Scottish power network for rapid growth in renewable generation
Dynamic voltage support during steady state and disturbances

1,200 MW **Multi-terminal design**
320 kV
160 km

Key facts

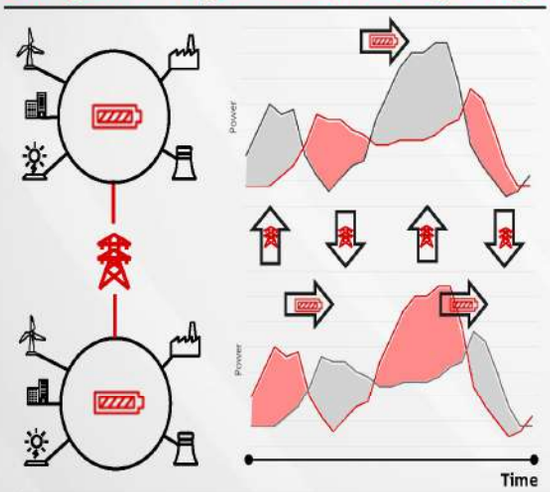
- 320 kV HVDC Light converter stations
- Sea & Land Cable connections
- DC link in synchronized AC grid

©ABB

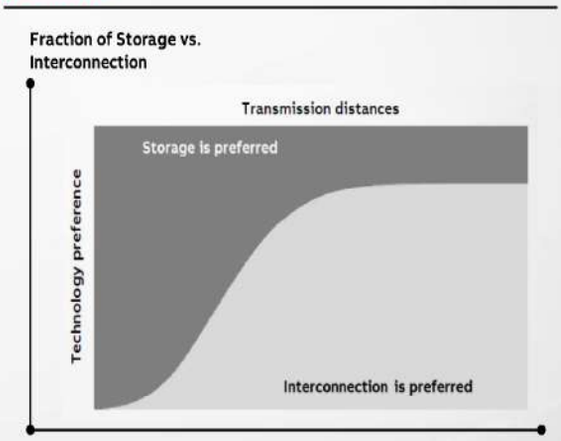
Courtesy:
Scottish & Southern Electricity Networks

There is a place for everyone – DC vs. storage
Helping supply to meet demand in a decarbonized world

Storage within a region vs. Interconnecting two regions



Optimal Mix



Hydro as balance to solar and wind, but located in different areas! For instance links between NO-UK, NO-DK, NO-DE

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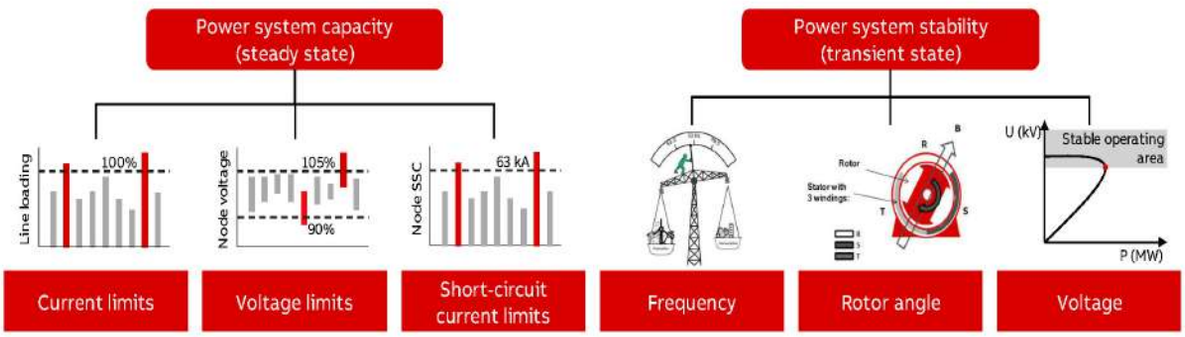
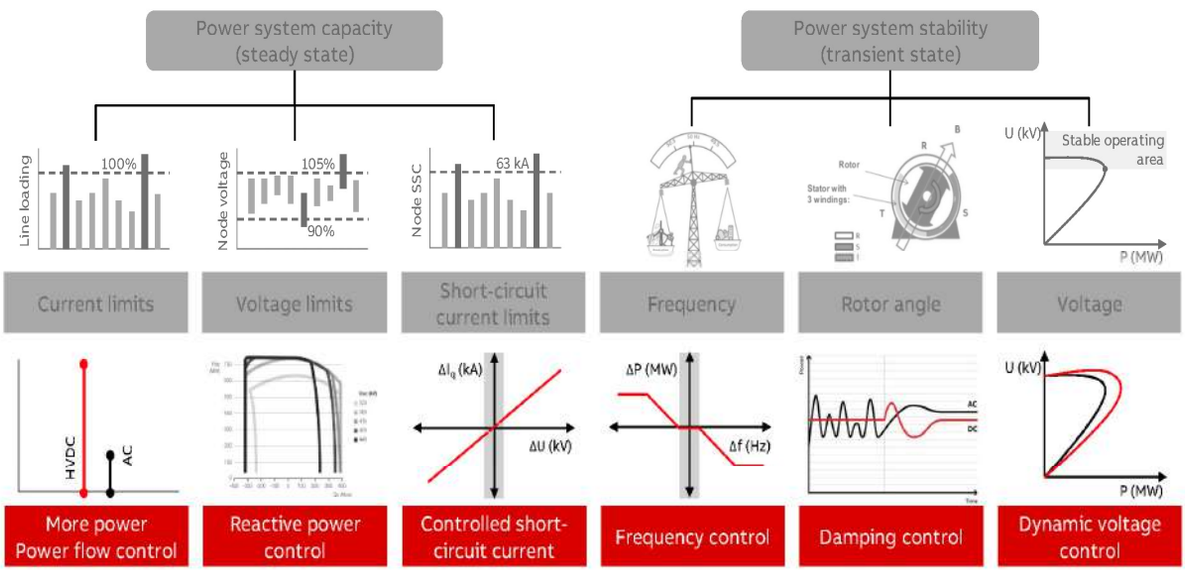
발 표 5. 유럽의 전력계통 연계 83

Operational constraints in AC grids



Operational constraints in AC grids

... and how HVDC helps

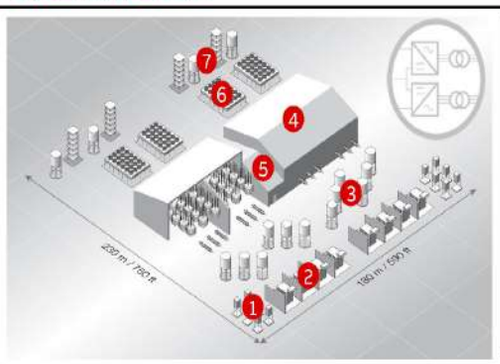


HVDC value chain and project phases - from AC to DC

Bipole and monopole footprint and layout example

Main circuit equipment **3,600 MW, ±640 kV** **2,800 MW, ±500 kV**

1. AC equipment
2. Transformers
3. AC Yard
4. Valve hall
5. Control building
6. Cooling
7. DC switch-yard



Pre-studies | System design | Procurement and production | Construction | Commissioning | Service

ABB

MACH™- Closed loop control

Flexible hardware solution, with adaptive control code and modular base design

ABB Ability™

Conditional Monitoring
Remote Service

SCM

Station Control & Monitoring

C&P

- Typically 10,000 - 40,000 I/O
- C&P resolution between microseconds to minutes
- 160 Gflops (floating point ops/s)

ABB

발 표 5. 유럽의 전력계통 연계

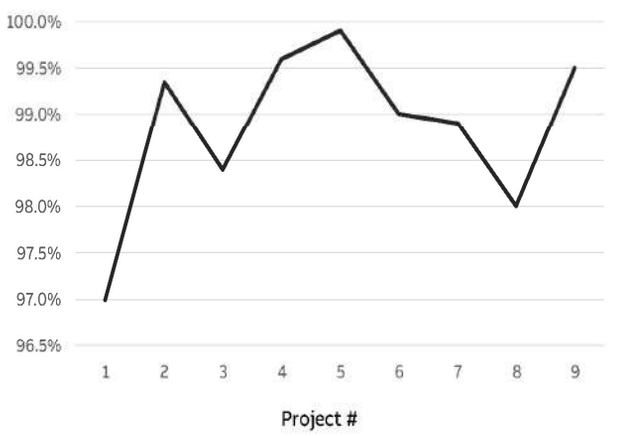
Availability of ABBs VSC systems

Present VSC systems offered at **98.5%** availability

Key design focus since 1994

- Design philosophy similar to LLC systems – valve with **designed redundancy** prevent forced outages
- **Integrated system and valve design** secure correct margins
- Focus on **maintenance and spare part strategy** integrated in the product
- Transmission-type **StakPak IGBT** optimized with **heatsink, cell capacitor and cell electronics as one unit**

Achieved availability during warranty in early projects



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Concluding remarks

- Interconnections in Europe are market-driven to facilitate energy trade and balance renewable generation with load
- HVDC is technology of choice due to long distance, marine connections, unsynchronized network and its ability to support the network quality beyond energy transmission
- Mainly VSC-HVDC in European projects around 900-1400 MW VSC-HVDC; globally up to 5 GW. For UHVDC above 5 GW, LCC-HVDC is still the technology of choice
- VSC-HVDC Grids start to emerge, showing the potential of large integration of remote intermittent renewable energy
- Digitalization and advanced control further enhance HVDC control, protection and monitoring

Lower losses, more power per square meter and ever increasing power

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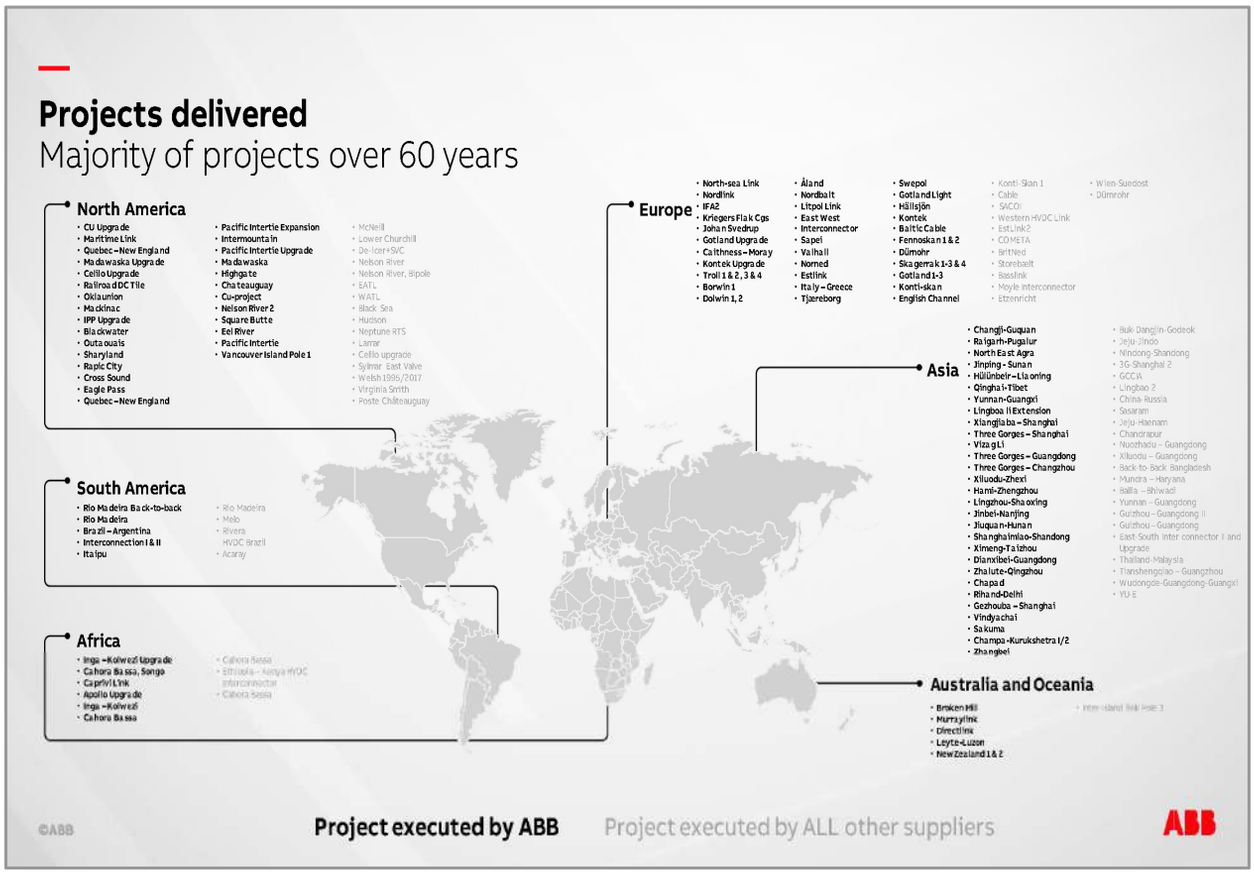


발 표 5. 유럽의 전력계통 연계 87

발 표 6

ADB의 동북아 전력연계 프로젝트 추진결과

Philippe Linehart
(EDF 이사)

European Power System Interconnection
&
Strategy for NAPSI
Northeast Asia Power System Interconnection

Philippe LIENHART
EDF Electricité de France
Team Leader of ADB Strategy for NAPSI
Future E Forum
September 18th, 2019
The National Assembly, Seoul, Republic of Korea

Summary

1. Short presentation of EDF
2. European Power System Interconnection
   - Main features
   - Lessons learnt
3. Strategy for Northeast Asia Power System Interconnection
   - Renewable energy in Mongolia
   - NEA Electricity Market
   - Interconnection infrastructure
   - Need of strong coordination among NEA countries

발 표 6. ADB의 동북아 전력연계 프로젝트 추진결과 91

EDF Group: a Responsible Industrial Firm with corporate social responsibility goals

1 Low carbon policy
Go beyond the requirements of the 2 °C trajectory set by COP21 by drastically reducing our CO_2 emissions.

17g/kWh of CO2 in France

2 Respect for people
Integrate best practice in the way we develop our people: health and safety, gender diversity and internal development.

3 Responsibility
Offer all vulnerable people information about and support with energy use and energy benefits.

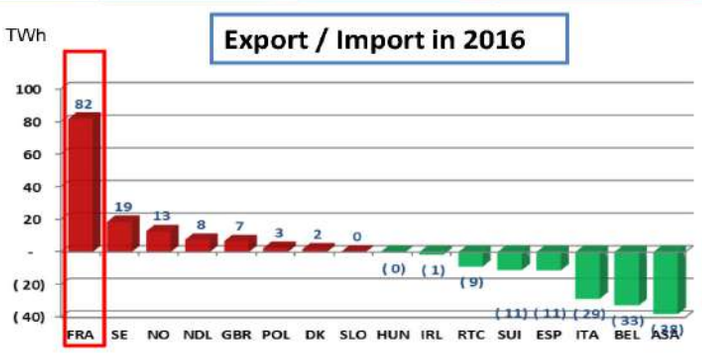
4 Innovation
Innovate through digital energy efficiency solutions to enable all customers to use energy better.

5 Concertation
Systematically organise a process of transparent and open dialogue and consultation for every new project around the world.

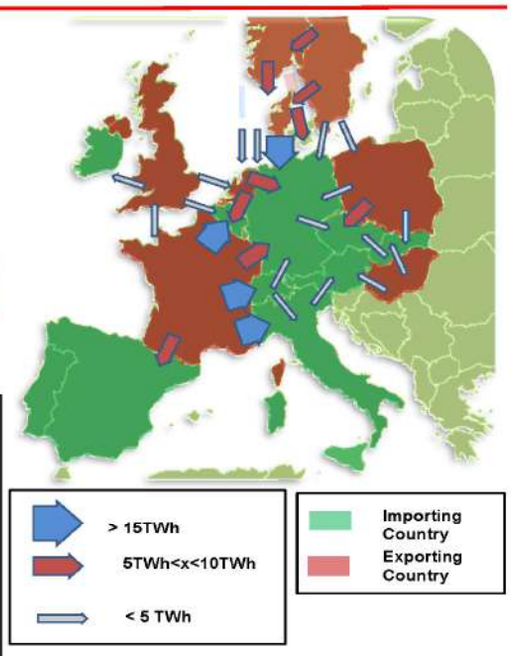
6 Environment
Launch a positive approach to biodiversity, not limited to understanding and reducing the impacts of our activities in the long run but having a positive effect on biodiversity.

39.8 millions customers worldwide | **160 000** employees | **€69billions** sales | **584TWh** electricity generation

EDF is the largest exporter of electricity in Europe through interconnections



- France : main export country in Europe
- Use rate of interconnectors by France: 77% (Europe Average : 64%)
- EDF branch Office in Brussels
- EDF is a member of EU Stakeholder Committee (feedback on Network Codes)

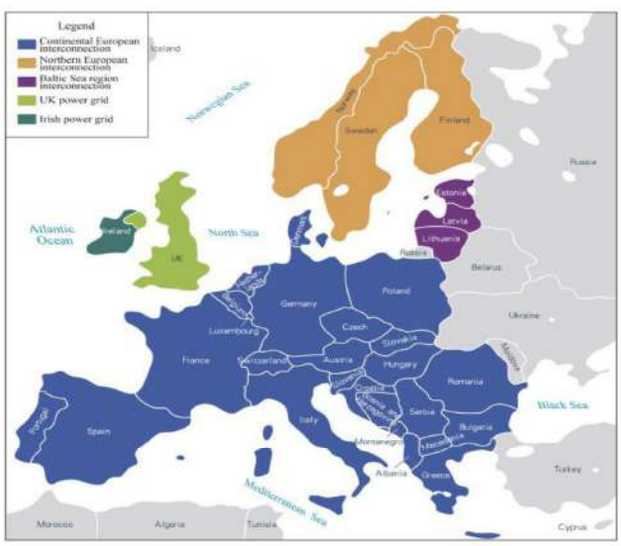


European Economic Community
A long time construction over the last 60 years

Number of Countries :

1957: 6
1973: 9
1981: 10
1986: 12
1995: 15
2004: 25
2007: 27
2013: 28

Europe Interconnection is larger than Europe Economic Community



- **1 Market**
- **Divided into 5 Synchronous Regions**
- **36 countries**
- **43 TSOs**

The 3 development phases of the European Interconnection
A long story of EDF contributions and adaptations

PHASE 1: 1956-2000 Common System Operation

Integration Goals:	Harmonized Rules:	EDF adaptation
•Exchanges of electricity	•UCTE	•Many Cross border OHL
•Grid Safety improvement	•NORDEL	•Submarine HVDC interco with UK: IFA
•Cost Optimization	•ETSOE	

PHASE 2: Since 2000, EU Electricity Market

TPA introduced deep changes:	EU GRID CODES:	EDF adaptation:
• Unbundling: 42 TSOs	•ACER	•Development of RES: EDF EN
• Private interconnections allowed	•ENTSOE	•Reduction of coal-fired fleet
• Interconnections vs price zones	•CORESO	•Few new OCGTs & CCGTs

PHASE 3: EU Energy Policy, 20% of RES in 2020

Interconnections are Key Assets
- Intermittency Management
- More Flexibility
- No RES Curtailment

EDF adaptation:
- Interconnections more difficult to build in OHL: underground HVDC interconnector with Spain INELFE

The construction of European Economic Community follows a legal process

A long run process that materializes Legal Integration

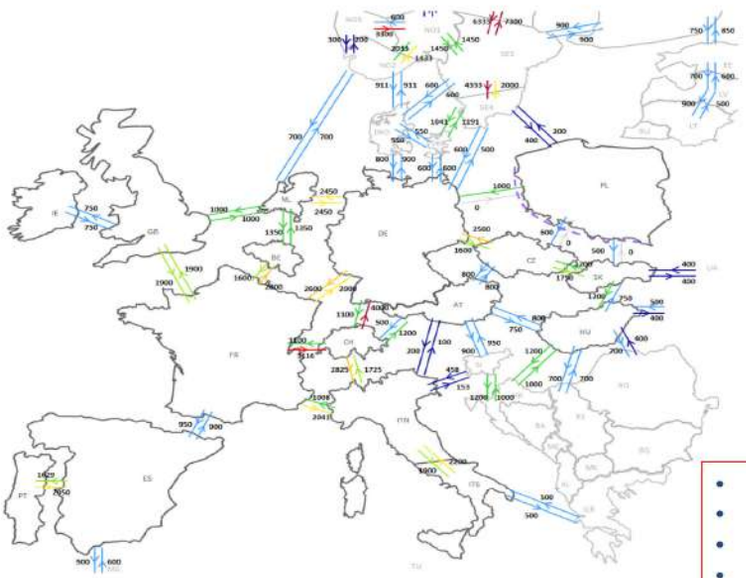
Treaties : Legally binding on EU member states on ratification and have direct effect in areas which are within the competency of the EU.

- **Regulations**: Have general application and are directly applicable in EU member states. No national implementation legislation is required. National governments are not required to ratify them to give effect.

Directives: Only bind EU member states in respect of the result to be achieved and the deadline for implementation. National governments choose the implementation means.

- **Decisions**: From the Council or the EC and used to give rulings on specific matters, addressed to specified parties and have a specified deadline for compliance. Decisions are binding on those addressed.
- **Recommendations/Opinions**: From the EC and have no binding legal force and are advisory.
- **Commission Communications**: Not legally binding and are used to express general or specific plans and work programs

Existing Europe Interconnections
50 Interconnectors allowing 15% of Energy Exchange



- 530 Millions of customers
- 310 000 km of transmission lines
- Power: 1000 GW
- Generation: 3000 TWh/year
- Exchange: 500 TWh/year

Europe Electricity Market was built through 3 Energy Packages

First Energy Package **1996**	The First Energy Package requires functional separation (separate business) and sets guidelines for transEuropean energy networks to integrate the continent's infrastructure	**National Regulator Agencies** **TSO – Unbundling** **National Grid Codes** **Wheeling Tariff** **Eligible Consumers** **Power spot Market**
Second Energy Package **2003**	The Second Energy Package requires functional and legal separation (separate businesses to be held in separate companies) and sets the Cross-Border Regulation	**Target Market Model** **Total and Free OTC market** **10% of average interconnection rate**
Third Energy Package **2009**	The Third Energy Package requires functional, legal and accounting unbundling and, in respect of Transmission System Operators (TSOs) only, ownership unbundling subject to certain permitted exceptions. The Third Energy Package also contains consumer protection measures including transparent belling contract information and assistance for vulnerable customers Also sets the Cross-Border Regulation 2009 Network codes (European Grid Codes)	**ACER Agency for the Cooperation of Energy Regulators** **ENTSOE European Network Transmission System Operator for electricity**

The Legal process includes technical rules called: European Network Codes

Goals:

- Harmonization of National Grid Codes
- Consensus among the Market players and TSOs
- European Stakeholders Committee for continuous improvement

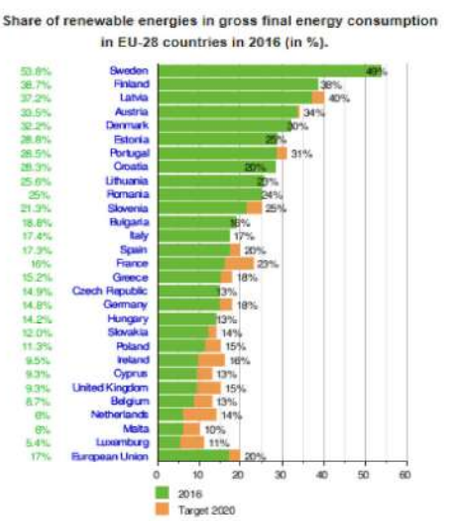
Connection	Operations	Market
Demand Connection Code	System Operations	Capacity Allocation & Congestion Management
High Voltage Direct Current Connections	Emergency and Restoration	Forward Capacity Allocation
Requirements for Generators		Electricity Balancing

The Clean Energy Policy for Climate Change started in 2001

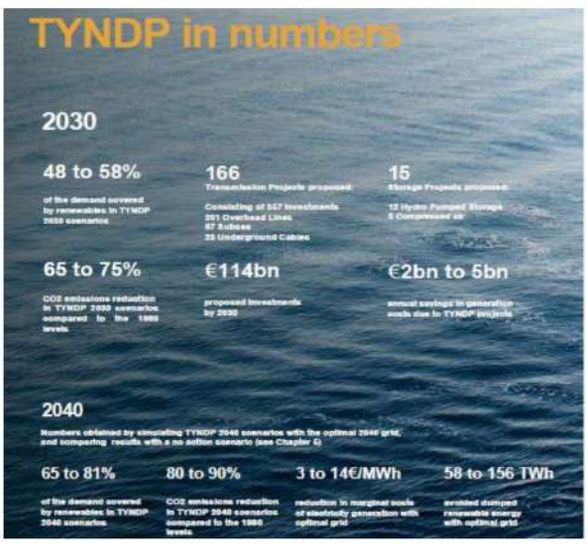
Current Clean Energy targets:

➢2020 (adopted in 2009)
•20% cut in greenhouse gas emissions (from 1990 levels)
•20% of EU energy from renewables
•20% improvement in energy efficiency

➢2030 (adopted in 2014)
•At least 40% cuts in greenhouse gas emissions (from 1990 levels)
•At least 27% share for renewable energy
•At least 27% improvement in energy efficiency



National Interconnection Grid Development are coordinated by the Ten Years Network Development Plan



2 Basic regimes for Interconnection in Europe

Regulated

Non discriminatory access

Revenue: fully regulated and controlled by Regulators

With consumer underwriting

Private

Exempted from regulatory requirements
Private access for a limited period

Revenue: free

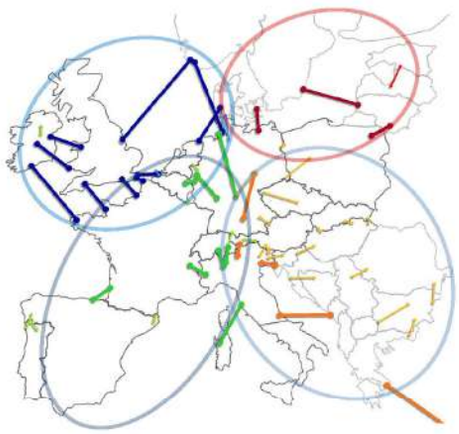
Without consumer underwriting

Project of Common Interest PCI can benefit grants from European Union

•PCI helps EU to achieve its energy policy, climate change goals and the long-term decarbonisation of the economy in accordance with the Paris Agreement.

North Sea Off shore Grid

Baltic Energy Market Interconnection Plan



North South Interconnection in Western Europe

North South Interconnection in Central Eastern and Southern Europe

PCIs may benefit from accelerated planning and permitting.
They also have the right to apply for funding from European Union.

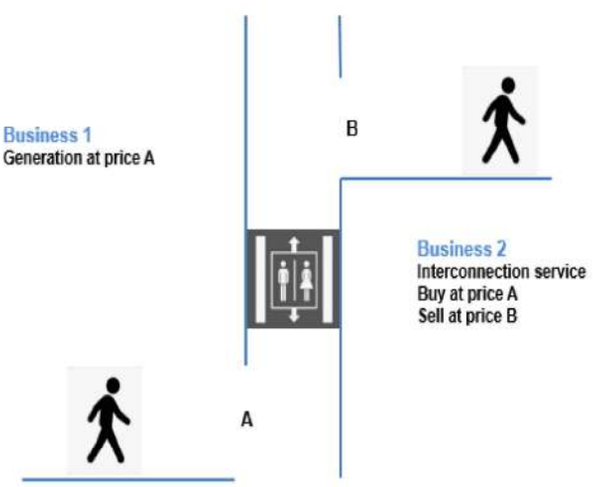
In Europe, the exchange of electricity is free of transmission charges

The main reason why this methodology is successful and efficient is that it is based on the separation of 2 businesses :

- **The Interconnection service**
- **The Generation and Exchange of electricity between countries**

By this way, electricity remains cost effective even in the importing country

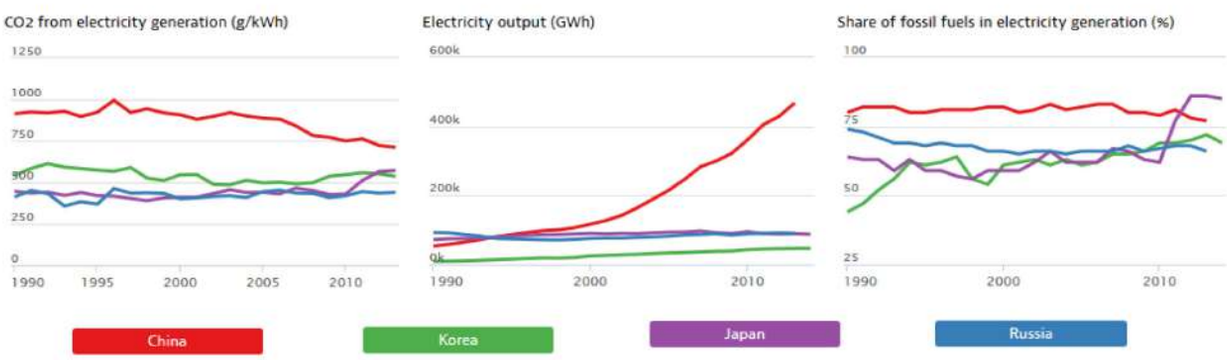
No transmission tariff will be added to generation cost



Lessons learnt from Europe Electrical Interconnections

- The European Economic Community has been developing through legal process that takes time for getting the consensus
- Europe Interconnection is larger than Europe Economic Community
- Market Integration and Climate Change Policy was implemented simultaneously since 2000
- Technical rules are discussed among the Market players and TSOs
- The financing of interconnections can be completed by grants from European Union under the condition they are eligible to Project of Common Interest
- The exchange of electricity is free of transmission charges

Introduction to Strategy for NAPSI



Source : OECD

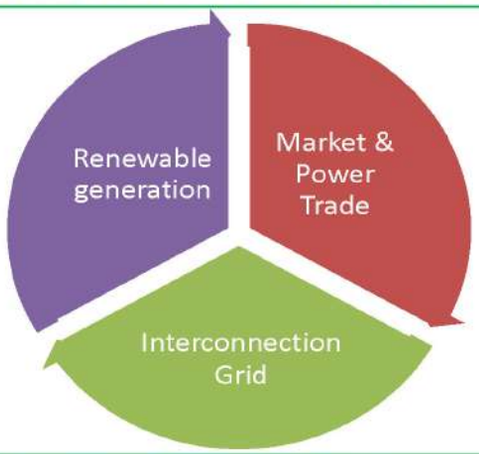
Northeast Asia
- **25% of Global GDP**
- **22% of Global population**
- **40% of Global CO2 Emissions**

Mongolia
- **Central Key Position**
- **Huge Potential in Wind and Solar RES**
- **Main Stake: Private investor attractiveness**

발 표 6. ADB의 동북아 전력연계 프로젝트 추진결과

ADB TA-9001 MON: Strategy for Northeast Asia Power System Interconnection

A coherent set of studies over the next 20 years regarding Renewable Energy, Market and Grid developments for supporting Mongolia State in the Northeast Asia interconnection discussions



A 2-year Project handled by EDF with:
- **Nova Terra** in Mongolia
- **China EPRI State Grid Research Center**
- In cooperation with **PJSC ROSSETI**

NOVATERRA
国家电网 STATE GRID
中国电力科学研究院
РОССЕТИ

Workshops in NEA countries

WS1 in Ulaanbataar MONGOLIA 6/2017	WS2 in Gwangju KOREA 11/2017	WS3 in Tokyo JAPAN 3/2018	WS4 in Beijing CHINA 10/2018	WS5 in Ulaanbaatar MONGOLIA 2/2019
				

The Final Workshop is scheduled late October in Seoul

Why interconnecting NEA countries? The current situation

High differences exist in retail and industrial prices of electricity

The NEA countries are developing renewable energies for meeting the Paris agreement heading to carbon neutrality in 2050
- China: World N°1 in Solar and Wind
- Korea: 40% of Renewable Energy by 2040
- Japan 22% - 24% of Renewable energy by 2030

Intermittency management in isolated country requires more flexibility which is generally provided with costly new fossil-fuel generation units for backup

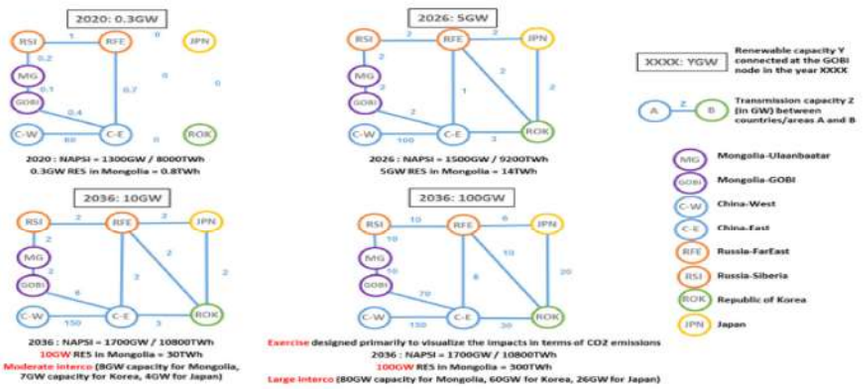
Fine dust are generated by the high proportion of coal-fired generation plants of the NEA region and spread at long distances

Mongolia: the abundant Solar and Wind potential is confirmed and more important compared to the previous studies

- The potential of Wind and Solar PV development in Mongolia is huge thanks to
  . Outstanding wind resource (wind speed > 8 m/s)
  . Good solar resource (Global Horizontal Irradiance GHI > 1700 kWh/m2)
  . Numerous suitable areas
- The results are much higher than previous potential assessment studies due to new wind and solar technologies
- The Wind and Solar PV potential capacity far exceeds the envisaged development Scenarios for exportation within the next 20 years: +5GW, +10GW, +100GW
- The best potential sites for wind and solar are situated in the same Southwest region close to the direction of export toward China, Korea and Japan
- The Solar and Wind energies produced in Mongolia are the most cost-effective of NEA region

Market Assessment: Mongolia Solar and wind exportation in NEA interconnection make sense economically

- The interconnection will be cost-effective due to important differences in marginal costs between the 5 involved countries
- The interconnection would already be cost-effective if it were existing today
- Solar and Wind power from Mongolia will replace fossil-fired electricity in the 4 other countries
- Exporting the abundant Renewable Resources of Mongolia in Solar and Wind through the future NEA Power System Interconnection (NAPSI) will help for cutting the CO2 emissions of the region and meeting the Paris agreement



Grid Development assessment: feasible with new HVDC technology

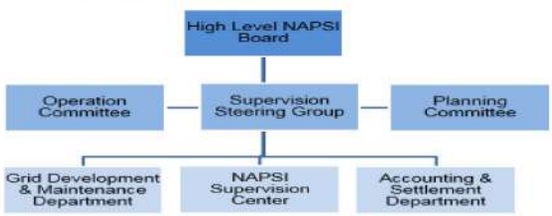
- The Interconnection Grid development among NEA region is feasible using new HVDC High Voltage Direct Current technology for long distance overhead lines and submarine cables
- Mongolia will require important Grid investment for upgrading the exportation capability
- The interconnection links must be connected close to huge power stations of main load center to minimize the Environment impact of the power exchanges on the internal grids
- The interconnection will improve the reliability of the 5 power systems that will bear increasing volumes of intermittent power

Solar and Wind in Mongolia: 10b$
NEA Grid: 9,1b$

A regional coordination is necessary for implementing the NEA Power Trade

1. **Political decision** by NEA Chiefs of States
2. Implement a strong **coordination among the MoE/Regulators** of NEA Countries
3. Set up the yearly **NEA Electricity Regulatory Forum** with participation of national regulatory authorities, Member State governments, TSOs, utilities, electricity traders, clean energy and customer representatives
4. Creation of the **NAPSI Platform Body** in charge of
   - Implementing the regional Regulations for Power Trade
   - Developing new interconnectors
   - Supervising Operation, maintenance and accounts

Co-operation between Countries,
Mutual assistance between Authorities
Fair competition between Players



Conclusion
The benefits brought by the NEA Interconnection

Energy producers with **Price reduction** following the importation of cheaper energy and new profit for utilities and renewable exportation

Interconnection brings the necessary **flexibility** required for
. compensating the variability of Solar Power (day/night, clouds) and Wind power with importation
. exporting renewable energies when Supply excesses Demand. No curtailment.
Interconnections replace more backup unit

Improvement of **System Safety** (less risk of blackout): the interconnections brings the necessary help in case of System disturbances (ex: unit breakdowns)

Cheap Solar and Wind power from Mongolia will replace fossil-fuel power plants and will help for cutting NEA CO2 emissions

A strong coordination between the Regulators/Ministers of Energy of the NEA countries is required

The creation of a common NAPSI Platform Body where all NEA countries are represented and work together is necessary


Thank You for Your Attention
Strategy for NAPSI Korea Parliament in Seoul on September 18th, 2019
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