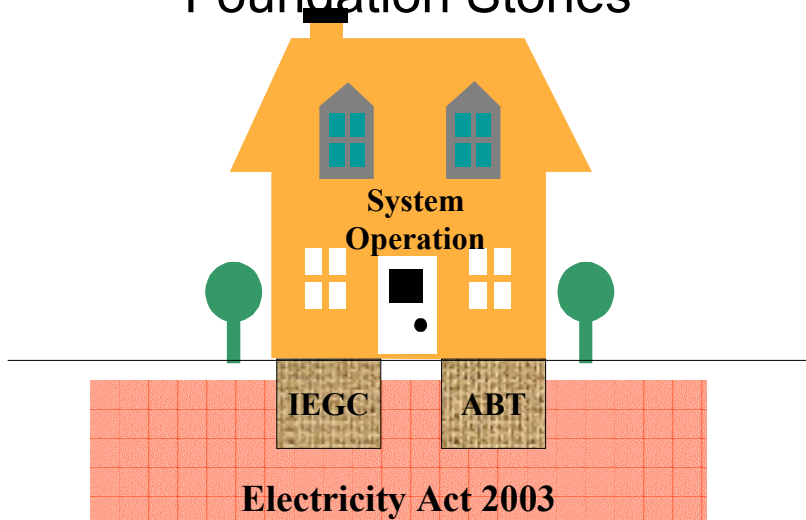


**RE REGULATION INDIA 2010
CONFERENCE AT PUNE - 4-5
FEBRUARY 2010**

**GRID CONNECTIVITY
STANDARDS/GRID CODES
GLOBAL BEST PRACTICES**

Foundation Stones



- **Two firm footings**
 - **INDIAN ELECTRICITY GRID CODE (IEGC)**
 - **AVAILABILITY BASED TARIFF (ABT)**

INTERCONNECTING RENEWABLES WITH THE GRID

- WIND RE'S ARE LOCATED IN REMOTE AREAS
- TRANSMISSION OR DISTRIBUTION AT THESE AREAS ARE WEAK
- LOW SHORT CIRCUIT LEVELS
- RELIABILITY ISSUES FOR EVACUATION

DO RENEWABLES NEED A GRID CODE?

- SIGNIFICANT PENETRATION LEVELS, ESPECIALLY OF WIND MEANS THEY INFLUENCE POWER SYSTEM OPERATION
- ACTIONS ON THE GRID COULD AFFECT **RE** GENERATION AND VICE VERSA
- CONNECTIVITY CONDITIONS WOULD HELP NEW **RE'S** CONNECT SEAMLESSLY
- BEHAVIOUR OF **RE** AND GRID TO BE HARMONISED ESPECIALLY DURING EMERGENCIES.
- SYNERGY IN PLANNING, OPERATION AND MAINTENANCE
- GRID OPERATOR MAY HAVE TO BE AWARE OF THE **RE** INJECTION QUANTUM AND ARRANGE FOR SPIN RESERVES

RE'S NEED GRID AS MUCH AS GRID NEEDS RE FOR RELIABILITY

SALIENT CHAPTERS OF A GRID CODE

- **Role of various Organizations and their linkages**
- **Planning Code for inter-State transmission**
- **Connection Conditions**
- **Operating Code for Regional Grids**
- **Scheduling & Despatch Code**
- **Inter-Regional Exchanges**
- **Management and Non Compliance**

THE PLANNING CODE

PLANNING OBJECTIVE: IEGC

- **SYSTEM TO BE SECURE AGAINST:**
 - - Outage of a 132 kV D/C line or,
 - - Outage of a 220 kV D/C line or,
 - - Outage of a 400 kV S/C line or,
 - - Outage of single Interconnecting Transformer, or
 - - Outage of one pole of HVDC Bipole line, or
 - - Outage of 765 kV S/C line.
- The above contingencies shall be considered assuming a pre-contingency system depletion (Planned outage) of another 220 kV D/C line or 400 kV S/C line in another corridor and not emanating from the same substation. The ISTS shall be capable of withstanding the loss of most severe single system in-feed without loss of stability. Any one of these events defined above shall not cause:
 - Loss of supply
 - Prolonged operation of the system frequency below and above specified limits.
 - Unacceptable high or low voltage
 - System instability ,Unacceptable overloading of ISTS elements

THE PLANNING CODE

PLANNING CRITERION: IEGC

The objectives of Planning Code are as follows:

- To specify the principles, procedures and criteria which shall be used in the planning and development of the ISTS and inter regional links
- To promote co-ordination amongst all Regional Constituents and agencies in any proposed development of the ISTS.
- To provide methodology and information exchange amongst Regional Constituents and agencies in the planning and development of the ISTS.

THE PLANNING CODE

PLANNING CRITERION: IEGC

- SYSTEM TO BE SECURE AGAINST:
 - - Outage of a 132 kV D/C line or,
 - - Outage of a 220 kV D/C line or,
 - - Outage of a 400 kV S/C line or,
 - - Outage of single Interconnecting Transformer, or
 - - Outage of one pole of HVDC Bipole line, or
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 - Loss of supply
 - Prolonged operation of the system frequency below and above specified limits.
 - Unacceptable high or low voltage
 - System instability
 - Unacceptable overloading of ISTS elements

THE PLANNING CODE

- **THE DETAILS GENERALLY ASKED BY GRID CODES OF OTHER COUNTRIES**
 - GENERATOR AND TURBINE DETAILS LIKE X_d , X_d' , DROOP, BLOCK DIAGRAM ETC
 - PROTECTION, LAYOUT, UNIT AUX DEMANDS
- **PLANNING POLICY IS NOT CLEARLY DISCUSSED IN OTHER GRID CODES**
- IEGC LEAVES THE DETAILS TO CTU
 - OBLIGATION ON CONNECTEE TO PROVIDE THE DETAILS ASKED BY CTU
- **PLANNING CRITERION**
 - CLEARLY SPECIFIED IN IEGC
 - MOST GRID CODES DO NOT SPECIFY IN DETAIL

THE PLANNING CODE

NGC, UK PLANNING PHILOSOPHY

- NATIONAL GRID, UK OPERATES A THREE MONTH QUEUE FOR APPLICATIONS.
- WITHIN THE THREE MONTHS THE NEW GENERATION APPLICATION IS ASSESSED AGAINST PLANNED DEVELOPMENTS.
- AN OFFER TO CONNECT WILL BE MADE TO THE CONNECTEE WHICH INCLUDES DETAILS OF THE WORKS REQUIRED TO BE COMPLETED BEFORE THE NEW GENERATION IS ALLOWED TO CONNECT.
- AN “INTERIM CONNECT AND MANAGE” PROCESS HAS BEEN PUT IN PLACE TO ALLOW GENERATORS TO CONNECT QUICKLY WITH POST FACTO DEALING OF COSTS

THE PLANNING CODE

PLANNING CRITERION: PROPOSED FOR WIND

- CRITERIA FOR EVACUATION LINES WOULD BE THE SAME AS BEFORE.
- RE TO GIVE DATA TO CTU/STU
- PLANNING PHILOSOPHY FOR WIND PROPOSED FOR IWGC: STUDIES FOR

**HIGH WIND
HIGH SYSTEM LOAD**

**HIGH WIND
LOW SYSTEM LOAD**

**HIGH WIND
LOW LOCAL LOAD**

- REACTIVE POWER COMPENSATION 0.95 LEAD TO 0.95 LAG

CONNECTION CODE

THE CONNECTION CODE

CONNECTION CODE: VOLTAGE

Country	E-ON GERMANY	Western Australia	UK Grid Code
Voltage Class 1	Nominal 380 Limits 350-420 KV		
Class2	Nominal 220 Limits 193-245 KV	90 -110 %	95 – 105 %
Class3	Nominal 110 Limits 96-123 KV		
PF Limits	0.925 lead 0.95 lag	0.95 lead 0.95 lag	0.95 lead 0.95 lag
Reactive Power	Area Defined		Area Defined

THE CONNECTION CODE

CONNECTION CODE: FREQUENCY

Country	E-ON GERMANY	Western Australia	UK Grid Code
Frequency	49.5-50.5 Hz	49.8-50.2 Hz	49.5-50.5 Hz
Frequency Stability	RE Exempted	No specific Derogation	
Islanded Operator & Black start	RE Exempted	No specific Derogation	Exempted
Frequency response	> 50.2 Hz Reduce power by 40% Hysteresis and dead band specified	No specific Derogation	

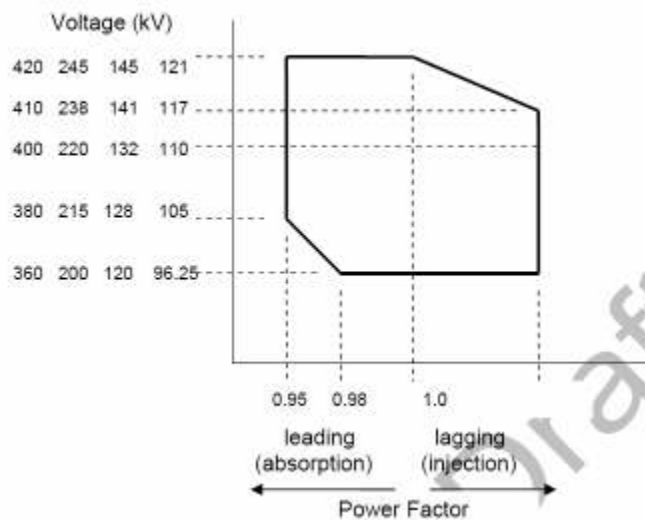
THE CONNECTION CODE

CONNECTION CODE: PROPOSAL FOR IWGC

Voltage (kV)			
Nominal	% Limit of variation	Maximum	Minimum
400	+5% to -10%	420	360
220	+11% to -9%	245	200
132	+10% to -9%	145	120
110	+10% to -12.5%	121	96.25
66	+10% to -9%	72.5	60
33	+5% to -10%	34.65	29.7

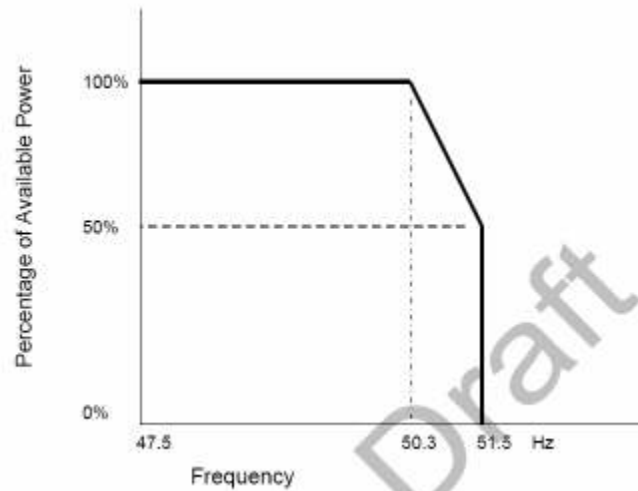
THE CONNECTION CODE

CONNECTION CODE: PROPOSAL FOR IWGC VOLTAGE AND POWER FACTOR



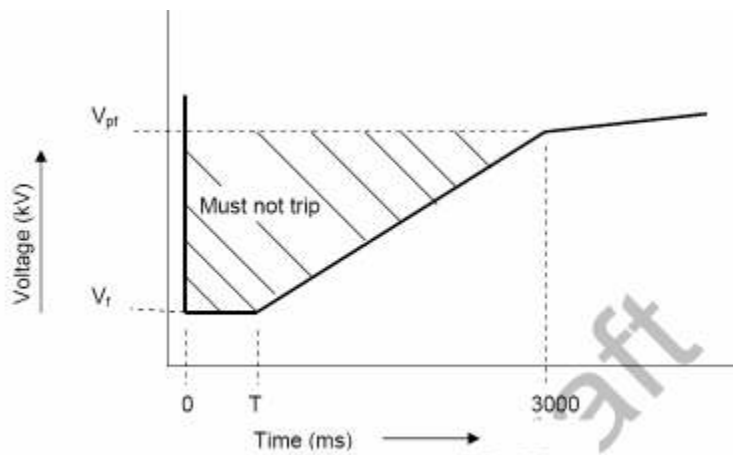
THE CONNECTION CODE

CONNECTION CODE: PROPOSAL FOR IWGC ACTIVE POWER AND FREQUENCY



THE CONNECTION CODE

CONNECTION CODE: PROPOSAL FOR IWGC FAULT RIDE THROUGH

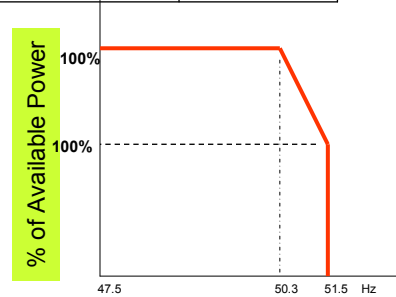


THE CONNECTION CODE

CONNECTION CODE: IWGC PROPOSAL

- RESONANCE SHALL BE AVOIDED
- VOLTAGE IMBALANCE LIMITED AS SHOWN
- REACTIVE CAPABILITY ADAPTED FROM VATTENFALL EUROPE GERMANY
- FREQ TOLERANCE 47.5-51.5 HZ WITH df/dt OF 0.5 HZ PER SEC WITHSTAND BY RE(BIS STANDARD)
- ACTIVE POWER CONTROL : LIMIT ACTIVE POWER ON SYSTEM OPERATORS REQUEST (ADAPTED FROM IRISH CODE)
- DATE REQUIREMENT FROM WIND FARM: MET DATA, FARM MW AND MVAR, SETPOINT OF VOLTAGE REG., # OF WTG'S ON/OFF(10 SEC SCAN RATE)
- PROTECTION, FLICKR, PHASE SEQUENCE ISSUES

Voltage level (kV)	Unbalance (%)
400	1.5
220	2
<220	3



OPERATING CODE

OPERATING CODE

- MAIN ISSUES IN THIS CODE ARE
 - FORECASTING
 - SCHEDULING
 - HANDLING IMBALANCES
- EXPERIENCE OF GRID CODES AND LITERATURE SURVEY IS BROUGHT OUT IN NEXT FEW SLIDES
- VITAL FOR DAY-TO-DAY OPERATION AND PARTICIPATION IN MARKETS

VERY LARGE POWER GRID
OPERATORS(VLPGO)
EXPERIENCE

INSTALLED CAPACITY - VLPGO

	Coal	CCGT	Oil	Hydro	Nuclear	RE	Total inst. Capacity
USA(PJM)	41	29	6.5	4.5	18		165000
USA(Mid West)							131308
India	53	10	1	25	3	8	150000
Brazil	12			80	2	6	99200
Britain	35	30			12		
France							
Spain	13	24		18	9	37	
Korea	34	26	8	7	24	1	
Japan	57			19	24		63981

SALIENT FEATURES: VLPGO

	Peak demand (MW)	Peak season	Sensitivity to Weather	Grid Code for RE	Nominal frequency Hz.
USA(PJM)	144,644	Summer	High	FERC CODE	60
USA(Mid West)	109157	Summer	High	FERC CODE	60
India	95000	Summer	High	UNDER PREPARATION	50
Brazil	64200	Summer		INCL IN MAIN CODE	50
Britain	61000	Winter	Medium	INCL IN MAIN CODE	50
France	92000	Winter	Low	OPERATION CIRCULAR	50
Spain	45450	Winter	Low		50
Korea	62794	Summer	High	UNDER PREPARATION	
Japan	64300	Summer		INCL IN MAIN CODE	60/50

NON VLPGO: CANADA, IRELAND, DENMARK HAVE SEPARATE WIND GRID CODE

Planning Code for RE: VLPGO

- **Evacuation of RE:**-PJM USA considers a capacity factor of 13 and a capacity credit of 13 for transmission planning. Whereas in UK, a factor of 60 is considered . Brazil and Japan consider the name plate rating for planning.
- **Cost Benefit Analysis for Transmission Planning for RE:-** PJM, Korea and Japan do not carry out any cost-benefit analysis
- UK undertakes cost benefit analysis using inputs of fuel prices, generation balancing market up and down costs by fuel type, generation availabilities by fuel type, annual demand profiles, seasonal system capacities, wind output/duration data.
- Brazil uses minimum cost criterion and carries out technical and economical analysis of the alternatives based on the electric configuration, and transmission system expansion.
- **Last Mile:** Except in case of France and UK, in all other countries, generally generation developer is responsible to provide last mile connectivity. However incase the transmission company builds the line, the costs are to be borne by the developer(s)
- **Relaxing of Reliability Criteria for RE** Evacuation:Except PJM, no other utility has relaxed the reliability criterion for RE.India and Korea are working out on the norms for relaxation.PJM has relaxed the pf requirement, however, if the system studies mandate a certain pf for a wind farm, the same is obligatory on the developer.

FORECASTING OF WIND: VLPGO

- Only PJM, MISO and RTE conduct forecast of wind energy. While PJM and MISO do it through a software supplied by Energy & Meteo Systems GmbH (<http://energymeteo.de/>)
- Similarly RTE carries out forecast using the data provided by their national meteorological centre METEO FRANCE (<http://www.meteofrance.com/>). They do it on 72 hour in advance , at a periodicity of 4 times a day for wind levels of 100m/sec)
- In Brazil the system operator use the forecast tool for preparing daily schedule. He receives forecast of monthly energy data with a granularity of week to week. This data is compared with the historical data and decomposed into day to day data with half hourly blocks.

INTERNATIONAL PRACTICES

- CIGRE 293: WORKING GROUP ON ELECTRIC POWER SYSTEM PLANNING WITH UNCERTAINTY OF WIND GENERATION

APRIL 2006

**SUMMARY OF APPENDIX 1
APPROACH TO INCENTIVES**

CIGRE: 293- INCENTIVES AND IMBALANCES

- EUROPE
 - SCHEME SIMILAR TO **REC** IN PLACE
 - INCENTIVES AND TAX BENEFITS WITH DIFFERENT NORMS IN DIFFERENT COUNTRIES
- UK AND NORTHERN IRELAND
 - SCHEME SIMILAR TO **REC** IN PLACE. ROC AND RPO IN PLACE
 - PENALTY FOR NOT MEETING RPO AT 'BUY-OUT PRICE' £ 0.03/UNIT TILL 2010
 - PROCEEDS OF 'BUY-OUT PRICE' REDISTRIBUTED TO RE'S
 - CREATES A HEALTHY FUTURES MARKET AS RPO IS INCREASED
 - 'CLIMATE CHANGE LEVY' FOR ALL NON RE PURCHASES AT £ 0.0043/UNIT
 - WHEN WIND ENERGY IS LOW RE SUPPLY CONTRACTS ARE FRUSTRATED OR AN ENERGY PREMIUM IS PAID
 - **GREAT BRITAIN MANAGES BY ALLOWING HEDGING CONTRACTS FOR RE'S**
 - NORTHERN IRELAND :- THIS COST IS BORNE BY MARKET AS 'Renewable output factor'. RE'S COMPENSATE BY SUPPLYING 120% EXTRA

CIGRE: 293- INCENTIVES AND IMBALANCES

- FRANCE
 - ATTRACTIVE FEED-IN TARIFF FOR SMALL RE
 - EDF (SUPPLIER) PROCURES WIND AND MAKES UP FOR IMBALANCES
- GERMANY
 - PURCHASE OBLIGATION ON NEAREST NETWORK OPERATOR
 - PREFERENTIAL TARIFF
- DENMARK
 - GREEN PURCHASE OBLIGATION
 - PREFERENTIAL TARIFF

SUMMARY OF VLPGO WORKING GROUP # 3 QUESTIONNAIRE ON RENEWABLES: IMBALANCE HANDLING

CONTROL AREA OPERATOR	DOES RE PARTICIPATE IN IMBALANCE POOL	DO RE'S GET SPECIAL TREATMENT FOR RESERVES	METHOD OF HANDLING IMBALANCES	PRICING OF IMBALANCES
PJM	YES LIKE ANY OTHER GENERATOR	NO	RESERVES	AVERAGE COST OF BALANCING RESERVES
NATIONAL GRID	PLANNING TO ENFORCE	NO	Reserves	AVERAGE COST OF TOP 500MWH BALANCING RESERVES
RTE	PLANNING TO ENFORCE	NO		AVERAGE COST OF BALANCING RESERVES
TEPCO	NOT YET	NO		
Korea	NOT YET	NO		
MidWest ISO	YES	YES A 20% CAPACITY FACTOR IS CONSIDERED FOR PLANNING RESERVES	Reserves	AVERAGE COST OF BALANCING RESERVES
BRAZIL	NOT YET	NO		
REE	NOT YET	NO		

SUMMARY OF OTHER COUNTRIES EXPERIENCE ON RENEWABLES: IMBALANCE HANDLING

CONTROL AREA OPERATOR	DOES RE PARTICIPATE IN IMBALANCE POOL	DO RE'S GET SPECIAL TREATMENT FOR RESERVES
Italy	YES	NO
Belgium	YES	NO
Denmark	YES	NO
UK	YES	NO
Spain	YES	NO
Sweden	YES	NO
Netherland	YES	NO
Poland	YES	NO

SOURCE: <http://www.labplan.ufsc.br/congressos/powertech07/papers/297.pdf>
Wind Generation in Day-Ahead Energy Markets
in Italy: Imbalances Penalties
C. Brunetto, M. Nicita and G. Tina, Member, IEEE

TABLE SHOWING PRACTICES ACROSS COUNTRIES FOR INCENTIVISING RENEWABLES

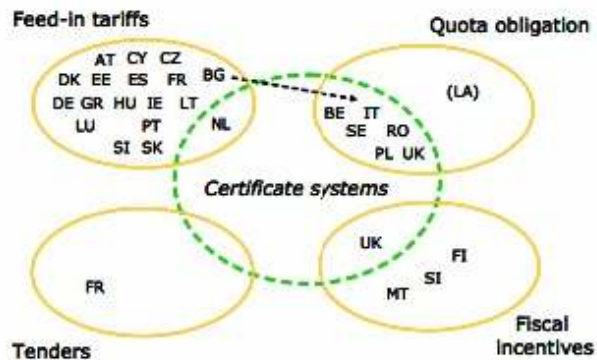
Country	Electricity Market	Gate Closure	FI T	Auctions	GC	Penalizing Imbalances
Austria	Yes	Day Ahead	Yes	No	No	No
Belgium	Yes	Ex-post	No	No	Yes	Yes
Denmark	Yes	½ h	Yes	No	Yes	Yes
Finland	Yes	½ h	Yes	No	No	No
France	Yes	6 sessions	Yes	Yes P>12 MW	No	No
Germany	Yes	3 sessions	Yes	No	No	No
Greece	Yes	Day Ahead	Yes	No	No	No
Ireland	Yes (mixed)	Day Ahead	Yes	Yes	No	No
Italy	Yes	Day Ahead	Yes	No	Yes	No
Portugal	Yes	2 sessions	Yes	No	No	No
Spain	Yes	2 ¼ - 3 ¼ hrs	Yes	No	No	Yes
Sweden	Yes	1 h	Yes	No	Yes	Yes
Nederland	Yes	1 h	Yes	No	voluntary	Yes
UK	Yes	½ h	Yes	No	Yes	Yes
Poland	Yes	Day Ahead	Yes	No	No	Yes P>50MW

SOURCE:
Wind Generation in Day-Ahead Energy Markets
in Italy: Imbalances Penalties
C. Brunetto, M. Nicita and G. Tina, Member, IEEE
<http://www.labplan.ufsc.br/congressos/powertech07/papers/297.pdf>

SUMMARY OF OTHER COUNTRIES EXPERIENCE ON RENEWABLES: IMBALANCE HANDLING

- **CAISO: PARTICIPANT INTERMITTENT RESOURCE PROGRAM**
- SCHEDULING IS 10 MIN BLOCK WISE
- PIRP ACCUMULATES 10 MIN DEVIATIONS OVER THE MONTH AND CHARGES THE RE AT A WIEGHTED AVERAGE MCP.
- PARTICIPATING IN THE PROGRAM ALLOWS THE WIND PRODUCER TO BE EXEMPT FROM ANY IMBALANCE PENALTIES AND CERTAIN MARKET CHARGES ARE ALSO WAIVED.
- REAL TIME TELEMETRY AND FORECAST BY THIRD PARTY IS AMUST FOR PARTICIPATING IN PIRP

INTEGRATION OF DISTRIBUTED GENERATION - RENEWABLE ENERGY SYSTEMS IN DIFFERENT EUROPEAN COUNTRIES STUDY BY KEMA AND LEONARDO ENERGY



Overview of primary renewable electricity support schemes in EU-27 (OPTRES Final Report, February 2007)

INTEGRATION OF DISTRIBUTED GENERATION - RENEWABLE

ENERGY SYSTEMS IN DIFFERENT EUROPEAN COUNTRIES STUDY BY KEMA AND LEONARDO ENERGY

- **SPAIN:-**
 - USES A FEED IN TARIFF SYSTEM WITH SPECIAL FEATURES.
 - RE CAN OPT FOR FIT, OR PREMIUM TARIFF WHICH IS A POSITIVE BIAS ON MARKET PRICE
 - RES-E PRODUCERS WHO CHOOSE THE PREMIUM OPTION STILL SELL THEIR ELECTRICITY TO THE DISTRIBUTOR AND RECEIVE A PREMIUM ON TOP OF THE FINAL HOURLY MARKET PRICE.
 - THE ELECTRICITY CAN ALSO BE SOLD DIRECTLY TO OTHER CUSTOMERS THROUGH BILATERAL CONTRACTS
 - ALL PREMIUM RE'S HAVE TO FORECAST
 - ALL FIT RE'S > 10 MW HAVE TO FORECAST
 - OPTION TO HANDLE IMBALANCE WITH ANY TYPE OF GENERATION, OR BY EXCESS FROM OTHER WIND PARKS
 - 20% DEVIATION IS ALLOWED FOR WIND AND SOLAR ABOVE WHICH THE GENERATOR PAYS A PENALTY OF 10% OF MARKET PRICE

INCENTIVISING WIND GENERATION: OPTIONS FOR INDIA

- **PECULIARITIES OF INDIAN GRID**
 - DECENTRALISED GENERATION CONTROL, LOOSE POWER POOL, FREQUENCY ALLOWED TO VARY-
 - SETTLEMENT MECHANISM FOR ISTS, NOT PERCOLATED TO STATE LEVEL
 - CONTROL AREA IMBALANCES ARE PRICED (UI MECHANISM)
 - MIX OF VERTICALLY INTEGRATED AND UNBUNDLED UTILITIES
 - HIGH PENETRATION OF RE IN SOME CONTROL AREAS

INCENTIVISING WIND GENERATION: OPTIONS FOR INDIA

- INCENTIVE OPTIONS:-
 - PREFERENTIAL TARIFF AND TAX SOPS (ALREADY IN PLACE)
 - RPO AND REC MECHANISM (IN PROCESS)
 - FULL MARKET PARTICIPATION (SUGGESTED)
 - FORECAST, SCHEDULE AND BE RESPONSIBLE FOR IMBALANCES – SELL ACROSS SEAMS- BILATERALS AND PX

INCENTIVISING WIND GENERATION: HANDLING IMBALANCES(SUGGESTIONS)

- IN A CONTROL AREA 3 TYPES OF RE INJECTION ARE POSSIBLE
 - PREFERENTIAL TARIFF RE
 - TARIFF PLUS REC
 - RE'S TRADING ACROSS SEAMS ON BILATERAL OR COLLECTIVE
- MULTIPLE WIND FARMS IN **BID AREA** COULD AGGREGATE FOR PX
- FORECASTING IS A MUST
 - INTERNATIONAL BEST PRACTICE
 - FORECASTING TECHNOLOGY AND TOOLS ARE AVAILABLE
- AS A SPECIAL CASE THE REGULATOR COULD ALLOW REVISION OF SCHEDULES FOR BILATERAL.

REFERENCES

- CIGRE 293: WORKING GROUP ON ELECTRIC POWER SYSTEM PLANNING WITH UNCERTAINTY OF WIND GENERATION
- WIND GENERATION IN DAY-AHEAD ENERGY MARKETS IN ITALY: IMBALANCES PENALTIES
C. BRUNETTO, M. NICITA AND G. TINA, MEMBER, IEEE
- INTEGRATION OF DISTRIBUTED GENERATION - RENEWABLE ENERGY SYSTEMS IN DIFFERENT EUROPEAN COUNTRIES
STUDY BY KEMA AND LEONARDO ENERGY
- F.O.R POLICIES ON RENEWABLES
- CERC ORDERS ON RENEAWBLES
- CALIFORNIA INDEPENDENT SYSTEM OPERATOR CORPORATION: INTEGRATION OF RENEWABLE RESOURCES REPORT
- DRAFT INDIAN WIND GRID CODE
- VLPGO QUESTIONNAIRE ON RENEWABLES

