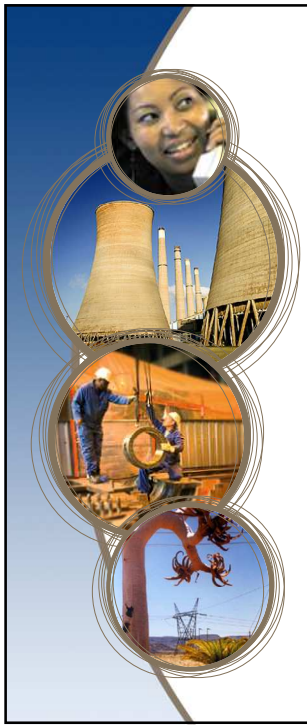


Grid connection requirements of Renewable Energy

Presented by: Riaan Smit
Chief Engineer:
Network Planning

2010-09-28

Content

- Summary of interest in renewable energy developments to date
- Renewable Energy Development Areas
- Embedded Generation (EG) Applications
- Interconnection of Embedded Generation
- Joint Transmission & Distribution Grid Planning
- Western Cape GTZ-DigSilent-Eskom grid integration study
- Conclusion
- Q&A

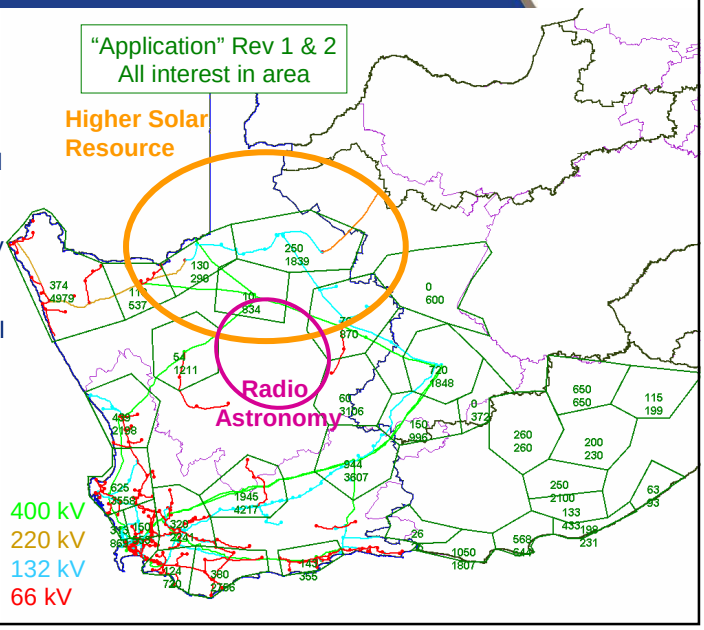
Renewable Energy "Potential" Summary (MW)

	WR	SR	NWR	Total
• Development interest in MW:				
• Wind Applications (Letter, Rev 1&2)	6 350	5 212	1 682	13 252
• Other RE sources	795	20	1 082	1 902
• **Requests for RE Grid Connection**	**7 145**	**5 232**	**2 764**	**15 154**
• Number of "application" projects	85	45	24	156
• Max potential listed for these sites	12 172	5 519	5 063	22 772
• Alternatives, Duplicate sites, too close to coast, "long term dreams",…..				
• New applications will assist with data cleanup - latest requirements				
• Formal process Applications expected ??				
• Expected approval levels by 2013 (IRP1)				1 025

- Actual RE potential — Precisely unknown
- Uncertainty high — Await IRP 2 by Nov 2010 / REFIT programme
- Excellent cooperation by potential developers – to share data
- Database with RE Projects shared with Eskom Network Planners only

Renewable Energy Development Areas (REDA) – Indicative "applications"

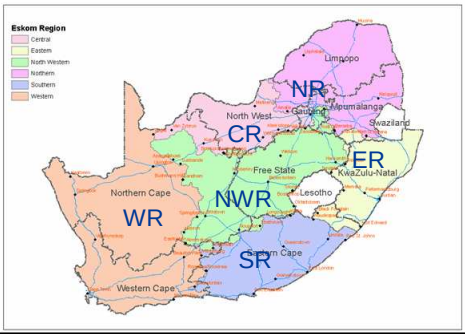
- MTS substation areas / Technical Areas
- Numerous extra ~500 MVA substations required – long term
- Additional transformer capacity required
- Allow 3+ year lead time – EIA, technical & resource, etc.
- Funding for shared networks need NERSA approval



Embedded Generation (EG) Applications

- Use Eskom EG Application form Revision 02, Dated 30 June 2010
- Forward request for Indicative Costs on Company Letterhead and Rev 2 to Customer Services (see contacts below)
- All letters, Rev 1 and Rev 2 considered in scenarios
- Formal national process not initiated as yet – all are waiting
- Company & Technical data

are.vanzyl@eskom.co.za	Western Region
billy.madike@eskom.co.za	Central Region
dirk.opperman@eskom.co.za	North West Region
eddie.leach@eskom.co.za	Southern Region
wolfgang.bohmer@eskom.co.za	Northern Region
ravi.moonsamy@eskom.co.za	Eastern Region



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Renewable Energy applications

- Applications to be processed once REFIT programme requirements fully available
- Indicative costs to support developers
- A quotation requires detail work for project submissions – Application Form Rev 2 Part 2 to be updated with all required technical data
- Selected projects to continue once commitment fee is paid to Budget Quote stage
- Project execution will follow once PPA allocated / financial close
- Will require a Connection and Use of System Agreement to be signed
- Any programme must cater realistically for project lead times and risks, including quotation phase, EIA, construction….

Interconnection of Embedded Generation

- SA Grid Code (Transmission) and Distribution Grid Codes from NERSA
- DST 34-1765 Distribution standard serves to fulfil Eskom Distribution's obligation under Section 8.2 (4) of the South African Distribution Code: Network Code:
  - "The Distributor shall develop the protection requirement guide for connecting Embedded Generators to the Distribution System to ensure safe and reliable operation of the Distribution System".
- This standard does not apply to generator interconnections at Low Voltage, or generators of capacity less than 100kW. NRS097 will cater for it.
- The present revision of this standard does not cater for specific requirements with regard to the interconnection of wind farms
  - Additional Wind Grid Code requirements under development
- Will require developer/IPP cooperation with proper technical data
  - E.g. wind turbine models

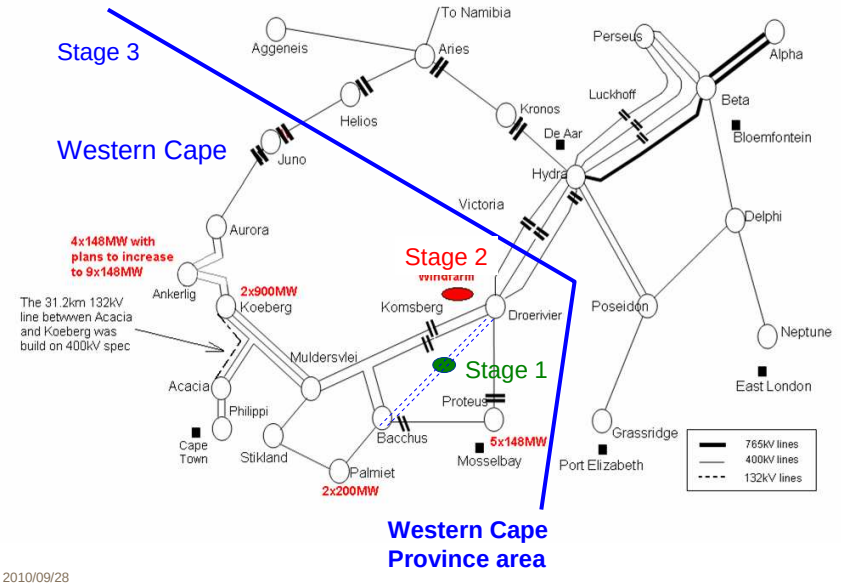
Joint Transmission & Distribution Grid Planning

- First real wind energy course in South Africa – March 2009
  - Arranged by DEADP, Western Province and Eskom with GTZ & DigSilent
  - Involved various role players and developers in industry
- GTZ-DigSilent-Eskom Western Province grid capacity study – March – Nov 2009
- GTZ-DigSilent-Eskom grid capacity credit study – March – Oct 2010
- Transmission and Distribution in-house network capacity, and fault studies in progress
  - Will be used in feedback to developers to assist with applications
  - Transmission & Distribution workshop held Sep 2010
- Planning procedures being developed and tested
- Developers treated as if only developer, until optimisation for projects accepted for REFIT programme
- DigSilent wind turbine modelling course to Eskom Network Planners – Oct 2010 – to support proper analysis and consistent approach
- The above deals only with Eskom, Municipal needs to be considered

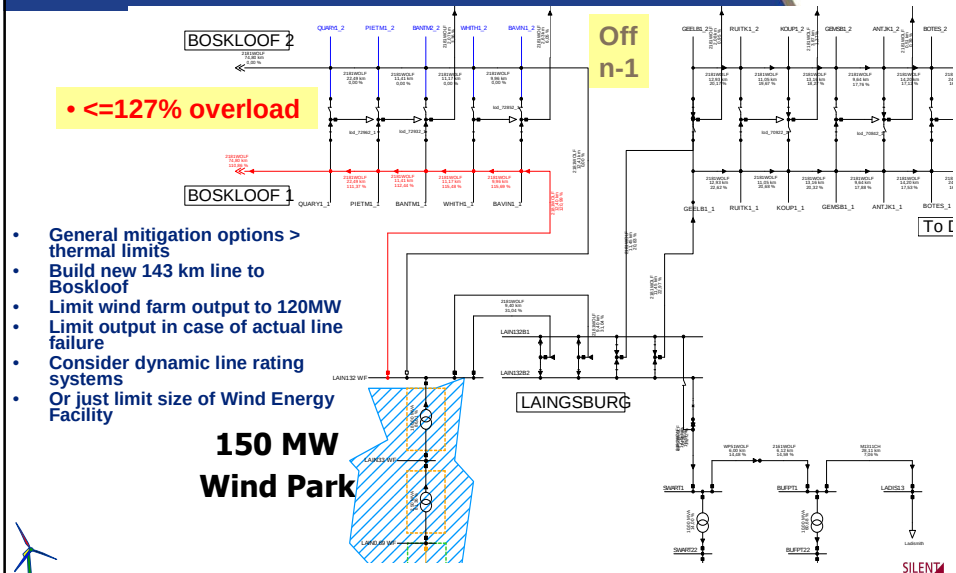
Grid connection “technical concerns”

- Thermal loading of lines/transformers
- Voltage variations during normal operation
  - Over voltages studies for Renewable Energy projects
- Voltage recovery after faults (incl. Low Voltage Ride Through)
- Voltage sags due to breaker operation
- Reactive power control
- Cable/Transformer inrush currents
- Short circuit currents
- Impact on Power Quality aspects (Harmonics/Flicker, IEC 61400-21)
- Influence on ripple control system
- Limit system losses
- Reliability required by wind developer
- Transmission system requirements such as stability, sub-resonance...
- Need to do technical studies / analysis to ensure acceptance

GTZ-DigSilent-Eskom Western Cape grid capacity study



Stage 1: 150MW – Impact on Thermal Limits



- General mitigation options > thermal limits
- Build new 143 km line to Boskloof
- Limit wind farm output to 120MW
- Limit output in case of actual line failure
- Consider dynamic line rating systems
- Or just limit size of Wind Energy Facility

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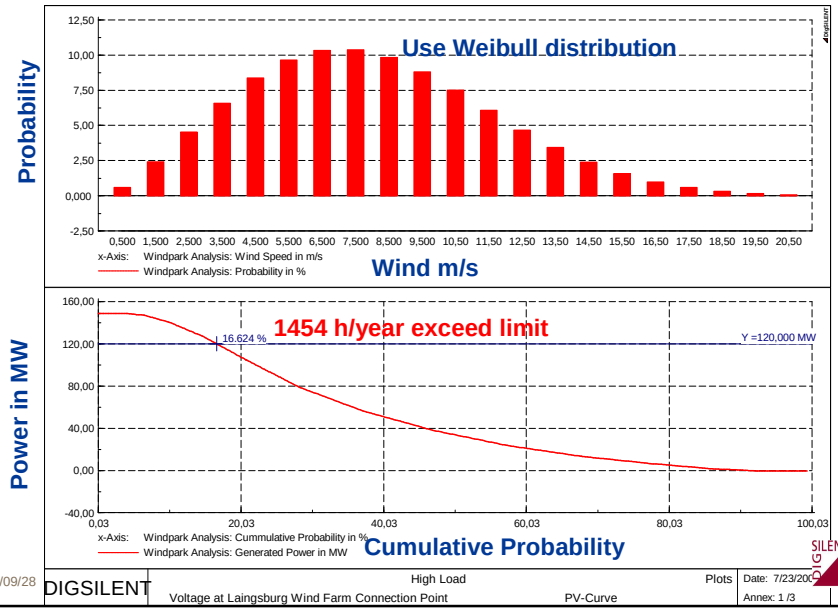
Violation of Thermal Limits – Cap Wind Farm Output



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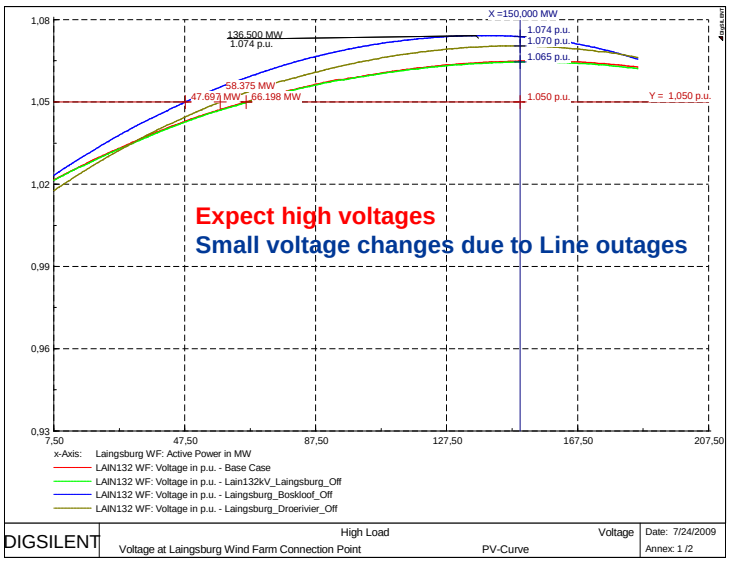
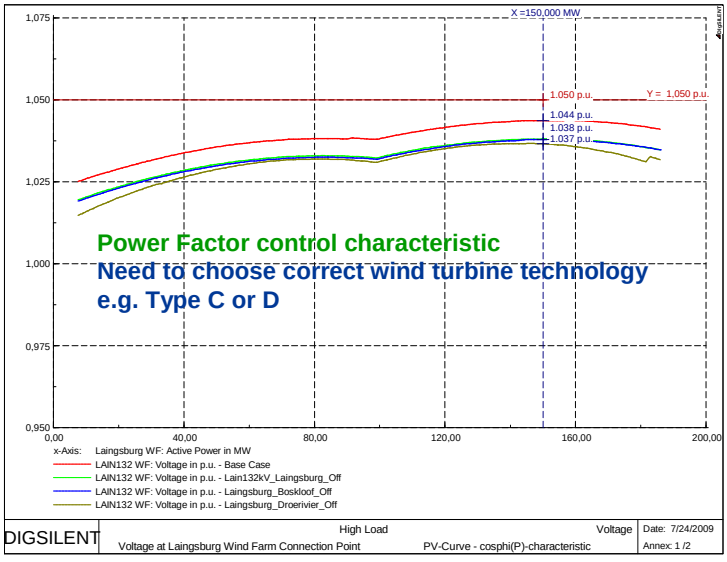
DIGSILENT	High Load	Plots	Date: 7/23/200
	Voltage at Laingsburg Wind Farm Connection Point	PV-Curve	Annex: 1 /3

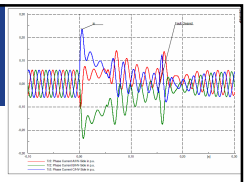
Voltage Variations – cos phi constant (=1)



Voltage Variations – cos phi(P)-characteristic



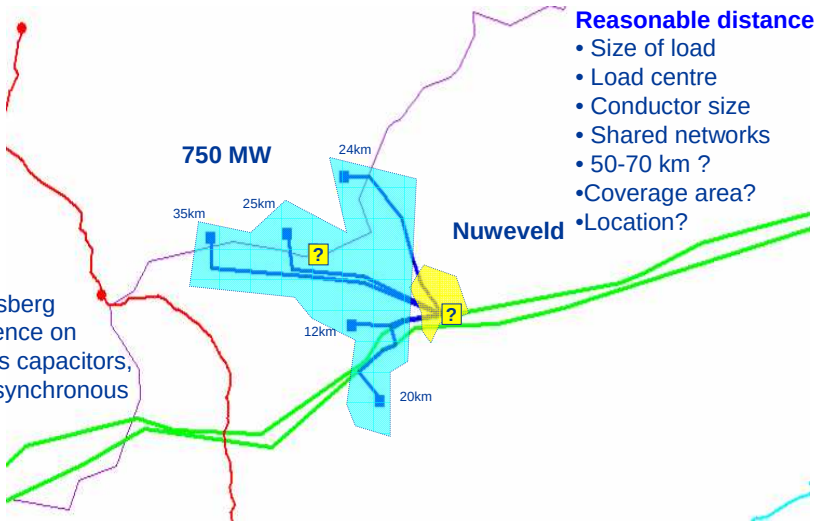
Specialist studies
– e.g. Impact on Short Circuit Currents



- DFIG:
  - Considerable contribution to peak short circuit current.
  - Contribution to thermal short circuit ratings: approx 1 p.u. shc-current
- WTG with fully rated converter:
  - Contribution to initial short circuit current: approx. 1 p.u. shc-current
  - Contribution to thermal short circuit ratings: approx 1 p.u. shc-current
- 150MW wind farm at Laingsburg:
  - Contribution to initial shc-current (Ikss): approx 2 kA (at 132kV)
  - Contribution to peak shc-current (ip): 4,4 kA
  - Contribution to transient shc-current (Iks): 0,67 kA
- Contribution to fault levels not critical in this particular example because of low fault level at wind farm connection point.

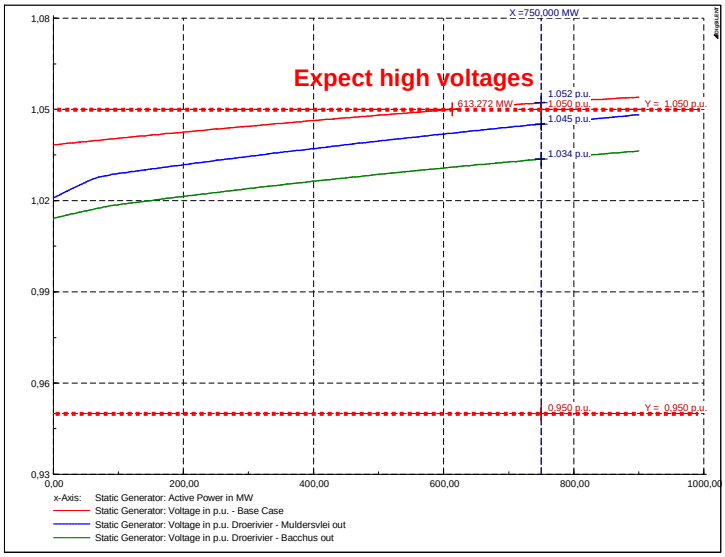
Stage 2 – 750MW of Wind Gen in Karoo
Represent a group of green field projects - example

Eskom



Reasonable distance
- Size of load
- Load centre
- Conductor size
- Shared networks
- 50-70 km ?
- Coverage area?
- Location?

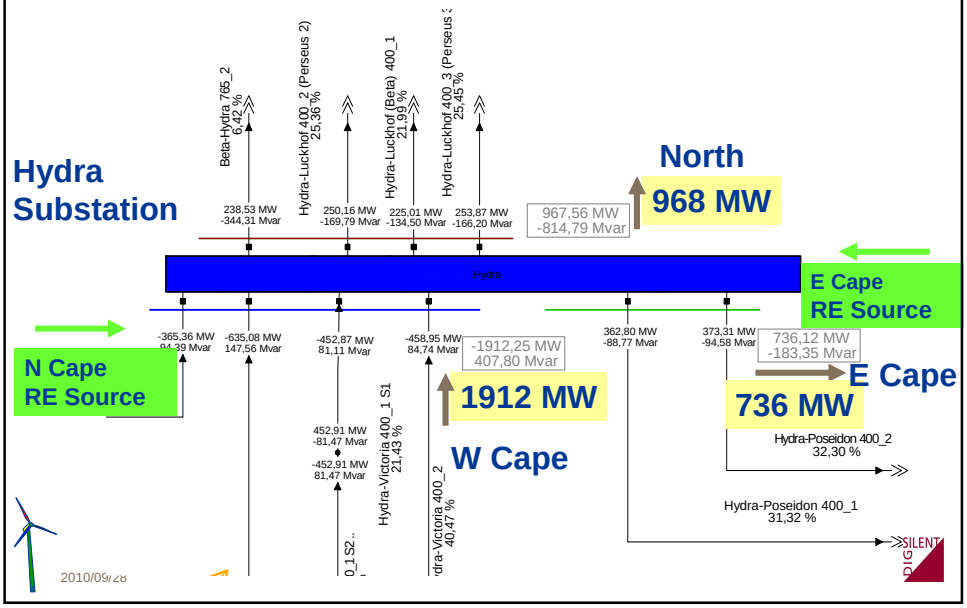
Stage 2 – 750MW wind in Karoo - Voltages



Stage 2 – 750MW – Summary of Results

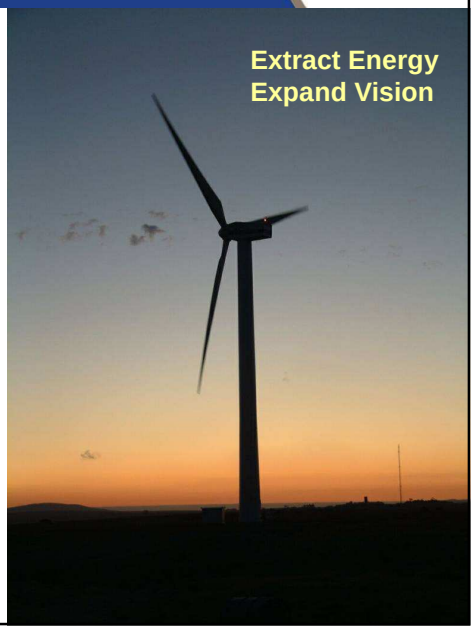
- No thermal overloads under n-1 conditions
- Voltage variations very small, even in constant power factor operation.
- Operation with constant Q (var-control) is appropriate.
- (Slow) voltage control is possible and should be considered.
- 4x100Mvar shunt reactors required at Nuweveld substation (or equivalent var-absorption of the wind farms) because of proximity to Komsberg series compensation.
- **Series compensation at Komsberg should be resized for considering new line configuration**.
- With adjusted series compensation, shunt reactors at Nuweveld might not be required.
- No power quality issues because of the large number of turbines and high fault level at the grid connection point

Stage 3 – 2800MW of Wind – Example: Low Load + High Wind, 2xKoeberg units, no OCGT's



Conclusion

- Various exciting disciplines
- Skills development good progress
- Methods and techniques being improved
- Eskom application form available
- Embedded Generation standard
- REDA being studied – to motivate long term grid solutions
- Await REFIT Rules & Criteria & IRP to determine grid requirements
- Need long term allocations and approvals to ensure 3-7 year large infrastructure lead times can be met
- Let us make RE work



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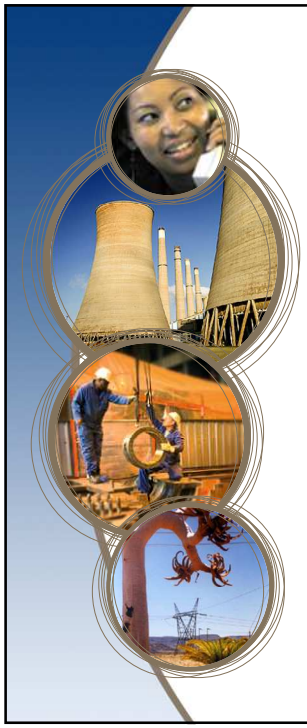

Thank you

Riaan Smit
riaan.smit@eskom.co.za

Contributions by:
Nish Rathanlall
Shirley Salvoldi