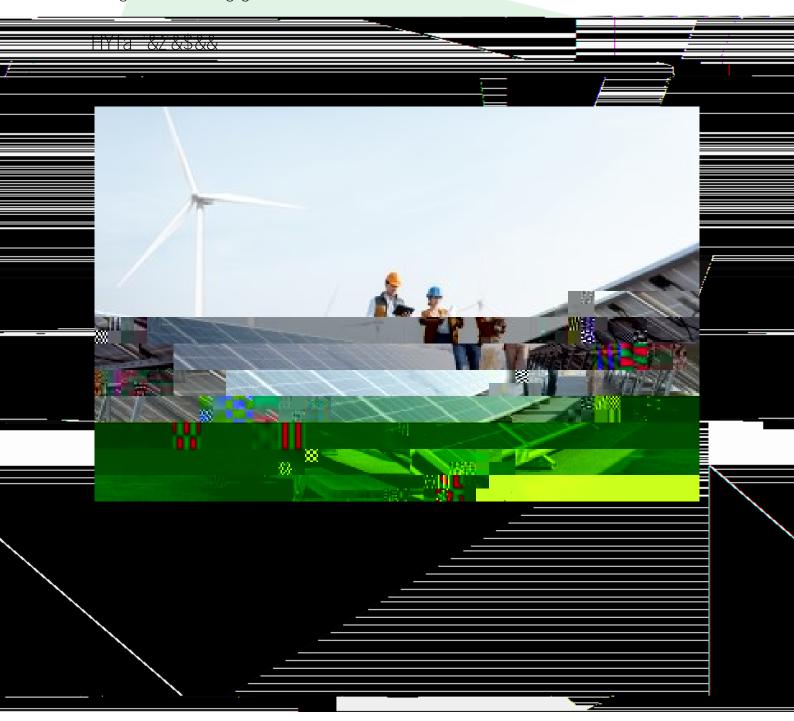


SOLA4952, SOLA9452

FYgYUfVX 'H\Yg]g'6



7ci fgY 8YHJ] g

 $\label{thm:condition} $$HY'bcfa\ U''k\ cf_cux'YI\ dYWfuhcbg'cZU'ghi\ XYbh'ufY'uddfcI\]a\ UhY'm'&) '\ci\ fg'dYf'hYfa\ 'Zcf'YUW'I\ C\ 7\ z'\]bWi\ X]b[\ 'WUgg'Wcbh'uWfi\ci\ fgz'ch\Yf''YUfb]b[\ 'UWhjj\]h]Ygz'dfYdUfUhjcb''UbX'hJa\ Y'gdYbh'cb''U'''UggYggUV'Yk\ cf_'''$

Mci 'g\ci `X'U]a 'hc'gdYbX'UVci h* '\f#k _'cb'h\]g'Wci fgY"'H\Y'UXX]h]cbU``h]a Y'g\ci `X'VY'gdYbh]b'a U_]b[gi fY'h\Uhmci 'i bXYfgHJbX'h\Y'a UhYf]U'ž'Wca d'Yh]b['h\Y'gYhXY`]j YfUV'Ygž'Z fh\Yf'fYUX]b[ž'UbX'd'Ubb]b["

$H\Yg]g$; i]XY]bYg

• H\Y'dfYfYei]g]hYg'Zcf'H\Yg]g'6'fGC @5(-) &# () &£'UbX'H\Yg]g'7'fGC @5(-)' # ()' £'UfY'H\Yg]g'5 fGC @5(-) \# () \%£'UbX'H\Yg]g'6'fGC \@5(-) &# () &£Z'fYgdYWhJ Y`m'

.

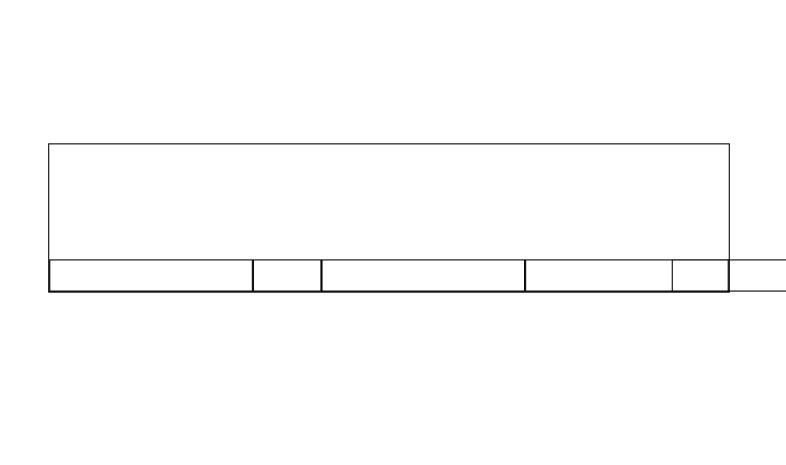
5ggYgga Ybh

DfYgYbhJh]cb

5```gi Va]gg]cbg`UfY`YI dYWYX`lc`VY`bYUh`UbX`WYUf`mgYhci h'`Mci f`fYgi `hg`UfY`h\Y`d]bbUWY`cZU```mci f`\UfX k cf_'UbX`g\ci `X`VY`hfYUhYX`k]h\`Xi Y`fYgdYWf`DfYgYbh]b[`fYgi `hg`WYUf`m[]j Yg`h\Y`a Uf_Yf`h\Y`VYghW\UbW cZi bXYfghUbX]b[`mci f`a Yh\cX/Yj Yb`]Zh\Y`bi a Yf]WU``fYgi `hg`UfY`]bWcffYWf

Gi Va]gg]cb

K cf_'gi Va]hhYX``UhY`k]h\ci h'Ub`Uddfcj YX`YI hYbg]cb`Vmh\Y`Wti fgY`WtcfX]bUhcf`cf`XY`Y[UhYX`Ui h\cf]hm]g



$\label{eq:hamiltonian} $$HY'UggYgga\ Ybhik\]``'HU_Y'UWWti\ bhicZhY'Zc``ck\]b[\ .$

7 f]hY f]U ·	A Uf_'	A Uf_YX ci hcZ	; i]XYg [·]
Ghfi Whi fY'		<u> </u>	l bgUhgZJWcfmO)ı
• `c[]WU` XYj Y`cda Ybh			5XYeiUhY'f)ı!*")ı Ł
• WUf]hmicZ			; ccX ⁻ ff*")। !+")। Ł
XYgWf]dh]cb			JYfm; ccX'f+")ı!,")ı Ł
			CihghUbX]b['f]")ı!%\$ı Ł'
Gi VYWnA UHYf''		%) ı	I bgUhgZJWcfmO+") ı
• 7 cbh/bhg cZh\Y dfcV'Ya 'UbX			5XYei UhY fh=") !- ") E
i bXYfm]b['h\Ycfm'			; ccX'ff")ı !%")ı Ł'
• ? bck `YX[Y cZh\Y UfYU cZ]bj Ygh][Uh]cb			JYfm; ccX f‰")ı!‰")ı Ł
			CinghUbX]b[
• F Y`Uhjcb hc di V`jg\YX`k cf_`			f%&")।!%)ı Ł
• '			
HYW.b]WU``7 cbhYbh		(\$1 '	l bgUhjgZJWhcfmiO&\$i
EiU`]lmicZh\Yg]gk cf_`			5XYeiUhYf&\$i!&*iŁ
• A YMcXc`c[mUbX			; ccX'f&*i !' \$i Ł'
k cf_'d`Ub'			JYfm; ccX'fl\$i!'(i Ł'
• DfY`]a]bUfm F Ygi `hg`			CihghUbX]b["f1(i!(\$i Ł"
Mci 'a i ghg\ck 'U'XYHJ]'YX a Yh\cXc`c[m"			
Mci k]``g\ck \ck mci \UjY`UW.]YjYXhYkcf_ U[U]bghhY'dfcYWhd`Ub"			
K_]``Wcj_Yf`U`XYHJ]`YX X]gW`gg]cb`cb`k.cf_			

Wca d`YhYXž'g\ck]b['Ub i bXYfghUbX]b['cZfYgi `hg nc'XUhY'UbX'h\Y]a d`]WUh]cbg'cZh\YgY fYgi `hg'Wca dUfYX'nc'k\Uh h\Ym'Zci bX']b'h\Y `]hYfUh fY"'		
DfYgYbhUh]cbif]"Y"'9b[`]g\ igu[YžfUhYcZgdYYW\ž UiX]v]`]hmžigYcZU]Xgž d`UhZcfaiaUbbYfYhWŁ		bgUr]gZJWrcfm0%\$1
7 ca dYMbWM]b \UbX`]b[ei Ygh]cbg	%\$ 1	bgUfgZJVVcfmO) 5XYei UfY f) !*") Ł ccX ff*") !+") Ł J Yfm; ccX f#") !, ") Ł

5 hyb XUb WY F Yei] fYa Ybhg

7 ci fgY GWX YXi `Y

H\Ya]a'K]h\XfUk U'ž'Gi adYba]cbž'UbX'H]a Y'91 hYba]cb'

F Yei YghgʻZcfʻh\Yg]gʻk]h\XfUk Uʻžgi gdYbg]cbʻcfʻYl hYbg]cbžV\Ub[YʻcZgi dYfj]gcfʻg\ci `X`VYʻa UXYʻ]bʻk f]h]b[hcʻh\YʻH\Yg]gʻ7 ccfX]bUhcfʻ'H\YʻZc``ck]b[ʻdfc\WXi fYgʻUbXʻfi `Ygʻk]``VYʻUdd`]YXʻk \YbʻUʻghi XYbhik]g\Ygʻhc k]h\XfUk 'Zfca žʻcfʻgi gdYbXʻGC @5(-) &#() &"`H\YgY`fi `Ygʻgi dd`Ya Ybhih\Yʻl BGK 'XYUX`]bYgž'WcbX]h]cbgž UbX'dfc\WXi fYgʻZcf`k]h\XfUk]b['Zfca 'UʻWci fgY"'

D@95G9BCH9.HYg]g7aighVYWcadYhYX]bhYYhYfaZc``ck]b[HYg]g6

%" +b Yj YfmWUgY k \YfY 'U 'ghi XYbhik]g\Yg 'hc 'dcghdcbY 'Wca d'Yhjcb 'cZh\Y 'h\Yg]gž]"Y" 'hc 'gi gdYbX 'k cf_ UbX 'Wca d'YhY 'h\Y 'h\Yg]g]b 'U '`UhYf 'gYgg]cbžk f]hhYb 'Uddfcj U '`cZh\Y 'gi dYfj]gcf 'a i ghZ]fghVY cVhU]bYX 'VYZcfY 'gi Va]hh]b['U 'k f]hhYb 'fYei Yghhc 'h\Y 'H\Yq]g '7 c!cfX]bUhcf"

H\Y`gi dYfj]gcf`a UmfYZ gY`Uddfcj U``Zcf`U`j Uf]YhmcZfYUgcbgžY"["'h\Uhih\Y`bYWYggUfm`ZJWj]h]Yg`k]```bc `cb[Yf`VY`Uj U]`UV`Y`Uhih\Y``UhYf`XUhYž'h\Uhih\Y`gi dYfj]gcf`k]```VY`UVgYbhžcf`h\Uhih\Y`ghi XYbh\Ug`U`fYUXm\UX`cj Yf`cb['h]a Y`cb`h\Y`dUfh]W``Uf`h\Yg]g`hcd]WžYhW

K \Yb'U'gi dYfj]gcf'ZYY`g'h\UhU'gh XYbh]g']b\WdUV`Y'cZgi \W\W'ggZ\``m\\ca d`Yh]b['h\Y'gY`Y\\YX'h\Yg]g'hcd]\\\\\X'gi dYfj]gcf'g\ci `X'ghfcb[`mUXj]gY'h\Y'gh XYbhhc'k]h\XfUk 'Zfca 'h\UhdUff]\\\``Uf'hcd]\WUbX'gYY_'U'bYk cb\Y\\\Zdcgg]\'`mk]h\`U'X]\ZYfYbhgi dYfj]gcf''

- %" 5 'ghi XYbhik \c']g'dYfa]hhYX'hc'k]h\XfUk 'k]h\ci hZJ]'i fY'Zfca 'gi VYWhGC @5(-) &#() &'g\ci `X'fY! Ybfc``]b'h\Y'Zc``ck]b['gYgg]cb'k]h\'U'H\Yg]g'Bca]bUh]cb': cfa "'BchY'h\Uhi bXYf'bcfa U' WjfW a ghUbWfg'X]gWcbh]bi Uh]cb'k]h\ci hZJ]'i fY'cf'Z[bUbW]U`'dYbU`hm]g'dcgg]V'Y'cb`mi d'hc'h\Y 7 Ybgi g'8 UhY"
- &" K \Yb'U'ghi XYbh']g'[fUbhYX'Ub'YI hYbg]cb'th\YfY'a Um'VY'U'dYbU'hmifYgi `h]b[']b'U'fYXi Wf]cb'cZh\Y h\Yg]g'a Uf_"'H\]g'k]``'VY']a dcgYX'UW\cfX]b['hc'fi `Yg'Uddfcj YX'Vm'h\Y'H\Yg]g'7 ccfX]bUhcf'UbX'k]`` VY'XcbY'UZhYf'Wcbgi `hUh]cb'k]th\Yh\Yg]g'gi dYfj]gcf"'Gi dYfj]gcfg'UbX'UggYggcfg'a Uf_]b['th\Y h\Yg]g'g\ci `X'\ck Yj Yf'Uk UfX'U'a Uf_'Ybh]fY`mcb'th\Y'a Yf]hg'cZh\Y'th\Yg]gž'th\Y'fYXi Wf]cb'th\Yb'VY]b[a UXY'gi VgYei YbhmVm'h\Y'H\Yg]g'7 c!cfX]bUhcf"

J]Yk 'WUgg'ha YhUV'Y

Hla YHJV`Y

8 UHY	HmdY	7cbhYbh
K YY_" . '% '>i bY ! '%+ >i bY	5ggYgga Ybh	Dfc[fYgg'l dXUhY.'Gi Va]hhc'A ccX`Y'UbX'Ya U]`'U Wcdmhc'mci f'gi dYfj]gcf
K YY_'+. '%%'>i `m'! '%)	5ggYgga Ybh	GYa]bUf.'D`YUgY'giVa]h`]b'h\Y'Zc`XYf'[fUX]b['Zcf

>i `m		gYa]bUf`cb`A ccX`Y
K YY_"%\$."%"5i [i gh!") 5i [i gh	5ggYgga Ybh	Dfc[fYgg'FYdcfh'D`YUgY'giVa]hhc'AccX`Y gYWncb'5ggYggaYbhaUf_]b['Zcf'XY`]jYfUV`Yg

FYgci fW/g

DfYgWf]VYX F Ygci fWYg

Mci f'gi dYfj]gcf'k]``'dfcj]XY't\\Y'fYgci fWYg'mci 'bYYX'Zcf'mci f'dfcYWYg"

FYWca a YbXYX FYgci fWYg

•

- GHJfhik cf_'cb'mci f'hcd]WJg'gccb'Ug'mci 'WJb"'H\]g'k]```[]j Y'mci 'd'YbhmcZh]a Y'hc'UXXfYgg dfcV'Ya g'h\Uh'mci 'a UmYbWci bhYf'cb'h\Y'k Um'
- D`Ub`h\Y`dfc[fYgg`cZmcif`h\Yg]g`ig]b[žZcf`Yl Uad`Yž`U`; 5BBH`W\Uffz`UbX`fYj]gY`h\Y`d`Ub`Ug`]h dfcWYYXg"
- GhufhiVmidYfZcfa]b['U'fYj]Yk 'cZh\Y'Uj U]'UV'Y'`]hYfUh fY 'cb'fYgYUfW\'Wca d'YhYX']b'h\Y'gUa Y'UfYU Ug'mci f'dfc YWh'H\]g'k]``\Y'd'mci 'Z fh\Yf'XYZbY'mci f'hcd]WUbX'h\Y'X]fYWhJcb'mci f'h\Yg]g'k]``\H\Z'"
- CfXYf'a UhYf]U`g'Ug'gccb'Ug'mci 'UfY'gi fY'k \Uh'mci 'bYYX"
- 7` V@afW]g'V]V`]c[fUd\]WgcZhk UfY'h\Uh'U``ck g'mci 'hc'a UbU[Y'mci f'fYZYfYbWfg']b'U'XUh'UVUgY" FYZYfYbWfg'Wbb'VY']bgYfhYX'Zfca ']bg]XY'A G'K cfX'XcW'a Ybhg'hc'WfYUhY']b!hYl hWjhUh]cbg'UbX V]V`]c[fUd\]Yg']b'j Uf]ci g'fYZYfYbW]b['ghmYg"'H\Y'dfc[fUa ']g'Uj U]`UV'Y'ZfYY'hc'l BGK 'ghUZZUbX ghi XYbhg"'+bZcfa Uh]cb'UbX'`]b_g'UfY'Uj U]`UV'Y'h\fci [\'h\Y'l BGK '@]VfUfm'

·····HUgh]b['cf'ga Y``]b[žY"["'ZccXg

······UbXž°cZWci fgYž′Xfi [`lf]U`gž′VcXmh]ggi YgʻUbX°ch\Yf`a YX]WU``UWfj]]h]Yg"

 $\label{eq:continuity} 5 \left[\text{gc} \text{\'z} \text{dfc} \text{\'YW} \text{g}^{-} \right] \text{bj c'j } \text{b['Ub]a U'g'k]}^{-} \text{bYYX'Yh} \left[\text{Wg'Uddfcj U'''} \right]$

Zmci f`dfcYWhXcYg`fYei]fY`UddfcjU`ž]b`h\Y`Z[fgh`]bghUbWYžX]gW gg`h\]g`k]h\`mci f`Gi i \]`c`"

-Zmci f`dfcYWNUiY```VXWc]dc`bbWmd`YUiYYaW_YYgciYZmc`U]hYUbX`cU]Ub]b[VYZcYXWc]XiWgh]b[`Um```Vg

₹mc'hU fY''YeYUahc]b-Y'a °"

5 WUXYa]W<cbYghmUbX D`U[]Uf]ga

 $\label{thm:continuous} IBGK ``Ug`Ub`cb[c]b[`Wcaa]haYbhhc`ZcghYf]b[``U`W``hifY`cZ`YUfb]b[`]bZcfaYX`VmUWUXYa]W]bHY[f]hm'`5``IBGK ``ghiXYbhg``UjY`U`fYgdcbg]V]`]hmhc`UX\YfY`hc`h\]g`df]bW]d`Y`cZUWUXYa]W]bHY[f]hm'`D`U[]Uf]gaibXYfa]bYg`UWUXYa]W]bHY[f]hmUbX`]g`bchhc`YfUhYX`UhIBGK "`B'SY[Sde_SfG@EI[eVW{`WSege[YfZW_aXSekagdai`ž$

D`U[]Uf]ga i]g`U`hmdY`cZ]bhY``YWi U``h\YZh'`±iWUb`hU_Y`a UbmZcfa gžZfca `XY`]VYfUhY`W\YUh]b[`hc`UWV]XYbhU``m Wcdm]b[`Zfca `U`gci fWYk]h\ci hUW_bck `YX[Ya Ybh'`I BGK `\Ug`dfcXi WYX`U`k YVg]hY`k]h\`U`k YU`h\`cZ fYgci fWYg`hc`gi ddcfhighi XYbhg`hc`i bXYfghUbX`UbX`Uj c]X`d`U[]Uf]ga žij]g]h`ghi XYbh'i bgk "YXi "Ui #d`U[]Uf]ga "H\Y`@YUfb]b[`7 YbhY`Ugg]ghg`ghi XYbhg`k]h\`i bXYfghUbX]b[`UWUXYa]W]bhY[f]hmUbX`\ck 'bchhc'd`U[]Uf]gY" H\YmU`gc`\c`X`k cf_g\cdg`UbX`WUb`\Y`d`ghi XYbhg`cbY!cb!cbY"

Mci 'UfY'U'gc'fYa]bXYX'h\Uh'WUfYZ\ ``h]a Y'a UbU[Ya Ybh']g'Ub']a dcfhUbhdUfhcZgh XmUbX'cbY'cZh\Y]XYbh]Z]YX'WUi gYg'cZd'U[]Uf]ga ']g'dccf'h]a Y'a UbU[Ya Ybh'Gh XYbhg'g\ci `X'U``ck 'gi ZZ]W]Ybh'h]a Y'Zcf

a dcfhUbh@]b_g

5```ghi XYbhg`UfY`YI dYWhYX`hc`fYUX`UbX`VY`ZJa]`]Uf`k]h\`I BGK`; i]XY`]bYg`UbX`Dc`]WYg"'±b`dUfh]W\`Ufžghi XYbhg`g\ci``X`VY`ZJa]`]Uf`k]h\`h\Y`Zc``ck]b[.

Œ MY b X U b WYŒ

ŒdYWU`7cbq]XYfUhcb

(Bei]hUV`Y`@YUfb]b[GYfi]WYg

1 Ua q

(Eddfcj YX'7 U'W 'Uhcfg

CH_BGK '9a U]`'5XXfYgg

.

8]gWU]a Yf

 $FZ[e\ UagdeWagf'[\ WeWfe\ agf\ VWeUd[bf[a\ aXU'SeeWe\ SffZWVSfWfZW5\ agdeWA\ gf'[\ W[e\ bgT'[eZW\ZFZW\ SfgdWaXU'SeeWe\ _Sk\ UZS'\ YWVgd[\ Y\ fZWFWd_\ SXfWdfZW5\ agdeWA\ gf'[\ W[e\ bgT'[eZW\Z'?\ aaV'WeZag'V\ TW\ Ua'\ egfW \ Xad\ fZWgb\ fa\ VSfWU'See\ VWeUd[bf[a'\ ez'; XfZWdW[e\ S'\ k\ ['\ Ua'\ e[efW'\ Uk\ ['\ fZWVWeUd[bf[a'\ aX\ SUf[h[f]We\ TWf]\ WW'\ fZWG'\ [hWde[fk\ f[_\ WfST'WS'\ V\ fZW5\ agdeWA\ gf'['\ W'\ Se\ gbVSfW ['\ ?\ aaV'Wf]\ fZWVWeUd[bf[a'\ ['\ fZW5\ agdeWA\ gf'['\ W'?\ aaV'WSbb']Wez']]$

7F = 7CG

7F = 7CG Dfcj]XYf 7cXY. \$\$\$-,;

5W bck `YX[Ya YbhcZ7ci blfm

 $K Y : UW \underline{b} ck `YX[Y : h Y : 6YXY[U : dY cd `Y : k \ c : UfY : h Y$

5ddYbX]I . '9b[]bYYfg'5i ghfU`]U'f95Ł'DfcZYgg]cbU` '9b[]bYYf'7ca dYhYbWm GHJbXUfX

Dfc[fUa =bhybXYX=@YUfb]b['Ci hWca Yg	
?bck `YX[Y`UbX'g_]```VUgY	
D9%"%7ca dfY\Ybg]j Yž'h\YcfmVUgYX'i bXYfghUbX]b['cZh\Y'i bXYfd]bb]b['bUhi fU`'UbX d\mg]\WJ`'g\WJYb\Wg'UbX'h\Y'Yb[]bYYf]b['Z bXUa YbhJ`g'Udd`]\WJV`Y'hc'h\Y'Yb[]bYYf]b['X]g\WJd`]bY	
D9%"&"7cbWYdh U``i bXYfgHJbX]b['cZh\Y'a Uh\Ya Uh]Wgžbi a Yf]WJ``UbU`mg]gžgHJh]gh]Wgž'UbX Wca di hYf`UbX`]bZcfa Uh]cb'gW]YbWYg'k\]W\'i bXYfd]b'h\Y'Yb[]bYYf]b['X]gW]d`]bY	
D9%" '=b!XYdh\'i bXYfghUbX]b['cZgdYW]U`]ghVcX]Yg'cZ_bck `YX[Y'k]h\]b'h\Y'Yb[]bYYf]b[X]gW]d`]bY	
D9%'('8]gWfba YbhcZ_bck `YX[Y 'XYj Y`cda YbhUbX'fYgYUfWX 'X]fYWf]cbg'k]h\]b'h\Y Yb[]bYYf]b['X]gW]d`]bY	
D9%) '? bck 'YX[Y'cZYb[]bYYf]b['XYg][b'dfUWjWY'UbX'WcbhYl hi U`'ZJWcfg']a dUWjb['h\Y Yb[]bYYf]b['X]gWjd`]bY	
D9%"* I bXYfgHJbX]b['cZh\Y'gWcdYž'df]bW]d`Ygž'bcfa gž'UWVci bHJV]`]h]Yg'UbX'Vci bXg'cZ gi gHJ]bUV`Y'Yb[]bYYf]b['dfUWfJWY']b'h\Y'gdYW]ZJWX]gW]d`]bY	
9b[]bYYf]b['Udd`]WUh]cb'UV]`]hm	
D9&"%5dd`]WUh]cb`cZYgHUV`]g\YX`Yb[]bYYf]b[`a Yh\cXg`hc`Wca d`Yl `Yb[]bYYf]b[`dfcV`Ya gc`j]b[
D9&"&": `i YbhiUdd`]WUh]cb'cZYb[]bYYf]b['hYVXb]ei Ygžhcc`g'UbX'fYgci fWYg	
D9&" '5dd`]WUh]cb`cZgmghYa Uh]WYb[]bYYf]b[`gmbh\Yg]g`UbX`XYg][b`dfcWYggYg	
D9&"('5dd`]WUh]cb'cZgmghYa Uh]WUddfcUWXYg'hc'h\Y'WcbXi WhUbX'a UbU[Ya YbhcZYb[]bYYf]b[dfcYWng	
DfcZYgg]cbU`'UbX'dYfgcbU`'Ultf]Vi hYg	
D9' "%'9h\]WU`'WcbXi Wh'UbX'dfcZYgg]cbU`'UWWci bHJV]`]hm	
D9' "&'9ZYWAj Y'cfU`'UbX'k f]MYb'Wcaaib]WUAjcb']b'dfcZYgg]cbU`'UbX'`Um'XcaU]bg	
D9' "' '7 fYUhjj Yž']bbcj Uhjj Y'UbX'dfc!UWhj Y'XYa YUbci f	
D9' "('DfcZ/gg]cbU`i gY'UbX'a UbU[Ya YbhcZ]bZcfa Uh]cb	
D9' ") 'C fXYf'mia UbU[Ya YbhcZgY`Zi'UbX`dfcZygg]cbU``WcbXi Wh	
D9' "* '9ZZYWNjj Y'NYUa 'a Ya VYfg\]d'UbX'NYUa 'YUXYfg\]d	